# An Investigation of Multitasking on the Web: Key Findings

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## Abstract

***Introduction.*** *This paper presents key findings from a study exploring how multitasking information behaviour is affected by people's working memory capacity and the flow they experience during the searching process.*
***Method.*** *The research is exploratory using a pragmatic, mixed method approach. 30 study participants, 10 psychologists, 10 accountants and 10 mechanical engineers, conducted Web searches on four information topics. The data collection tools used were: pre and post questionnaires, pre interviews, working memory test, the flow state scale of Jackson and Marsh (1996), audio-visual data, web search logs, think aloud data, observation, and the critical decision method.*
***Results.*** *The results suggested that people with high working memory, high flow and mechanical engineers generated more cognitive coordination and cognitive state shifts than people with low working memory, low flow, accountants and psychologists. The most frequent cognitive state and coordination shift for all groups was from strategy to information topic. Low working memory participants rated task complexity at the end of the procedure more highly for tasks without prior knowledge compared to tasks with prior knowledge. Participants with high flow levels experienced a greater change of knowledge for information tasks without prior knowledge compared to participants with low flow. The degree of change of knowledge for participants with high flow was higher for tasks without prior knowledge rather than for tasks with prior knowledge.*

***Keywords****: Multitasking information behavior, web searching, working memory, flow, PAT model, cognitive coordination, cognitive shifts.*

## Introduction

When people search the web, their behaviour is often described as multitasking (Rogers and Monsell, 1995; Carlson and Sohn, 2000). Multitasking information behaviour has been defined as the, "library search and use behaviours, or database or Web search sessions on multiple information tasks" (Spink 2004, p. 336).
According to the literature as discussed below, however, further research is needed to explore particular psychological factors in the specific environment of multitasking information behaviour on Web. The purpose of this study was therefore to identify the impact of working memory and flow on participants' multitasking information behaviour.

## Literature Review

Multitasking is people's ability to perform many tasks concurrently and switch between them successfully (Just et al., 2001; Ionescu, 2012). Many models have been developed to define factors that may affect peoples' information behaviour on web, performance and selection of web tools (Wang et al., 2000; Choo et al., 2000; Ford et al., 2001, 2005; Knight and Spink, 2008; Du and Spink, 2011).

Du and Spink (2011) provided a new model for multitasking information behaviour while web searching. They identified three cognitive coordination levels: task, mechanism and strategy. Task coordination level is the level in which people coordinate and evaluate the different information problems. The mechanism coordination level involves mechanisms such as feedback (for example judgements about the content). Lastly, the strategy level concerns the query reformulation and people's plans about the overall seeking process. The two cognitive shifts levels were described as holistic shift and state shift. Holistic shift is the person's cognitive change in understanding and knowledge on one topic measured before and after web seeking. State shift is the change regarding the interaction between people and web search system (Du and Spink, 2011).

Working memory capacity has been found to predict the success or not of multitasking performance (Bühner et al., 2006; Just et al., 2001; Hambrick et al., 2010; Colom et al., 2010). Working memory influences the ability to hold a specific amount of information while approaching other information tasks. Low levels of working memory may negatively affect performance (Colom et al., 2010; Hambrick et al., 2010).

Flow also has an impact on behaviour. When people feel flow and when they are motivated, they tend to have high levels of performance and tend to be happier (Csikszentmihalyi, 1990; Wigfield et al., 2012). Finneran and Zhang (2003) proposed the PAT model of flow and related it to information behaviour, in which the variables of person, artefact, and task have been identified as flow's antecedents in a Web environment. The task variable relates to the level of complexity of the task. A complex task could provoke high levels of flow because it may involve multiple challenges. On the other hand, a highly complex task could also provoke anxiety.

These factors, however, have not been investigated in a multitasking context in relation to cognitive mechanisms, for example cognitive coordination and cognitive shifts. This research is addressing this gap relating working memory capacity, flow and their effect on the cognitive state and coordination shifts.

