

A New Integrated Model for Multitasking During Web Searching

by

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ABSTRACT

Investigating multitasking information behaviour, particularly while using the web, has become an increasingly important research area. People's reliance on the web to seek and find information has encouraged a number of researchers to investigate the characteristics of information seeking behaviour and the web seeking strategies used. The current research set out to explore multitasking information behaviour while using the web in relation to people's personal characteristics, working memory, and flow (a state where people feel in control and immersed in the task). Also investigated were the effects of pre-determined knowledge about search tasks and the artefact characteristics. In addition, the study also investigated cognitive states (interactions between the user and the system) and cognitive coordination shifts (the way people change their actions to search effectively) while multitasking on the web. The research was exploratory using a mixed method approach. Thirty University students participated; 10 psychologists, 10 accountants and 10 mechanical engineers. The data collection tools used were: pre and post questionnaires, pre-interviews, a working memory test, a flow state scale test, audio-visual data, web search logs, think aloud data, observation, and the critical decision method. Based on the working memory test, the participants were divided into two groups, those with high scores and those with lower scores. Similarly, participants were divided into two groups based on their flow state scale tests. All participants searched information on the web for four topics: two for which they had prior knowledge and two more without prior knowledge.

The results revealed that working memory capacity affects multitasking information behaviour during web searching. For example, the participants in the high working memory group and high flow group had a significantly greater number of cognitive coordination and state shifts than the low working memory group and low flow group. Further, the perception of task complexity was related to working memory capacity; those with low memory capacity thought task complexity increased towards the end of tasks for which they had no prior knowledge compared to tasks for which they had prior knowledge. The results also showed that all participants, regardless of their working memory capacity and flow level, had the same the first frequent cognitive coordination and cognitive state sequences: from strategy to topic. In respect of disciplinary differences, accountants rated task complexity at the end of the web seeking procedure to be statistically less significant for information tasks with prior

knowledge compared to the participants from the other disciplines. Moreover, multitasking information behaviour characteristics such as the number of queries, web search sessions and opened tabs/windows during searches has been affected by the disciplines. The findings of the research enabled an exploratory integrated model to be created, which illustrates the nature of multitasking information behaviour when using the web. One other contribution of this research was to develop new more specific and closely grounded definitions of task complexity and artefact characteristics). This new research may influence the creation of more effective web search systems by placing more emphasis on our understanding of the complex cognitive mechanisms of multitasking information behaviour when using the web.

Keywords: multitasking information behaviour, web searching, working memory, flow, PAT model, cognitive coordination, cognitive shifts.

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Chapter 1 Introduction

1.1. Problem Statement

Information behaviour has been an important research area for many years in the field of information science. Information behaviour as Wilson (2000, p. 49) defined is "*the totality of human behaviour in relation to sources and channels of information, including both active and passive information seeking, and information use. Thus, it includes face to-face communication with others, as well as the passive reception of information as in, for example, watching TV advertisements, without any intention to act on the information given*". Many models have been developed through which researchers tried to investigate the steps of this behaviour, the reasons behind each step, the intermediating variables and the mechanisms that occur during this behaviour (Wilson, 1981; Dervin, 1983; Ellis, 1989; Kuhlthau, 1991; Ellis et al., 1993; Ellis and Haugan, 1997; Sutcliffe and Ennis, 1998; Vakkari, 2001; Hepworth, 2004).

Information retrieval has also been explored because this process enables people to represent, store, seek, find, and filter new information (Ingwersen and Järvelin, 2005). As Mooers (1951, p.25) mentioned, "*Information retrieval is the name for the process or method whereby a prospective user of information is able to convert his need for information into an actual list of citations to documents in storage containing information useful to him....it embraces the intellectual aspects of the description of information and its specification for search, and also whatever systems, technique, or machines that are employed to carry out the operation. Information retrieval is crucial to documentation and organization of knowledge*".

Interactive information retrieval is about seeking information through web technology and information systems (Ingwersen and Järvelin, 2005). In order to describe the relationship between the user and the system information scientists have developed interactive information models (Bates, 1989; Ingwersen, 1992, 1996; Belkin, 1996; Saracevic, 1996, 1997; Spink, 1997). These models incorporated cognitive elements, however, they did not explore in-depth the cognitive mechanisms, which underlie the information retrieval procedure and which may positively or negatively affect the information retrieval interaction.

Finneran and Zhang (2003) constructed the PAT model (person, artefact, and task), in which these three variables are flow's antecedents in computer environments. They suggest that people are more likely to experience flow if they have: an autotelic nature, exhibit exploratory behaviour, become absorbed in the task, lose a sense of time, feel a loss of self-consciousness, are able to balance skills and challenges, have clear task goal, and are able to benefit from the artefact, feedback, and playfulness. Flow is also more likely to be obvious when the artefact has vividness and responsiveness, and when the task is autonomous, goal-directed, enables more variety, has an appropriate level of complexity, and fits with the artefact (Finneran and Zhang, 2003). This model identifies the importance of separating the task from the artefact within a computer-mediated environment (Finneran and Zhang, 2003).

