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A New Integrated Model for Multitasking during Web Searching

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Abstract

There have been many studies in the field of information behavior. Recently Du and Spink (2011) presented a model, which simulates multitasking, cognitive coordination and cognitive shifts on web. However, this model does not incorporate personal variables and the impact of task or web design. This research addresses this gap. Information and psychological scientists have shown that information behavior (IR) is affected by: the affective domain, cognitive attributes, psychological factors, personality dimensions and sociological factors. This study investigates how IR is affected by working memory (wm), cognitive coordination, cognitive shifts and various artifacts and task variables influenced by the PAT model (Personal, Artifact and Task characteristics) of flow. The research is exploratory and takes a pragmatic, mixed method approach. Thirty University students will participate. The research tools include: pre and post questionnaires, working memory tests, Flow State Scale test, think aloud data, observations, audio-visual data, web search logs and use of the Critical Decision Method. The qualitative data will be coded and analyzed thematically and will be related to the quantitative data. This study is expected to identify the impact of all these variables on multitasking IR in the web and provide a new integrated framework, which is not only going to help information scientists to better understand this behavior but also web companies to develop more effective web products.

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1. Introduction

People use web and web search engines in order to investigate and retrieve information. As web seeking becomes increasingly necessary for information access across the world, there is a need for more effective models describing people's interaction with web systems.

Web searching usually characterized as multitasking information seeking behavior, described as “ the process of searches over time in relation to more than one, possibly evolving, set of information problems (including changes or shifts in beliefs, cognitive, affective, and/or situational states)” (Spink A, Ozmutlu HC, Ozmutlu S. 2002). A number of factors are involved when people multitask using the web: the affective, the cognitive,

psychological states, personality dimensions and sociological factors. However these factors affect multitasking information behavior at different levels in the searching process and further research is needed to explore them more in a multitasking environment on web.

This study is expected to identify:

- The impact of cognitive factors on multitasking information behavior when using the web. It is expected that this study will expand the previous model of web searching considering people's cognitive variables (Du JT, Spink A. 2011). The investigation of working memory should also throw light on multitasking information behavior particularly in relation to cognitive coordination, cognitive shifts and their sub levels.
- Relationships, if any, between cognitive shifts and coordination levels for each participant according their working memory capacity. Patterns of cognitive coordination and shifts will be investigated.
- The impact of web artifact and tasks characteristics, according to the PAT model of flow. Multitasking in previous models consist of task switching between original and evolving information problems, and of multiple web search sessions and windows browsing. This study is going to involve tasks and web artifacts characteristics according the PAT model of flow because this model identifies the importance of separating the task from the artifact within a computer-mediated environment. The impact of web artifacts and tasks characteristics will be compared to flow, cognitive shifts and cognitive coordination.
- The relationship between flow, during the whole multitasking information behavior event, to cognitive coordination, cognitive shifts and web seeking procedure. The results of flow tests will be compared to working memory results, enabling correlations to be investigated and their impact on multitasking information behavior to be explored.

2. Background Research

2.1 Information behavior

Information behavior has been explored for many years. Many information scientists have provided models, in which they tried to illustrate the strategies and mechanisms of this behavior (Wilson TD. 1981, Ellis D, Cox D, Hall K. 1993, Du JT, Spink A. 2011, Ellis D. 1989, Kuhlthau CC. 1991, Ellis D, Haugan M. 1997, Dervin B. 1983, Hepworth M. 2004, Hepworth M. 2001, Sutcliffe AG, Ennis M. 1998).

Information Retrieval (IR) is about searching, filtering and finding the information that people desire (Ingwersen P, Järvelin K. 2005). Different approaches have been used to depict the process. The system approaches highlight the importance of the system (Larsen B, Ingwersen P. 2005). The user approaches, on the other hand, focus, as expected, on the user and their main role. Other approaches concentrate on the cognitive factors involved in the processes between the user and the system (Larsen B, Ingwersen P. 2005).