## Methodology

The research was exploratory using a mixed method approach. 30 undergraduate and postgraduate students in Greece and in the UK participated from three different disciplines: mechanical engineering, accounting and psychology. There were ten participants in each field. The research had two phases. In the first phase, thirty-four participants took the automated operation span task working memory test. The researcher then excluded those participants, who got less than 85% in a time pressured mathematical calculation test, which left thirty participants. The researcher then conducted short pre-interviews where participants chose from two lists several topics about their discipline that they would like to search for on the web and for which they had firstly, prior knowledge and secondly, no or little prior knowledge. The researcher then categorised participants' answers into four broad categories for each discipline: two for which participants had prior knowledge and two for which participants had no or little prior knowledge.

The second phase was the main experiment. The participants completed a questionnaire and then they sought for one hour for information on the Web on the four information-seeking tasks. Camtasia software captured participants' searches on the web. They were asked to think aloud during the experiment and they were observed by the researcher. At the end of the information seeking process, participants answered another questionnaire and undertook the flow state scale test. Finally, the researcher interviewed each participant using the critical decision method. The interviews were recorded.

## Key Findings

Fifteen participants were in the low quartile (low memory capacity), and 15 were in the upper quartile (high memory capacity). 15 participants had high flow and 15 experienced low flow.
In total, 406 Web searches were performed. The mechanical engineers generated more queries, opened more windows and conducted more web search sessions than accountants and psychologists.
The most frequent cognitive coordination and state shift for all groups was from STR (WSS) (web search strategy) to CSG (current search goal). Most participants chose their preferred web search engine first and then examined the topic.
Low working memory participants rated task complexity at the end of the procedure more highly for tasks without prior knowledge compared to tasks with prior knowledge. They also generated less cognitive state and coordination shifts than the high working memory group.
Participants with high flow levels generated more cognitive state and coordination shifts than the low floe group and they experienced a greater change of knowledge for information tasks without prior knowledge compared to participants with low flow. The degree of change of knowledge for participants with high flow was higher for tasks without prior knowledge rather than for tasks with prior knowledge.
The figure below shows the new model for multitasking information behaviour:

