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Multitasking during Web search sessions

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Abstract

A user's single session with a Web search engine or information retrieval (IR) system may consist of seeking information on single or multiple topics, and switch between tasks or multitasking information behavior. Most Web search sessions consist of two queries of approximately two words. However, some Web search sessions consist of three or more queries. We present findings from two studies. First, a study of two-query search sessions on the AltaVista Web search engine, and second, a study of three or more query search sessions on the AltaVista Web search engine. We examine the degree of multitasking search and information task switching during these two sets of AltaVista Web search sessions. A sample of two-query and three or more query sessions were filtered from AltaVista transaction logs from 2002 and qualitatively analyzed. Sessions ranged in duration from less than a minute to a few hours. Findings include: (1) 81% of two-query sessions included multiple topics, (2) 91.3% of three or more query sessions included multiple topics, (3) there are a broad variety of topics in multitasking search sessions, and (4) three or more query sessions sometimes contained frequent topic changes. Multitasking is found to be a growing element in Web searching. This paper proposes an approach to interactive information retrieval (IR) contextually within a multitasking framework. The implications of our findings for Web design and further research are discussed.

1. Introduction

Due to the increasing complexity of the global information environment people are increasing engaged in multitasking and information task switching behaviors. Multitasking is the ability of humans to

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simultaneously handle the demands of multiple tasks through task switching (Just et al., 2001; Rubinstein, Meyer, & Evans, 2001). Multitasking continues to be an important research area for technologies designers in general. However, many interactive technologies do not provide effective support for managing multitasking behaviors (Wickens, 1992).

Wickens (1992) suggests that *time sharing* allows the simultaneous performance of multiple tasks and time swapping allows the sequential performance of tasks. Multitasking is a critical human behavior that allows people to cope with ever more complex environments by handling multiple tasks through task switching (Burgess, 2000; Carlson & Sohn, 2000; Lee & Taatgen, 2002). Web search can also include information multitasking behaviors that occur when users juggle the challenge of searching on multiple topics.

Web search engine users may information multitask in two ways. First, a user may begin their Web search with multiple topics, or second begin with a single topic and then develop additional topics during the search process. Both processes include information task switching, or switching back and forth between different topics during a search session. For example, a user may switch between seeking health information and new car information as they think and work on multiple information problems concurrently.

Currently, search technologies necessitate that users search sequentially and are designed to largely support only limited types of searching by specifying queries using terms to select documents or Web sites to fulfill a single information task. However, people in fact accomplish searching in much more complex ways than just this method of query specification and selection.

This paper first provides an overview of the research into general multitasking behavior, then multitasking information behavior and information task switching. The paper then details the research goals, research design and results from a study of multitasking on the AltaVista Web search engine.

2. Related studies

2.1. Multitasking behavior

Cognitive psychologists have studied many aspects of multitasking or task switching (Carlson & Sohn, 2000; Miyata & Norman, 1986). Rubenstein et al. (2001) found that multitasking between different types of tasks can reduce productivity. Recent studies suggest that users' searches may have multiple goals or topics and occur within the broader context of their information-seeking behaviors (Miwa, 2001). Research studies also indicate that users' searches may have multiple goals or topics and occur within the broader context of their information-seeking behaviors (Spink, 2004; Spink, Jansen, Wolfram, & Saracevic, 2002).

2.2. Multitasking information behavior

A growing body of studies shows that people often have many tasks (or information problems/topics) at hand at the same time. In these cases, a person may pool their topics together and interact with the Web on more than one related or unrelated topics. Overall, a user's single session with a Web search engine or a library may consist of seeking information on single or multiple topics, and also switching among topics (Spink et al., 2002). In 1999, Spink, Bateman, and Greisdorf (1999) found that 11 (3.8%) of the 287 Excite users responding to a Web-based survey reported multitasking searches. Spink et al. (2002) show that IR searches often include multiple topics, during a single search session or *multitasking search*. They found that multitasking information seeking and searching is a common human behavior as many IR system users conduct information seeking and searching on related or unrelated topics. In addition, Web or IR multitasking search sessions are longer than single topic sessions with mean topics per Web search ranging from 1 to more than 10 topics and a mean of 2.11 topic changes per search session.