The term Interactive Information Retrieval (IIR) has been coined to describe information retrieval in relation to web searching (Ingwersen P, Järvelin K. 2005). Several model exist which attempt to describe this process, (Bates NJ. 1989, Saracevic T. 1996, Saracevic T. 1997, Belkin NJ. 1996, Ingwersen P. 1992, Spink A. 1997); however, they do not adequately describe the cognitive mechanisms involved. For completeness, some of these models are described in the following sessions.

2.2 Web searching

Many models have been developed to depict factors that may affect web use, performance and selection of web search engines and tools (Wang P, Hawk WB, Tenopir C. 2009, Wang P, Hawk WB, Tenopir C. 2005, Knight SA, Spink A. 2008, Ford N, Miller D, Moss N. 2005, Du JT, Spink A. 2011, Shneiderman B, Byrd D, Croft WB. 1997). Du and Spink (2011), for example, in their model linked multitasking with cognitive

coordination and cognitive shifts. They found that when users multitasked on web, they searched for solutions to several problems or tasks at once. Even when given an information task, they searched for answers for other relevant and irrelevant information problems. People tended to coordinate their tasks, strategies, and mechanisms. They found that a person's cognitive shift could be either a change in knowledge for one topic ('holistic shift') or a change in users' cognitive states while seeking ('state shift'). While useful, the main limitation of this model is that it does not provide details about the cognitive factors and procedures, which may underlie and influence all these processes.

Another well-known model describing web searching is that proposed by Wang, Hawk and Tenopir (2009). Three factors are included in their multidimensional model: the user, interface, and World Wide Web (WWW). The authors proposed that these factors are connected to each other and that they affect people's cognitive, affective and physical behaviors. In their experiment, participants completed a questionnaire about web experience, anxiety and cognitive styles. Then, they had to search on the web for two information problems. Rieh and Xie (2006) explored how people search the WWW. Participants searched for six different topics per session and how their affective, cognitive and situation level affected their query reformulation was investigated. They found that, people reformulated their queries as a result of their cognitive, affective, and situation stages and according three factors: content, format, and resource. Palmquist and Kim (2000) explored the effects of cognitive styles. They found that cognitive styles may affect only novice users' web use and performance in contrast to experienced users who were not influenced so much by their cognitive styles.

2.3 *Multitasking*

Multitasking has been defined as the ability to do many things concurrently and switch between them successfully (Pashler H. 2000, Just MA, et. al 2001, Lee FJ, Taatgen NA. 2002).

It is a common behavior when people seek information on Web. Spink, Ozmutlu and Ozmutlu (2002), for example, conducted experiments to investigate the behavior of users when searching for multiple topics. The results showed that multitasking sessions were more frequent, with a maximum number of topics per session 10, with a mean of 2.11 topic changes. In another study, Spink's et al., (2006) users were asked to conduct two and three seeking sessions on web. The results showed that participants switched between multiple queries and sessions. There were frequently changes of topics, with 81% of two-query sessions with multiple tasks and 91.3% of three or more query sessions. The researchers also found that people tended to coordinate the tasks and the seeking strategies.

Several researchers have tried to unveil the cognitive procedures behind this complex behavior. They have found, for example, that working memory capacity and attention can be predictors for the success or otherwise of multitasking performance (Just MA, et al. 2001, Hambrick DZ, et al. 2010, Bühner M, et al. 2006, Bühner M, et al. 2011, Colom R, et al. 2010, Logie RH, Trawley S, Law A. 2011). Morgan et al. (2011) also found that, in addition to working memory, a person's spatial ability as well as general aptitude could affect multitasking performance. In their experiment, participants had to multitask and complete questionnaires about their cognitive abilities. Judd and Kennedy (2011) studied students' multitasking information behavior. They found that when people multitask between different kinds of tasks, their memory performance was low level.