People use the web to seek and retrieve wanted information. Information seeking is *“the purposive seeking for information as a consequence of a need to satisfy some goal. In the course of seeking, the individual may interact with manual information systems (such as a newspaper or a library), or with computer-based systems (such as the World Wide Web)”* (Wilson, 2000, p.49). Researchers have investigated various web search engines that people use and their performance (Ding and Marchionini, 1996; Chu and Rosenthal, 1996; Shneiderman et al., 1997; Hoelscher, 1998; Silverstein et al., 1999; Jansen et al., 2000; Meghabghab, 2001). Others have tried to explore web seeking behaviour and the possible variables that may affect it providing various web models (Wang et al., 2000; Choo et al., 2000; Ford et al., 2001, 2005; Knight and Spink, 2008; Du and Spink, 2011).

Multitasking is very common to people's everyday life. Multitasking information behaviour can be defined as the *“library search and use behaviours, or database or web search sessions on multiple information tasks”* (Spink, 2004, p. 336) or as the, *“human ability to handle the demands of multiple information tasks concurrently”* (Spink et al., 2007, p.177). Researchers have found that multitasking information behaviour may be affected by multiple cognitive variables such as retrospective memory and visuospatial working memory (König et al., 2005; Colom et al., 2010; Solovey et al., 2011). Multitasking can negatively influence people's performance due to their limited capacity to perform two or more tasks at the same time (Just et al., 2001; Bühner et al., 2006).

Furthermore, researchers have explored multitasking information behaviour on the web (Spink et al., 2002; Ozmutlu et al., 2003a, 2003b; Spink et al., 2006; Du, 2010; MacKay and Watters, 2012). Du (2010), for example, provided a model about multitasking information behaviour, cognitive coordination, and cognitive shifts. She mentioned that people need to coordinate multiple tasks using multiple strategies. This procedure leads to cognitive shifts of knowledge, which can be either holistic or state. Holistic shifts are the changes of users' perception about the information problems, and cognitive state shifts are the changes during the interaction between the user and the system. This study highlights multitasking information behaviour by exploring the cognitive procedure which takes place in it and examines the research gap about users, task and web design variables that may affect this behaviour. This research enhances knowledge about multitasking while using the web and provides an integrated and comprehensive model. It investigates multitasking information behaviour using new cognitive and psychological state variables. This study combines the previous fields of research, trying to provide new elements.

Two personal variables, working memory and flow, involved in the information seeking process, have been identified from a review of the fields of psychology and information science. There are five main dimensions, which have been highlighted:

1. The affective (emotions, feelings, moods) (Damasio, 1994; Bless et al., 1996; Armitage et al., 1999; Wang et al., 2000; Picard, 2003; Nahl, 2005; Yuan et al., 2011; Belk et al., 2013; Yeykelis et al., 2014).
2. Cognitive factor (cognitive styles, working memory, attention, user's experience, developmental stages, and aging) (Baddeley and Hitch, 1974; Bandura, 1986; Engle et al., 1999; Palmquist and Kim, 2000; Wang et al., 2000; Kane et al., 2001; Ford et al., 2005; König et al., 2005; Bühner et al., 2006; Spink, 2010; Hambrick et al., 2010; Reuter-Lorenz, 2013; Dunning et al., 2013; Gulbinaite et al., 2014; Farach et al., 2014; Bruder et al., 2014).
3. Psychological states (flow and motivation) (Humphreys and Revelle, 1984; Keller, 1987; Csikszentmihalyi, 1990; Finneran and Zhang, 2003; Shin, 2006; Cocea and Weibelzahl, 2007; Wigfield et al., 2012; Huang et al., 2014).
4. Personality dimensions (Humphreys and Revelle, 1984; Costa et al., 2001; Amichai-Hamburger et al., 2002; Heinström, 2003; Tan and Tang, 2013).

5. Sociological factors (Bandura, 1986; Chen and Feeley, 2014; Bronstein, 2014).

All these factors have been shown to positively or negatively affect information seeking and retrieving behaviour. Many of them are correlated with others and affect user's performance. However, these variables have not been investigated in a multitasking environment while people seek information while using the web. They have also not been studied in relation to cognitive coordination and cognitive shifts levels.

It seems that multitasking information behaviour especially while using the web has become an increasingly important research area. The extended use of the web in conjunction with people's need to seek and find information has forced researchers to investigate the characteristics of information seeking as well as the web seeking strategies. There have also been multiple attempts to explore personal variables, which may be related to information behaviour. However, these attempts have focused either on personal variables but in other environments than multitasking or on similar environments without exploring personal variables in-depth.