Recent studies have examined multitasking searching on the Excite and AlltheWeb.com Web search engines (Ozmutlu, Ozmutlu, & Spink, 2003a; Ozmutlu, Ozmutlu, & Spink, 2003b). Ozmutlu et al. (2003a) provide a detailed analysis of multitasking sessions on AlltheWeb.com. They found that almost one third of AlltheWeb.com users perform multitasking Web searching. Multitasking Web search sessions often included more than three topics per session, are longer in duration than regular searching sessions, and most of the topics in multitasking searches were switching among general information, computers and entertainment. Ozmutlu et al. (2003b) found that multitasking Web searches are a noticeable user behavior, as one tenth of Excite users and one third of AlltheWeb.com users conducted multitasking searches. Multitasking Web search sessions are longer than regular search sessions in terms of queries per session and duration, with both Excite and AlltheWeb.com users searching for about three topics per multitasking session and submitting about 4–5 queries per topic.

Spink and Park (forthcoming) studied multitasking information and non-information behaviors by business consultants. Key findings include: (1) seeking information formed 10.5% of business consultant daily tasks, (2) information seeking tasks occurred within multitasking and task switching sequences with computing and communication tasks, and (3) information seeking tasks often occur to support or respond to communication or computing tasks. Spink and Park (forthcoming) provide a model of multitasking and task switching during human information behavior that includes cognitive, cognitive style and individual differences variables.

Typical Web search sessions are two queries, and some Web search sessions contain three or more queries (Spink & Jansen, 2004). Limited studies have examined if the typical two-query Web user and the more complex Web searcher information multitask during their Web searching. To extend the studies of multitasking search, this paper examines the prevalence of multitasking, first during Web search sessions that are two queries, and secondly during Web search sessions that include three or more queries.

3. Research objectives

The objective of the study reported in this paper is to further examine the prevalence and characteristics of information multitasking during Web search sessions of two-query and three or more queries by AltaVista users.

The specific research questions addressed by the study were:

1. To what degree do two-query and three or more query search sessions include two or more topics?
2. What are the topics in multitasking Web search sessions?
3. What are the patterns of topic task switching during multitasking Web search sessions?

The broader goal of our study is to compare our findings with previous studies in order to identify overall changes that have occurred for Web searching on AltaVista along with presenting the current state of Web searching by AltaVista users.

4. Research design

4.1. Data collection

4.1.1. AltaVista query set

In 2002, AltaVista was an important Web search engine, had a content collection of over a billion Web pages, and approximately 5.6 million visitors per month Overall, AltaVista offered a full range of searching

options, had an extremely large content collection, and millions of unique visitors per month. After being an independent company for several years, Overture Services purchased AltaVista in 2003. At the time of this study Web query data from other Web search engines (e.g., Google, Inktomi) was not available and is a matter for future research.

The queries examined for this study were submitted to AltaVista on Sunday, 8 September 2002 during a 24 h period. The queries were recorded in a transaction log and represent a portion of the searches executed on the Web search engine on this particular date. The AltaVista Web query transaction log contains approximately 3,000,000 records.

Each record contained three fields.

Time of Day: Measured in hours, minutes, and seconds from midnight of each day as recorded by the AltaVista server;

User Identification: An anonymous user code assigned by the AltaVista server in the form of a scrambled IP address.

Query Terms: Terms exactly as entered by the given user.

The AltaVista Web query transaction log contained searches from both human users and agents. We were interested in only those queries submitted by humans rather than by some automated process. Given that there is no way to accurately identify human from non-human searchers, most researchers utilizing transaction logs for data collection must either ignore it or assume some temporal or interaction cut-off.

All sessions with 100 or less queries were separated into an individual transaction log. The 100 query cut-off was almost 50 times greater than the reported mean search session (Jansen, Spink, & Saracevic, 2000; Spink et al., 2002) for human Web searchers, assuring that we were not excluding any human searches. Although this cutoff probably introduced some queries by Web agents, we were satisfied that we had retrieved a subset of the transaction log that contained queries submitted primarily by human searchers in a non-common user terminal, yet broad enough not to introduce bias by too low of a cut-off threshold.

When a searcher submits a query, then views a document, returns to the search engine, and views another page, the AltaVista server logs this second visit with the identical user identification and query, but with a new time (i.e., the time of the second visit). This is beneficial information in determining how many of the retrieved results pages the searcher visited from the search engine, but unfortunately it also introduces duplicate queries. We therefore collapsed these duplicate records in order not to skew our analysis.