Four mechanisms are thought to be related to successful task switching: task selection, which is about the prioritizing of each task; demand level, which is about the difficulty of each task; multiple resources, which relates to the number resources needed/available to complete the tasks; and confusion about the requirement of each task (Wickens CD. 1989). Spink and Park (2005) in their model of multitasking mentioned the importance of cognitive styles, individual differences, and the relations between information and non-information behavior tasks.

Du and Spink (2011) provided a model for multitasking on Web. They suggested that people tend to multitask between relevant and irrelevant information topics, as well as conduct serendipity browsing. Cognitive coordination appears to be key in the management of the successful completion of the tasks.

2.4 Cognitive procedures

The successful coordination of multiple tasks depends on the user's prior knowledge of the subject area and their ability to employ different seeking strategies (Spink A, et al. 2006).

Ma (2008) in her IR coordination model suggested that perceptual, linguistic evidence and the exploration of seeking web logs lead to coordination. However, she did not mention in detail the cognitive processes. Du and Spink (2011) described three cognitive coordination sublevels: task, mechanism and strategy level. The task coordination level is the coordination of the information tasks. The mechanism coordination level is about people's mechanisms, such as feedback. The strategy level contains two sub levels. The first is the task specific strategy level, which is about how people reformulate their queries in order to find more information. The second sublevel is the global strategy level, which is the main plan according to which people manage timely their seeking actions.

Cognitive shift is another cognitive process that has been explored (Spink A. 2002, Rieh SY, Xie HI. 2006, Robins D. 2000, Xie HI. 2000). Kulthau (1991) suggested that people transferred cognitively from the stage of uncertainty when they start to seek information to the stage of confidence. Du and Spink (2011) found two different types of cognitive shifts: the holistic and the state shifts. However, they found that each participant may have different levels of cognitive shifts, but they did not mention which individual cognitive procedures lead to these results.

2.5 Personal dimensions from the fields of psychology and information science

As previously mentioned, five main dimensions are thought to influence multitasking on web: the affective, cognitive, psychological states, personality and sociological factors. Previous research has shown that:

Affective factors which include feelings and emotions category (Kleinginna PR, Kleinginna AM. 1981).

- Positive feelings can improve people's information seeking strategies as well as performance (Gwizdka J, Lopatovska I. 2009, Nahl D. 2005, Wang P, Hawk WB, Tenopir C. 2009).
- Positive emotions lead to better performance and seeking process; having negative emotions, lead to lower performance (Picard RW. 2003).

Cognitive factors which include cognitive styles, the users' experience, working memory, developmental stages and aging factors (Marchionini G. 1997, Brand-Gruwel S, et al. 2005, Navarro-Prieto R, Scaife M, Rogers Y. 1999, West R, Bell MA. 1997).

- Verbalizer cognitive styles negatively affect the seeking process because people tend to focus on visual images and at the end they get lost (Ford N, Miller D, Moss N. 2005, Thomas PR, McKay JB. 2010). Field-independent people are more analytic and have better performance than field-dependent (Yuan X, Liu J. 2011, Ford N, et al. 2002).
- Poor working memory (the ability to hold a specific amount of information while approaching other information tasks (Conway ARA, et al. 2002, Colom R, et al. 2005, Engle RW, et al. 1999)) negatively affects performance (Hambrick DZ, et al. 2010, Colom R, et al. 2010). Working memory capacity may predict reading and language comprehension (Daneman M, Merikle PM. 1996, Daneman M, Green I. 1986, Bühner M, et al. 2006), which are related to information behaviour.