1.2. Aims and Objectives of Research

The aim of the research was:

- To investigate multitasking information behaviour while using the web in relation to cognitive coordination and cognitive shifts levels.

The objectives of the research were:

- To explore multitasking information behaviour while using the web in relation to working memory and flow
- To investigate the effects of pre-determined knowledge about search tasks and the artefact characteristics.
- To investigate cognitive states and cognitive coordination shifts while multitasking on the web.
- To investigate working memory in relation to cognitive coordination and cognitive shifts.
- To determine whether flow is influenced by working memory.
- To explore the relationships between task characteristics, artefact characteristics, working memory, disciplines and flow.

- To provide an integrated framework based on the results of the study.

1.3. Mixed Methods Research Questions and Hypotheses

According to Creswell (2009), researchers can write their research questions or hypotheses in a mixed methods study creating the qualitative and quantitative research questions separately. In that way, the emphasis is given to the separate methods. Qualitative research questions start with a central broad question, which highlights the central phenomenon. After that, many sub questions may follow, which narrow the central question. Qualitative research questions start with the words “how” or “what” (Creswell, 2009). On the other hand, researchers are able to do the three following things with the quantitative hypotheses: compare groups or variables, relate them, and describe responses.

Below are the qualitative research questions and the quantitative hypotheses.

1.3.1. Research Questions

The major research problem in this study was:

To examine the effects of working memory, flow as defined by the PAT model, cognitive coordination and cognitive shifts on multitasking information behavior while using the web.

There are also two sub queries:

1. How do participants' different levels of working memory and flow affect their cognitive coordination levels in a multitasking environment while using the web?
2. How do participants' different levels of working memory and flow affect their cognitive shifts in a multitasking environment while using the web?

1.3.2. Hypotheses

The hypotheses of this study are the following:

Hypothesis 1a: Working memory affects multitasking information behaviour during web searching.

Hypothesis 1b: Participants with high working memory capacity have different cognitive coordination shifts from participants with low working memory capacity.

Hypothesis 1c: Participants with high working memory capacity have different cognitive state shifts from participants with low working memory capacity.

Hypothesis 2a: Flow is related to working memory.

Hypothesis 2b: Flow affects cognitive state and cognitive coordination shifts of participants.

1.4. Contributions and Significances

It has been argued that the future aim of information scientists is not to concentrate on the understanding of technology, but on the understanding of human interaction and involvement in information (Saracevic et al., 1988). This philosophy underlies this research as well as its contributions. The contributions of this research are described below.

1. The significance of this study lies in the fact that it provided a new framework of multitasking during web seeking with a new cognitive variable, working memory, and also the psychological state factor, flow. It explored personal variables in detail and the underlying mechanisms of multitasking information behaviour while using the web such as cognitive coordination and cognitive shifts. It also investigated personal variables, which may affect information process.
2. This research contributes to the knowledge of human-computer interaction and interactive information retrieval research. It reached a better understanding of web searching; the exploration of cognitive and psychological state factors; and the investigation of their relationships in multitasking during web seeking highlighting the user-web search model.
3. This research contributes to the detailed knowledge of the processes during web searching, evolving psychological states and cognitive information retrieval factors. These are basic elements for human information behaviour models and human–interaction models. Through the correlation of the new variables, an integrated model of interactive web searching was developed.
4. This research does not only enlighten user web processes, but it could also help web companies to create more effective web products. Trying to understand how personal characteristics such as working memory and flow are

related to web interaction, web designers may find the key for better web systems.

Chapter 2 Literature Review

2.1. Introduction

This research investigated, in more detail, people's information behavior while using the web and especially multitasking information behavior during web searching. This behavior was related to cognitive (working memory) and psychological state variables (flow).

This chapter of literature review contains: information about multitasking in various contexts (cognitive framework, human information behavior, while using the web), the most relevant information behavior and information retrieval models; and a review of the interactive information retrieval and web search models as well as web search systems and engines characteristics. Cognitive coordination and cognitive shifts are also investigated in-depth.

There is a section about the personal dimensions in information seeking behavior derived from the fields of information science and psychology. In this section through the investigation of variables, the researcher explains the reasons why some variables were explored in this study and why some other variables were not explored and identifies the research gaps that this research attempts to fill. Finally, based on the literature, a preliminary theoretical model is proposed about multitasking information behavior while using the web.

Figure 1 below describes the structure of the literature review. All research areas, which are analysed, are interconnected and the central purple circle shows the focus of the research area of this study.