4.2. Session analysis

Using the three fields (*Time of Day*, *User Identification*, and *Query Terms*), we located the initial query and then recreated the chronological series of actions in a session.

A *term* is any series of characters separated by white space or other separator.

A *query* is the entire string of terms submitted by a searcher in a given instance.

A *session* is the entire series of queries submitted by a user during one interaction with the Web search engine. Session length varied from less than a minute to a few hours.

From the transaction log, we extracted a random sample of two query sessions and a random stratified sample of sessions with three or more queries. The multitasking search sessions were sifted manually from the two-query and three or more query dataset. Two researchers qualitative analyzed each search session using categories developed by Spink et al. (2002) to identify different topics in the multitasking search sessions, and determine if the topic switch was fairly distinct (e.g., a topic switch from *black jaguar cars* to*Italian operas*).

Data was also collected during the micro-analysis on the information task/topic switching occurrences and the sequences in which the information task occurred. This type of sequential data, in sufficiently large quantities, can be used as input for the statistical analysis of the patterns and transitions of multitasking sequences.

5. Results

This paper extends results reported in Spink, Park, Jansen, and Pedersen (2004).

5.1. AltaVista sessions

5.1.1. Two-query sessions

Table 1 provides results from the analysis of the AltaVista Web two-query data.

For the AltaVista dataset, of 254 user sessions of two queries, 206 (81.1%) were multitasking Web search sessions. The 206 multitasking AltaVista sessions encompass 532 queries. A majority of AltaVista users seem to be conduct multitasking searches, as they submitted more multitasking Web search sessions and queries than non-multitasking sessions.

5.1.2. Three or more query sessions

Table 2 shows results from the analysis of the AltaVista Web three or more query data set.

For the AltaVista dataset, there were 441 (91.3%) multitasking sessions in the 483 three or more query search sessions analyzed. AltaVista users submitting in 3 or more query sessions engaged in multiple topic sessions and investigated more than one topic. Both Excite and AlltheWeb.com users also searched more three different topics per search session Amanda, references? Approximately 7798 queries were included in the 441 AltaVista multitasking sessions; with the mean queries per multitasking session was 17.7 for AltaVista users.

Previous research by Ozmutlu et al. (2003a, 2003b) examined multitasking on the Excite and AlltheWeb.com search engines, although not specifically two-query and three and more query sessions. The researchers reported that the mean queries per multitasking search session were 14.9 for Excite and 14.3

Table 1
AltaVista two-query sessions

	AltaVista 2002
Total sessions	254
Multitasking sessions	206
% of multitasking sessions	81.1%
Total queries	655
Queries in multitasking sessions	532
% of queries in multitasking search sessions	81.2%
Mean queries per session	2.0

Table 2
Session and query characteristics for three or more query sessions

	AltaVista 2002
Total sessions	483
# of multitasking sessions	441
% of multitasking sessions	91.3%
Total queries	8035
# of queries in multitasking sessions	7798
% of queries in multitasking sessions	97.1%
Mean queries per session	17.7

for Alltheweb.com users. The mean queries per session for the entire Excite sample was 10, making Excite multitasking sessions about 50% longer than regular search sessions. The same statistics for the AlltheWeb.com dataset shows that the mean queries were 10.3 for the entire sample and 14.3 for multitasking sessions.

5.2. User search topics

5.2.1. Two-query sessions

The queries in multitasking sessions were categorized with respect to the topics provided in Spink et al. (2002). Table 3 shows the categories used in the study and the number of queries falling into each category for the AltaVista query dataset.

The most preferred categories for the sample of two-query AltaVista sessions examined were general information, computers and shopping. These three categories form about 35% of the queries in multitasking sessions.

5.2.2. Three or more query sessions

The queries in multitasking sessions were categorized with respect to the topics presented in Spink et al. (2002). Table 4 shows the categories used in the study and the number of queries classified into each category for the AltaVista query dataset.

The most preferred categories for the sample of three or more query AltaVista sessions we examined were general information (14%), entertainment (13%), shopping (13%), and computer/internet (10%). These categories form about 50% of the queries in multitasking sessions. In comparison, Ozmutlu et al. (2003a, 2003b) report that Excite users query subject categories of hobbies, shopping and business formed about 47% of all queries in multitasking sessions. The subject categories might reflect topic at the same time. They found out that multitasking search sessions included more than three topics per search session.