- People tend to search for relevant information, a process that is called biased information (Lowin A. 1969). Hence, through attention, people can select which information to store and process and which not (Oberauer K, Hein L. 2012).
- People tend to search for information based on their prior knowledge, see Festinger (1957) who proposed the dissonance theory.
- A person's prior experience positively affects the information seeking performance (Navarro-Prieto R, Scaife M, Rogers Y. 1999, Marchionini G. 1997, Ford N, Miller D, Moss N. 2005, Brand-Gruwel S, et al. 2005). It has been shown that experts use multiple and different seeking strategies in less time and with better outcomes than novice users (Navarro-Prieto R, Scaife M, Rogers Y. 1999, Marchionini G. 1997).
- Developmental stages involve multiple cognitive processes, such as memory, language, decision making). These processes take various forms in each cognitive stage. From that evolutionary point of view, information behavior involves multiple information seeking stages.
- Aging has been found to decrease the performance of many cognitive abilities, such as working memory and attention, as well as to increase visual and motor problems (Balota DA, Duchek JM. 1988, Filley CM, Cullum C. 1994, West R, Bell MA. 1997).

Psychological states which includes motivation and flow (Wigfield A, Cambria J, Ho AN. 2012, Csikszentmihalyi M. 1997, Chen H, Wigand RT, Nilan M. 2000).

- People tend to be more happy and satisfied about their performance when they are motivated. (Humphreys MS, Revelle W. 1984). Illies and Palmon (2004) however, found that when people search and find information, which may confront their values, then motivation tend to be a negative predictor of the information seeking performance.
- People having good flow, defined as “a balance state between “skill” and “challenge” (Csikszentmihalyi M. 1990) with characteristics such as : clear goal, feedback, concentration, focus, control, loss of self-consciousness, transformation of time, and autotelic nature (Csikszentmihalyi M. 1997), aids performance. Finneran and Zhang (2003) in their PAT model distinguished the variables of person, artifact, and task. These variables are flow's antecedents in computer environments; they are independent but at the same time correlated to each other.

Personality dimensions such as: neuroticism, extraversion, openness to experience, competitiveness and consciousness (Heinström J. 2003).

- Extraversion is connected with information performance, when the task was only positive (Rusting CL, Larsen RJ. 1998).

Sociological factors which includes self-efficacy from the social cognitive theory of Bandura (1986), also mentioned by Wilson (1999).

- Self-efficacy (people's belief to search successfully information from the web) appears to be a mediator of personal involvement, people's seeking procedure, and perceived success (Rains SA. 2008).

3. Methodology

This study aims to investigate the relationships of working memory, flow, as well as artifact and task characteristics influenced by the PAT model in a multitasking environment on web.

The research is exploratory and takes a pragmatic, mixed method approach. Thirty University undergraduate and postgraduate students will participate in the main experiment. The research will have two phases. In the first phase, more than 30 participants will take the Automated Operation Span Task working memory test (Unsworth N, et al. 2005). Then, the researcher will exclude participants who do not meet the accuracy criterion of the test.

After that, the researcher will conduct short pre -interviews. Participants, from the same field, will be asked about several information seeking tasks they need to undertake and for which they have prior knowledge; and about other tasks for which they have no or little knowledge. Then, the researcher will develop two broad categories of information seeking task: two tasks for which participants have prior knowledge and two more for which participants will have no or little prior knowledge. These four tasks will form the basis of the test scenarios and will be the same for all participants.

The second phase will comprise the main experiment. All participants will be expected to complete pre-questionnaires containing open and closed questions and will be asked to complete the four information seeking tasks simultaneously (multitask) for one hour. They will be asked to “think aloud” during the experiment and they will be also observed by the researcher. Camtasia software will be used to capture exactly how the participants search on the web. After that, participants will be required to answer a post questionnaire and undertake a Flow State Scale test. In conclusion, the researcher will interview each participant using the Critical Decision Method. The interviews will be recorded. The qualitative data will be coded and analyzed thematically and will be related to the quantitative data.

4. Proposed Model

A preliminary theoretical model is proposed, which indicates the possible relationship between multitasking on web, working memory and flow, and the influence of the PAT model.

Environmental and demographic factors will be controlled in this research because the research will be conducted in a quiet environment and it is intended to select participants with similar age and educational levels. Similarly, controls will be in place to standardize the web task characteristics and the systems used. The intention is to investigate the lower part of the model, in particular, the connection between working memory capacity, flow levels and cognitive coordination and shifts.