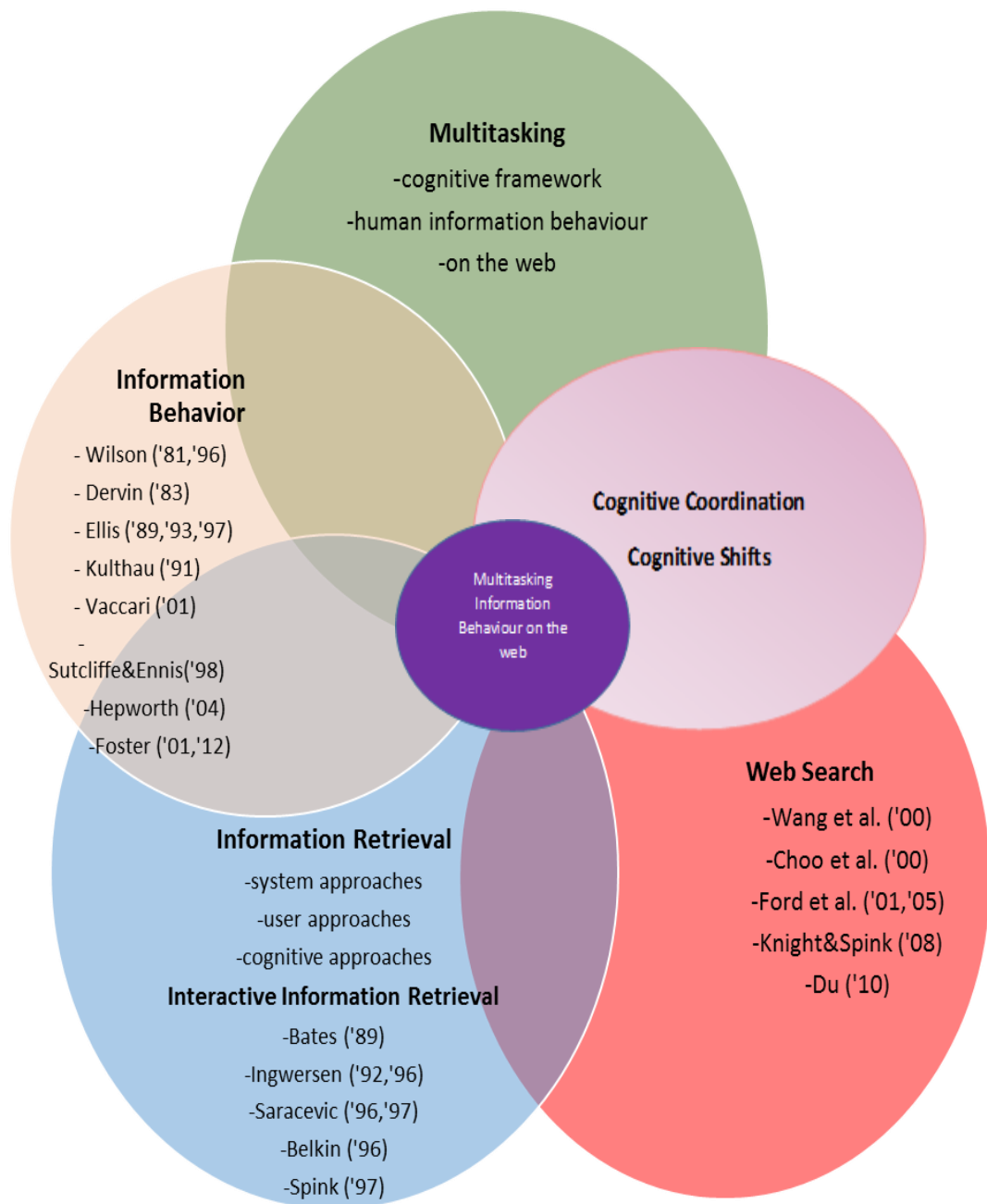


Figure 1. Structure of the literature review

2.2. Multitasking

2.2.1. Multitasking in a Cognitive Framework

Multitasking is the ability to do many things at the same time and switch between them (Pashler, 2000; Just et al., 2001; Lee and Taatgen, 2002). Effective multitasking means being able to quickly switch between many tasks (Jersild, 1927; Rogers and Monsell, 1995; Carlson and Sohn, 2000; Monsell, 2003; Ionescu, 2012). Schweickert and Boggs (1984) examined the hypothesis of the single channel theory, in which people cannot do multiple cognitive actions concurrently because there is only one central executive system. They suggested that people could do multiple things together because all these procedures may use multiple resources.

Rubinstein et al. (2001) studied multitasking behaviour from a cognitive point of view. In their experiment people multitasked among multiple tasks or did the same task many times. They tried to build a model for task switching. They found that performance was lower when people multitasked among different types of tasks. On the opposite side is Wickens (1992) who claimed that people function better when they multitask different types of tasks, because *time sharing* helps them to organise their time more effectively in simultaneous tasks, and *time swapping* allows them to be more effective in sequential tasks (Spink et al., 2008).