Table 3
Topic categories for two-query sessions

Topic category	Number of queries	%
General information	100	19
Computer/Internet	64	12
Shopping	58	11
Inexplicit	46	9
Entertainment	37	7
Education	33	6
Sex	32	6
Business/economy	27	5
Individual/family	24	5
Medical/health	28	5
Employment/job	14	3
Hobbies	13	2
Science	13	2
Travel	12	2
News	11	2
Arts/humanities	11	2
Government/politics	9	2
Total	532	100

Table 4
Topic categories for three or more query sessions

Topic category	AltaVista 2002	
	Number	%
General information	1091	14
Shopping	1014	13
Entertainment	1014	13
Computer/Internet	780	10
Sex	468	6
Business/economy	468	6
Education	468	6
Medical/health	390	5
Inexplicit	390	5
Employment/Job	312	4
Travel	312	4
Hobbies	312	4
Individual/family	234	3
Arts/humanities	234	3
Science	155	2
Government/politics	78	1
Total	7798	100

5.3. Information task/topic switching

5.3.1. Two-query sessions

As examples, two two-query sessions by different users are provided below:

Time	Queries
Example 1	
7.07.59 AM	Trident Dental Laboratories
7.13.06 AM	scorpions

Time	Queries
Example 2	
8.26.11 PM	dc8p.com
8.29.30 PM	moon hoax

In both examples above, the users' changed topics during their two-query Web search sessions. Table 5 shows the data relating to topic changes during the AltaVista two-query data set.

For the AltaVista dataset, there were 206 topic changes in 206 multiple topic sessions, yielding a mean of 1 topic change per session. Typical AltaVista users engaged in multiple topic sessions and investigated more than one topic. For the Excite users, there were 246 topic changes in the 114 user query sessions, with a mean of 2.2 topic changes per session that can also be interpreted as a mean of 3.2 topics per session (Ozmutlu et al., 2003a; Ozmutlu et al., 2003b).

5.3.2. Three or more query sessions

For example, two three or more-query sessions by different users are provided below:

Time	Queries
Example 1	
2.33.37 AM	recipe bathtub crank
2.34.14 AM	recipe for making crystal meth
2.39.48 AM	queer and free
2.44.26 AM	uses of ephedrine
2.48.11 AM	woman known as catwoman
2.54.11 AM	addicted to plastic surgery

Time	Queries
Example 2	
3.28.16	nautical accessories
3.29.54	primate
3.32.34	"Anglican + primat"
3.33.31	"Solomon Norton/Hannah culver"
3.36.58	hannah culver

Table 5
Topic changes in two-query sessions

	AltaVista 2002
Total topic changes	206
Mean topic changes per session	1
Topics per session	2
Mean queries per topic	1

In both examples above, the users' changed topics during their Web search sessions. In Example 1, the user ranged over more than three topics during a period of 11 minutes from *crystal meth* to *ephedrine* then *catwoman* and finally *plastic surgery*. Table 6 shows the data relating to topic changes during the AltaVista three or more-query data set.

Ozmutlu et al. (2003a, 2003b) also found that most of the Excite and AlltheWeb.com users make 1–3 topic changes (cover 2–4 topics) per session. The mean queries per topic was 4.3 queries for the AltaVista dataset, meaning that on average users making multitasking searches changed the search topic every 4.3 queries. The relevant figures for the Excite dataset and AlltheWeb.com dataset are 4.7 queries 4.5 queries per topic meaning users submit almost the same number of queries per topic in multitasking sessions.

The next section of the paper further elaborates the key findings of the study.

6. Discussion

We identified characteristics of two-query AltaVista search sessions. Many two-query sessions were multitasking sessions where users switched from a single query on one topic to a single query on another topic.

Table 6
Topic changes in three or more query sessions

	AltaVista 2002
Total topic changes	2976
Mean topic changes per session	6.7
Topics per session	4.1
Mean queries per topic	4.3

Spink et al. (2002) found that most multitasking search sessions were twice as long as regular search sessions in terms of duration, and the mean queries per Web multitasking search session were 50% higher than that of regular search sessions. Although the reasons for multitasking behaviors were not directly tested in the studies discussed above, one can draw some insights from the data analysis, especially when combined with analysis from Web sessions of three or more queries.