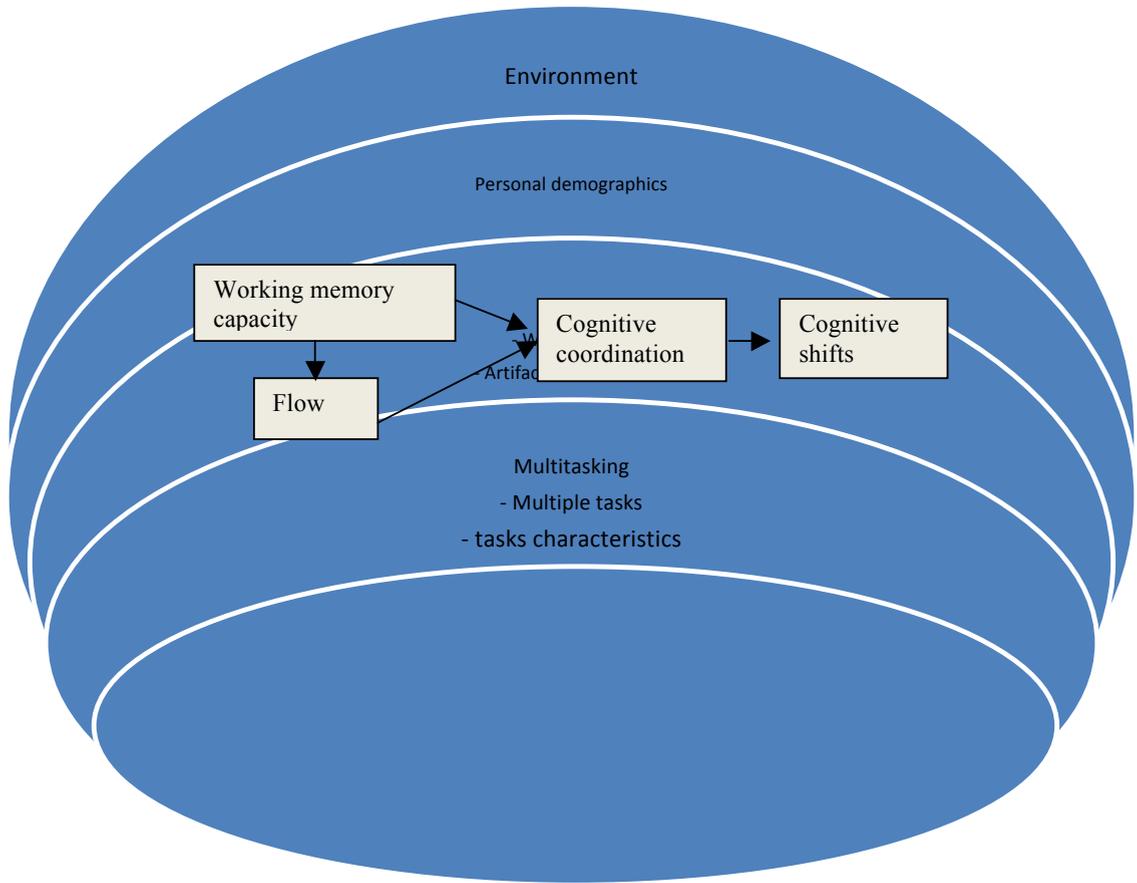


Fig. 1. Preliminary model of the study.

5. Discussion

It is expected that a new integrated framework of multitasking information behavior on web will be developed. This new model will encompass people’s personal dimensions in relation to web design and task characteristics and provide an insight into how multiple and different factors may have an impact on web seeking behavior.

It will also indicate how people’s working memory capacity, attention and flow levels, influenced by the PAT model, may affect cognitive coordination and cognitive shifts of knowledge.

In particular, cognitive coordination and cognitive shifts will be explored in-depth in relation to working memory and flow. It is expected that patterns of cognitive coordination and cognitive shifts will appear.

It is expected that the results will help web designers and companies to develop more effective web products.

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