Many researchers have found that cognitive variables influence the multitasking process (König et al., 2005; Colom et al., 2010; Solovey et al., 2011) and especially working memory (König et al., 2005; Bühner et al., 2006; Colom et al., 2010; Logie et al., 2011; Morgan et al., 2013). Burgess et al. (2000) tried to explore the neuroanatomical basis of multitasking. Participants performed a multitasking task, in which they learned and remembered their planning actions. They found that there were three cognitive elements in a multitasking procedure: the retrospective memory, the prospective memory, and the planning actions. Retrospective memory is about remembering plans, actions, and people from the past, whereas prospective memory is about actions that have to be planned in the future (Meier et al., 2006; McDaniel and Einstein, 2007). Logie et al. (2011) expanded the findings of Burgess et al. (2000). In their experiment participants searched information while using the web for different everyday life topics. They found correlations between retrospective memory, visuospatial working memory, and planning actions, but not between verbal working

memory and prospective memory. Rekart (2011) found that multitasking reduced learning performance, and affected short-term memory and probably long-term memory.

Attention is crucial for multitasking. Attention is people's ability to focus and allocate their attentional resources (Kahneman, 1973). Sanjram (2013) investigated the effect of attention on memory performance to understand the nature of prospective memory errors. 60 participants multitasked and at the same time they performed another task, a 'mouse clicking'. This was a prospective memory task in which words appeared and participants were advised to click the time words appeared before they disappeared.

The results revealed that there was a likelihood for decreased prospective memory performance when people were required to allocate more attention in stimulus driven situations. This, however, was not directly linked to an increase in cognitive workload, which is information processing demands (Wickens and Hollands, 2000).

Todorov et al. (2014) examined the effects of age and gender on multitasking performance. Young and older participants searched information for four tasks as well as for separate tasks measuring executive functioning and spatial ability. Older men performed better than older women in multitasking confirming previous studies, which stated that different aspects of spatial processing influence these gender differences (Ronnlund and Nilsson, 2006; Schaie, 2008; Thilers et al., 2010; Munro et al., 2012). Finally, the cognitive executive functions (component of working memory) influenced multitasking performance across the older participants. These findings confirm previous research, which mentioned the challenge nature of multitasking for older users due to limitations of the central executive system (Hasher and Zacks, 1988; Salthouse, 2005).

Just et al. (2001) investigated the human brain in multitasking conditions. They used functional magnetic resonance imaging in their experiments. Functional magnetic resonance imaging (fMRI) measures brain activity by indicating changes in blood flow (Huettel et al., 2009). They found that people could achieve performance in each task while multitasked, but they had low degrees of productivity and performance. The causes for this could be the limited amounts of attention and activation (Just et al., 2001).

Hambrick et al. (2010) tested multitasking predictors. Participants completed questionnaires about working memory capacity, experience, and processing speed. They found that working memory capacity was a predictor for multitasking process, only when the task process was slow. Individual differences and web experience also had an impact on multitasking strategies. Buhner et al. (2006) found that working memory and attention predicted multitasking and reasoning. They tested working memory's three dimensions: storage, coordination, and supervision. Participants took working memory tests, attention, and reasoning tests, and then they multitasked. The speed of multitasking process correlated with the coordination dimension of working memory and the multitasking errors with the storage working memory dimension. Morgan et al. (2013) found which cognitive variables are related to multitasking. In their experiment participants completed questionnaires about their cognitive abilities such as working memory and spatial ability, and then they multitasked. They found that working memory, spatial ability, and general aptitude predicted multitasking performance. Judd and Kennedy (2011) studied students and their multitasking information behaviour. They found that students multitasked among different tasks, but memory encoding had low results.

Bai et al. (2014) explored people's multitasking performance regarding cognitive ability and people's ability to recover from interruptions. Participants were advised to sort different kind of objects into bins regarding their colour, shape, and size while being unexpectedly interrupted. The researchers also measured participants' cognitive abilities, which were related to working memory. The results suggested that interruptions negatively influenced people's multitasking performance.

Guatello et al. (2014) examined multitasking performance in relation to personality traits. 174 undergraduates participated in their experiment. Participants completed the Sixteen Personality Factor Questionnaire, and then they performed a computer-based task. The task involved an arithmetic and a mental rotation task to measure multitasking performance. It has been found that low emotional sensitivity, high abstractedness, self-control, and high general intelligence were positively related to multitasking performance. Finally, males multitasked better than females.

2.2.2. Multitasking in Human Information Behaviour

Multitasking information behaviour may have many characteristics. As Spink and Cole (2005b, p. 100) said, "*It may involve a combination of cognitive and physical actions, on dual or multiple tasks concurrently or sequentially, including switching between different information tasks*". It is a procedure, which involves switching between different tasks in order to find relevant information (Spink et al., 2008).