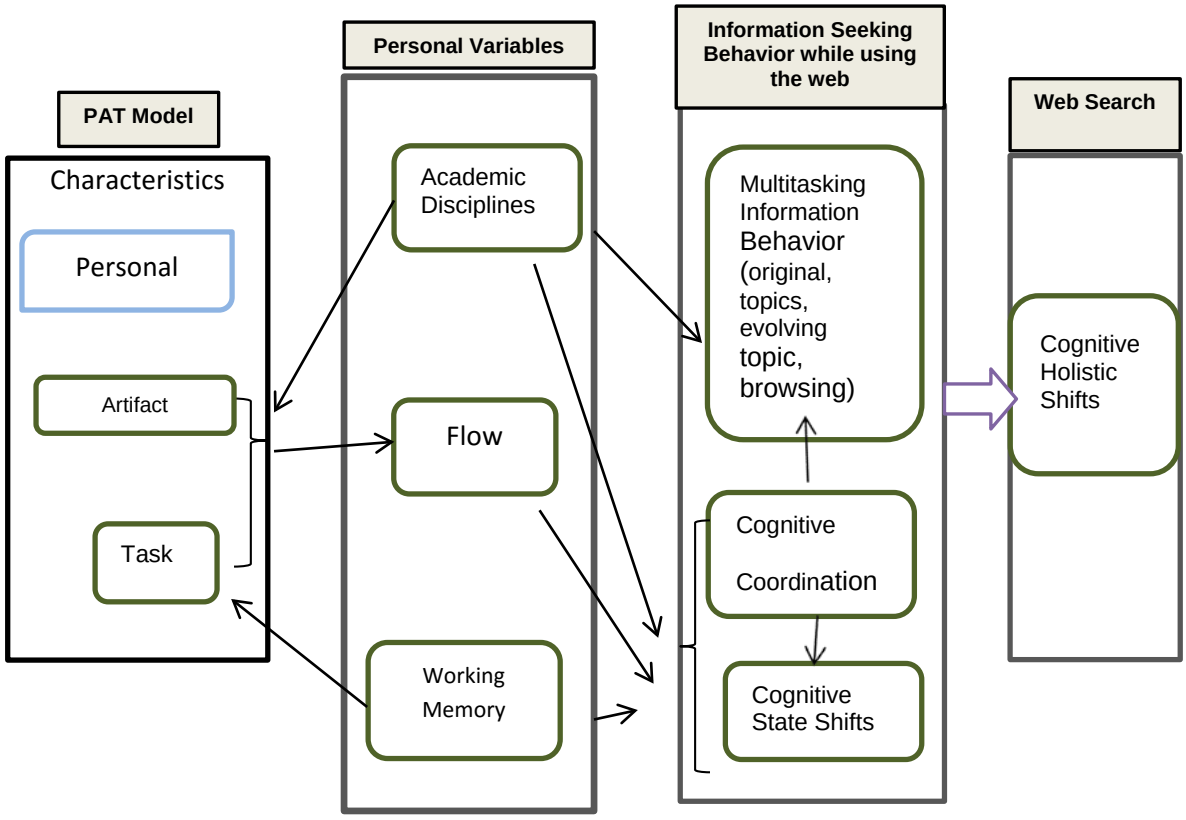


**Figure1.** The new model

## Discussion

The results indicate that web searchers do exhibit multitasking behaviour as suggested by Du and Spink (2011). The mechanical engineers generated more queries, opened more windows and conducted more web search sessions than accountants and psychologists. The analysis of

web logs and the interviews revealed that the accounting information topics were regarded as being more straightforward and as a result, they did not need to generate many web search sessions. The mechanical engineers, however, generated more queries, opened more windows and conducted more web search sessions because, as it seemed from the web logs, they were keen to explore the information topic provided as well as this particular discipline is more often updated, so the participants were keen to explore new facts.

Previous studies suggested that working memory could influence multitasking behaviour (Colom et al. 2010; Hambrick et al. 2010; Buhner et al., 2006). In this study, the high working memory group generated more cognitive state and coordination shifts than the low working memory group. Except that, people with low working memory rated task complexity at the end of the procedure more highly for tasks without prior knowledge compared to tasks with prior knowledge. This confirms previous finding of Engle et al. (1999) who mentioned that people with high working memory capacity tend to allocate their attention to task-relevant information and coordinate information more successfully in contrast to people with low working memory who allocate their attention to task-irrelevant information.

This study indicates that flow is linked to multitasking information performance as suggested by Csikszentmihalyi (1990) and Wigfield et al. (2012). In this research, performance was regarded as being related to the number of cognitive state and coordination shifts experienced. Participants with high flow levels generated more cognitive state and coordination shifts than the low flow group because they felt more engaged to the seeking procedure. They also experienced a greater change of knowledge for information tasks without prior knowledge compared to participants with low flow. The degree of change of knowledge for participants with high flow was higher for tasks without prior knowledge rather than for tasks with prior knowledge. When participants did not experience high levels of flow, their performance suffered as indicated by less cognitive state and coordination shifts than those with higher levels of flow.

## Conclusion

The key findings thus far appears to suggest that working memory capacity and flow do affect the number of cognitive state and coordination shifts during the search process. Working memory and flow are predictors and mediators of multitasking information behaviour on the web.

## References


BÜHNER, M., KÖNIG, C.J., PICK, M., and KRUMM, S., 2006. Working memory dimensions as differential predictors of the speed and error aspect of multitasking performance. *Human Performance,* 19(3), 253-275.