Some characteristics of three or more query search sessions were identified during this analysis. Many three or more query sessions were multitasking sessions where users switched from a single query on one topic to a single query on another topic. Ozmutlu et al. (2003a, 2003b) found that most multitasking search sessions were twice as long as regular search sessions in duration (i.e., time) and length (i.e., queries). The mean queries per Web multitasking search session were 50% larger than that of regular search sessions.

Performing multitasking searches on the Web could be the result of accessing a Web search engine at a particular moment and aggregating several searches during one interaction. In addition, it appears that users' Web searching behaviors, including the most prevalent Web search sessions of two queries, often includes a need or desire to seek and search on more than one topic concurrently due to the complex nature of work or living tasks. In 1999, Spink et al. (1999) found that some 3.8% of Excite users' responding to an online survey reported multitasking. The results of the current study suggest that topic switching or multitasking information behaviors have become more common behavior by Web searchers.

Rubenstein et al. (2001) highlight the need for people to multitask in work environments as they use the microprocessor at the same time they talk on the telephone. People have many tasks at hand at the same time, including information seeking tasks. In these cases, a person may pool their topics together and interact with the Web on more than one related or unrelated topics. Users' Web search sessions range in duration from less than a minute to a few hours.

The next section of the paper elaborates the multitasking aspects of interactive information retrieval.

6.1. Interactive information retrieval as multitasking

During multitasking, humans cognitively and physically coordinate multiple tasks through task switching. The paper proposes that interactive IR is contextually a multitasking behavior on two levels.

First, on an *interactive search task* level, people construct an interactive IR session as a series of tasks, including an embedded interplay of information problem, interactive search and other tasks. For example, embedded between telephoning and computing tasks, a search engine user coordinates many tasks when looking for medical information, such as translating their information problem into a set of search terms and strategy, search engine and search term selection, relevance judgments, etc.

On a second level, people engage in *multitasking information behaviors* or are seeking information on more than one topic concurrently. For example, a search engine user switches between seeking fashion information and medical information. Interactive IR can be conceptualized as interplay between different types of tasks and often different information problems.

Conceptualizing interactive IR as a multitasking process embeds interactive IR within the broader framework of multitasking research in the cognitive/behavioral sciences. Recent cognitive and behavioral

science studies suggest that dual tasking (e.g., driving and talking concurrently) and workplace multitasking behaviors on unrelated task are counterproductive (Just et al., 2001; Rubenstein et al., 2001). However, one can argue that effective interactive IR is successfully coordinating switching between related tasks.

However, in the information retrieval context, multitasking information behavior, is still largely under-researched. In addition, current search technologies are designed to largely support only limited types of searching by specifying queries using terms to select documents or Web sites to fulfill a single information task. However, people in fact accomplish interactive IR in much more complex ways than just this method of query specification and selection.

The next section of the paper further conceptualizes interactive IR as two levels of multitasking.

6.2. Coordinating and multitasking

On one level, people construct an interactive IR session as a series of tasks and interplay of interactive search tasks. For example, embedded between telephoning and computing tasks, a search engine user may coordinate their interactive search tasks when looking for medical information.

People must coordinate the translation of their information problem(s) by performing search term selection task, tactic and strategy tasks, search engine interaction tasks, relevance judgments, etc. Research shows that human's have different levels of cognitive coordination (Miyata & Norman, 1986). Interactive IR occurs as series of coordinated task actions. To achieve interactive IR, humans' *coordinate* a number of tasks, including their cognitive state, level of domain knowledge, and their understanding of their information problem, into a coherent series of activities that may include seeking, searching, interactive browsing and retrieving and constructing information.

Humans cognitively coordinate their information seeking level behaviors with their interactive searching level (human–system interaction) level behaviors; including the recognition and making sense of and cognitively articulating an information problem or a gap in their knowledge. Human's then coordinate these processes to construct an interactive IR process embedded within their broader information and non-information behaviors.