Wickens (1989) proposed four mechanisms, which are responsible for the success or not of task switching. These are task selection, which is responsible for the scheduling and prioritising of each task; demand level, which indicates how difficult or not each task is; multiple resources, which allude to the processing of different sources; and confusion, which is about the confusing or otherwise task characteristics.

Salvucci et al. (2009) believed that sequential and concurrent multitasking information behaviours are included in the same big framework of multitasking behaviour, but as they mentioned they are different and unique entities. Concurrent multitasking is the rapid switching between tasks, and sequential multitasking is the longer switching between them.

Spink and Park (2005) provided a model of multitasking, which included cognitive styles and individual differences. They have also mentioned the interactions between information and non-information behaviour tasks. Coordination and cognitive style are essential for creating knowledge.

Spink (2004) researched multitasking information behaviour and task switching in a library. A participant had to search for four everyday life topics visiting a library twice. The participant found the first day information for the first two topics. The second day she found information for the other two. The results showed many details about multitasking information behaviour. There was a lot of information seeking patterns such as electronic, physical library searches, serendipitous browsing, and successive searches. There were in total seventeen switches among tasks.

Sanjram and Khan (2011) tested attention, time orientation, and expertise effect while participants multitasked on line. They found that these variables played an important role in multitasking performance.

Waller (1997) suggested that people multitask in two different stages: individually or in groups. People multitask in their everyday life among various tasks and topics, and these interactions can either be at an individual or group level (Waller, 1997).

Adler and Benbunan-Fich (2011) connected multitasking with performance. They suggested that there are different states or *scenarios* of multitasking with different outcomes. They concluded that people who multitask more than others, could have better performance, but when their multitasking activity is too much, then the switching and return costs may negatively affect it. Buser and Peter (2012) tested participants who were forced to multitask, and participants who were free to schedule their work. The results showed that participants who were forced to multitask, had worse performance than the others. Researchers claimed that performance and productivity are connected with planning and scheduling (Buser and Peter, 2012).

Mark et al. (2014) explored the nature of multitasking and how it is related to stress. Participants multitasked while wearing biosensors to measure stress. They found that increased use of computers was positively related to high levels of stress. However, social media use was negatively related to it. Finally, use of academic sites lead to low levels of stress.

2.2.3. Multitasking while using the Web

Spink et al. (2006) examined multitasking information behaviour during web searching. Participants conducted two and three seeking sessions on web. They found that people switched between multiple queries and multiple sessions. They also found that there were many changes among three or more sessions. The results were: (1) 81% of two-query sessions concluded various tasks, (2) 91.3% of three or more query sessions concluded various tasks, (3) there were many different areas of topics, and (4) there were frequent topic changes (Spink et al., 2006). All these results proved that multitasking is frequent on web searching. They concluded that multitasking in this

interactive environment was a coordination mechanism among different information problems, searches, and tasks.

Ozmutlu et al. (2003a, 2003b) researched the multitasking process using two different web search engines: Excite and AlltheWeb.com. They found that one third of participants switched between different tasks. Multitasking was a noticeable behaviour. The results also showed that multitasking process was longer than typical searches, with approximately three tasks in each session. They mentioned (2003b) that queries for each topic could be between four and five.

Spink et al. (2002) suggested that multitasking is very natural and frequent in human behaviour. People could search for various and different (or not) topics. Multitasking sessions were longer in duration, and the maximum number of topics per session was ten, with a mean of 2.11 topic changes. The topic themes were hobbies and shopping.

Benbunan-Fich and Truman (2009) researched the type of multitasking during professional meetings. They found that if people search online for relevant to their work information, then these multitasking behaviours are compatible. On the other hand, if people multitask among irrelevant topics, then these are distracting factors, and people may be distracted from their work (Benbunan-Fich and Truman, 2009).

MacKay and Watters (2012) researched the types of multitasking sessions. There were two studies. For one week, people multitasked online and wrote down their multitasking sessions. The second study was for one month. People multitasked while using the web with a particular software (a customised version of Firefox), which stored their online sessions. They found that users switched between eight topics in sessions with various subtasks. People also used many different strategies in order to be helped with their multitasking sessions such as search engines, browser tools, and other applications such as Word. Researchers suggested that web designers should include a reminder list for the users' sessions that have been conducted recently in order people to multitask more effectively.

Judd and Kennedy (2011) captured usage logs of undergraduate medical students. The researchers captured students' common activities such as accessing email, the student portal, web searching, browsing, and word processing, every time they logged on and off. The results showed that all students engaged in task switching and

multitasking but this behaviour was neither high nor consistent. Male and international students multitasked significantly more than female and local students.