CARLSON, R.A., and SOHN, M.H., 2000. Cognitive Control of Multistep Routines: Information Processing and Conscious Intentions. In: JON DRIVER, S.M., ed. *Control of Cognitive Processes*. Cambridge, MA: The MIT Press, pp. 443-464.

CHOO, C.W., DETLOR, B., and TURNBULL, D., 2000. Information seeking on the Web. *First Monday,* 5, 2-7.

COLOM, R., MARTÍNEZ-MOLINA, A., SHIH, P.C., and SANTACREU, J., 2010. Intelligence, working memory, and multitasking performance. *Intelligence,* 38(6), 543-551.

CSIKSZENTMIHALYI, M., 1990. *Flow: The Psychology of Optimal Experience.* NY: Harper and Row.

DU, J.T., and SPINK, A., 2011. Towards a Web search model: Integrating multitasking, cognitive coordination and cognitive shifts. *Journal of the American Society for Information Science and Technology,* 62(8), 1446–1472.

ENGLE, R.W., TUHOLSKI, S.W., LAUGHLIN, J.E., and CONWAY, A.R.A., 1999. Working memory, short-term memory, and general fluid intelligence: a latent-variable approach. *Journal of Experimental Psychology: General,* 128(3), 309-331.

FINNERAN, C.M., and ZHANG, P., 2003. A person–artefact–task (PAT) model of flow antecedents in computer-mediated environments. *International Journal of Human-Computer Studies,* 599(4), 475-496.

FORD, N., MILLER, D., and MOSS, N., 2001. The role of individual differences in Internet searching: An empirical study. *Journal of the American Society for Information Science and Technology,* 52(12), 1049-1066.

FORD, N., MILLER, D., and MOSS, N., 2005. Web search strategies and human individual differences: Cognitive and demographic factors, Internet attitudes, and approaches. *Journal of the American Society for Information Science and Technology,* 56(7), 741-756.

HAMBRICK, D.Z., OSWALD, F.L., DAROWSKI, E.S., RENCH, T.A., and BROU, R., 2010. Predictors of multitasking performance in a synthetic work paradigm. *Applied cognitive psychology,* 24, (8), 1149-1167.

IONESCU, T., 2012. Exploring the nature of cognitive flexibility. *New Ideas in Psychology,* 30(2), 190-200.

JUST, M.A., CARPENTER, P.A., KELLER, T.A., EMERY, L., ZAJAC, H., and THULBORN, K.R., 2001. Interdependence of non-overlapping cortical systems in dual cognitive tasks. *NeuroImage,* 14, 417-426.

KNIGHT, S., and SPINK, A., 2008. Toward a Web search information behavior model. *Web Search,* 14, 209-234.

ROGERS, R.D., and MONSELL, S., 1995. Costs of a predictable switch between simple cognitive tasks. *Journal of Experimental Psychology*, 124, 207–230.

SPINK, A., 2004. Multitasking information behavior and information task switching: An exploratory study. *Journal of Documentation*, 60(3), 336–345.

WANG, P., HAWK, W.B., and TENOPIR, C., 2000. Users' interaction with World Wide Web resources: An exploratory study using a holistic approach. *Information processing & management,* 36(2), 229-251.

WIGFIELD, A., CAMBRIA, J., and HO, A.N., 2012. *Motivation for reading information texts.* University of Maryland, College Park.

## Author Biography

After graduating in psychology from Panteion University in Greece, I continued and completed my Master in Counselling Psychology. I also have Professional Diploma in Special Learning Difficulties–Dyslexia. I worked from 2006 to 2012 as voluntary psychologist in a Psychosocial Rehabilitation Centre in Greece providing psychological help to staff and patients with severe mental disorders. I have also worked as coordinator and psychologist in other Psychosocial Rehabilitation Centre providing psychological help. I had a private office as a psychologist and special educator before starting my PhD. During my PhD I have proactively undertaken further work such as marking, invigilating, working as a tutorial assistant, a PhD representative and taking the responsibility of managing the department's research blog for two years.