Establishing and sustaining an effective interactive IR process require humans' to coherently coordinate and multitask their information problem and interactive search tasks. In other words, an information seeker must coordinate a number of tasks, including their cognitive state, level of knowledge, their understanding of their information problem, into a coherent series of sustained activities that may include seeking, searching, retrieving and using information. We know that hand-eye coordination is a physiological process that humans develop from childhood. Nevertheless, how do humans learn the process of cognitively coordinating their information problems into coherent processes of human information behavior and interactive information retrieval?

6.3. Multitasking information behaviors

On a second level, people often engage in multitasking information problems concurrently. Studies have highlighted the nature of task in information behavior, but have focused on single tasks and generally consider information task in isolation form other tasks. Recent empirical studies show that information retrieval system users often engage in *multitasking information behaviors*. Information behaviors are not limited to single discrete information problem tasks, but often range over multiple topics or browsing behavior on specific multiple topics. Therefore, many humans engage in information related multitasking behaviors during interactive IR.

In the interactive IR context, an IR system user may multitask (either begin their search with multiple topics or develop further topics during the search process), and information task switch (switch back and forth between different topics during a search session). Users often search on more than one information

task (topic) during a single search or multiple search interactions. Users may engage in many related multitasking search episodes over time. For example, a person switches between seeking health information and fashion information as they are thinking and working on multiple information problems concurrently. However, search technologies generally require them to search sequentially.

Multitasking information behavior research is a significant area of study. Despite the focus on tasks (Vakkari, 2003), current models of interactive IR do not consider multitasking behaviors. Human information behavior is more complex that the consideration of information tasks in isolation from people's other tasks. Understanding and modeling multitasking information behaviors, requires an understanding of the coordination and interplay between information problem, interactive search and other tasks.

7. Implications

How might multitasking search sessions be supported by Web systems and interfaces? Some commercial IR systems have a save search feature based on the assumption that many users come back to the IR system for more than one search on their topic over time. There exist many Web systems that support searching on one information task in a single database or support browsing within a single database or many Web systems, e.g., meta-search tools. Largely, current search systems are based on the assumption that users will (or need to) engage in only one search task (topic) at a time during one search. However, as our research shows, many users now routinely engage in multitasking searches in the course of a single or multiple search episodes. Users at different information seeking and problem solving stages may conduct different search behaviors. Multitasking is a major systems design research topic in this regard. Windowing features provide support for interactive multitasking behaviors within operating systems. However, few information retrieval systems provide effective support for managing multitasking behaviors.

Based on our analysis, we derived some initial Web systems features to assess in supporting multitasking search:

- Provide users with the ability to access, refine, and use results from a previous searches within the confines of a session across multiple topics.
- Assist users in coordinating multiple topics into effective queries (i.e., search histories, various thesauri or keyword generation tools).
- Provide searchers the ability to create multiple sets of working notes related to different or related search topics (i.e., sketching, hyper-linking, and note creation tools).
- Enable the submission and tracking of multiple queries concurrently on different or related topics.
- Allow for searching multiple search engines or collections concurrently on multiple topics.
- Enable the reformulation of multiple queries on different or related topics.
- Provide windowing facilities to allow Web users to generate and track separate topic or related topic queries and facilitate topic switching.
- Enable the generation and comparison of relevance judgments from different or related searches.
- Enable the tracking, storing and manipulating retrieved results and printouts related to different topics over multiple searches.
- Provide the ability to create clusters of retrieved information related to different topics.

8. Conclusion and further research

This paper has proposed that, theoretically and practically, interactive IR can be conceptualized as a multitasking and coordinating processes on various levels as interplay of information problem and inter-

active search tasks. Exploring multitasking and coordination behaviors are relatively new and heuristic direction for interactive IR research. The authors are currently conducting further studies to extend our understanding of the nature, patterns and impacts of interactive IR as multitasking. Currently, Web systems and interfaces provide limited support for multitasking search. As the complexity of information structures and problems increases, more complex human information processes and more effective Web technologies are required to sustain effective human information behaviors.

Further research is being conducted to investigate:

1. How multitasking searches differ from non-multitasking sessions.
2. If a user's information-seeking stage affects the number and performance of multitasking searches.
3. The relationship between the nature of the user's information problems and multitasking, and how they are coordinated.
4. The interplay between information and non-information tasks (Spink & Park, forthcoming).

A model of multitasking and task switching during human information behavior is also being developed (Spink, 2004; Spink & Park, forthcoming). Further research is also required to compare and characterize information problems that lead to multitasking.

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