Yeykelis et al. (2014) examined physiological arousal and task-switching in a natural environment. Twelve undergraduate students used their computers to perform various tasks such as see their email, Facebook, and word-processing applications. The data recorded through computer monitoring software as well as mobile sensors (watch-sized device, which was worn on the wrist). The researchers found that students switched between few tasks every 19 seconds. High levels of arousal observed when people switched between the tasks. Enhanced arousal therefore may influence people's desire to search more between applications and information.

Lehmann et al. (2013) explored online multitasking and users' engagement. They collected anonymised web data such as browser cookie, URL and referring URL from a sample of 2.5M users, who consent to provide browsing data through the toolbar of a large Internet company. It has been found that when people spend a longer time between two visits on different websites and they return to one of them, the likelihood is they will perform a similar type of task and not a new one.

Adler and Benbunan-Fich (2014) explored how types of multitasking in conjunction with perceived task difficulty can influence performance. 636 participants divided into three groups: discretionary, in which users decided when and how often to switch tasks; mandatory, in which users were told when to switch; and sequential, in which participants did not switch between tasks but they performed tasks sequentially. The researchers found that when the first task was considered difficult, users in the mandatory group had lower multitasking performance than users from the other two groups. On the other hand, when users believed that the primary task was easy, the second group had better performance than the other two groups. When people in the second group were interrupted while they performed a difficult task, this negatively influenced their performance. The opposite happened when people performed an easy task and there were interruptions.

Du (2010) provided a new model for multitasking activities while web searching, the MCC (multitasking, cognitive coordination and cognitive shifts). This model analyses the cognitive coordination levels, the mechanisms and the cognitive shifts. The three

cognitive coordination levels are: task, mechanism, and strategy, and the two cognitive shifts levels are: holistic and state. She found some types of multitasking information behaviour such as serendipity browsing, various seeking sessions, and levels between original and evolving information problems (Du, 2010).

However, there is a gap regarding the detailed relationship between the online multitasking information behaviour and people's personal characteristics as well as the impact of this relationship on people's change of knowledge and how they use the web. This study explored in detail multitasking information behaviour while using the web in conjunction with cognitive (working memory) and psychological state (flow) factors and how these factors affect the way people search on the web. Task and artefact characteristics were also investigated in relation to these factors.

2.3. Information Behaviour

2.3.1. Overview

Information scientists have highlighted various factors that may affect information behaviour. For example, Wilson (1996) identified psychological, demographic and environmental factors. Kuhlthau (1991) mentioned the impact of feelings, thoughts and emotions. Hepworth (2004) identified psychological, behavioural, sociological and source characteristics. However, there is a gap between how working memory, flow, cognitive shifts, cognitive coordination, task and artefact factors influence information behaviour in detail. The present study therefore explored thoroughly the impact of these factors to enhance the understanding of information behaviour and its underlying mechanisms.

2.3.2. Information Behaviour Models

The area of information behaviour has been researched for many years and as Wilson (1999, p.250) mentioned, "*Research in information behaviour has occupied information scientists' since before the term 'information science' was coined. The term originated at Royal Society Scientific Information Conference of 1948, when a number of papers on the information behaviour of scientists and technologists were presented*". Many models have been developed, but in this section the following highly cited ones will be discussed: Wilson's (1981) model of information seeking behaviour; Wilson and Walsh's (1996) model, which expands Wilson's 1981 model; Devin's (1983) Sense-Making theory; Ellis's (1989,1993) behavioural model of information seeking strategies; Kuhlthau's (1991) model; Vakkari's model (2001); Sutcliffe and Ennis's (1998) model; Hepworth's model (2004) and Foster's (2004) model.

2.3.2.1. Wilson's Models 1981, 1996

Wilson and Walsh's (1996) model, which is very different from Wilson's first in 1981, covers areas such as decision-making, consumer research, psychology, health communication, and innovation. In his first model in 1981, he focused on information behaviour and information need as the outcome of information seeking (Wilson, 1999). The weakness of the previous model was that, "*It provides no suggestion of causative factors in information behaviour, and consequently, it does not directly suggest hypotheses to be tested*" (Wilson, 1999, p. 252). The new model was similar to the previous, however, the "intervening variables" and "information-seeking behaviour" were explored (Wilson, 1999) in more depth, highlighting the factors that may influence information seeking.

Furthermore, a feedback loop was added. Three major factors stand out in this model: stress/coping, risk/reward, and social learning theory (Wilson, 1999).

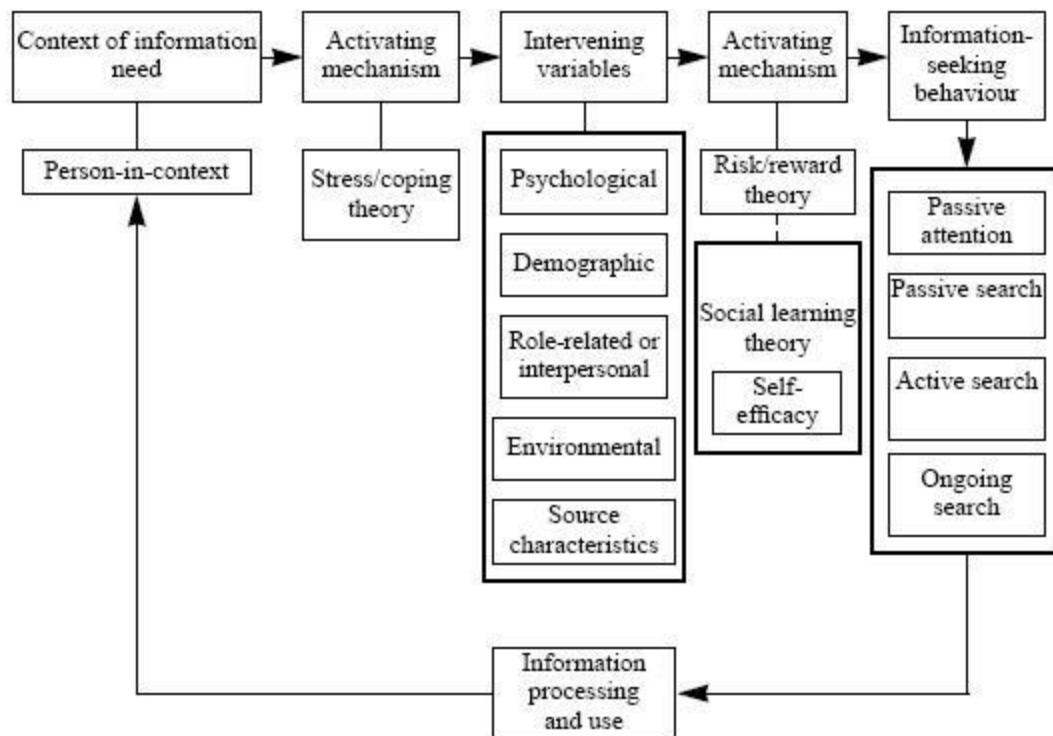


Figure 2. Wilson's 1996 model of information behaviour (Wilson, 1999).

Wilson's model identifies factors which can influence the information seeking process, however, specific factors deserved further exploration. Specifically, this study

investigated cognitive and psychological state factors and their influence on information seeking behaviour.

2.3.2.2. Dervin's Model 1983

Dervin's (1983) sense making model contained the four following basic elements: situation, gap, outcome, and bridge (Wilson, 1999). She believed that people have different perspectives about the world and reality. She mentioned that, "*The human condition [is] a struggle through an incomplete reality... Humans make sense individually and collectively as they move: from order to disorder, from disorder to order*" (Dervin 2000, pp. 40-41). This process is the sense making. As Dervin (1986) mentioned, there are also some major factors in this model such as time, space, movement, and step taking.

Niedźwiedzka (2003) mentioned that Dervin's model is important because it enhances the meaning of attention and cognitive discomfort. Wilson and Walsh (1996) studied the model proposing that an "activating mechanism" should be incorporated in the gap between "situation" and "use"; and therefore they included it in their updated model.

This model highlights the importance of perceiving information activity as a dynamic and flexible process. Huotari and Chatman (2002) described this model as of major importance in the field of information behaviour. However, Dervin's model did not explore in-depth the factors of attention and cognitive discomfort. This study explored in-depth any cognitive discomfort or cognitive load that people may face during the information seeking behaviour.

2.3.2.3. Ellis 1989 and Ellis, Cox and Hall 1993, and Ellis and Haugan 1997 Model

Ellis (1989), Ellis et al. (1993), and Ellis and Haugan (1997) identified the following characteristics associated with information searching-seeking behaviour:

- Starting, which incorporates the means by which the user begins the seeking process.
- Chaining, following footnotes and citations in known material.
- Browsing, identifying relevant sources.

- Differentiating, using known differences to filter material.
- Monitoring awareness of new developments in the area of focus.
- Extracting, working through material in relevant sources.
- Verifying, checking the accuracy of information, ending (Ellis, 1989).

Ellis and Haugen (1997) tested their model beyond laboratory environments in natural environments such as the industrial framework. The strength of this model is that it can be used in multiple knowledge fields and all user groups (Ellis and Haugen, 1997; Katsirikou and Skiadas, 2011). Its empirical and experimental base has influenced research in information behaviour (Katsirikou and Skiadas, 2011). This study, however, explored in-depth how people’s cognitive and psychological state factors influenced their information seeking stages.

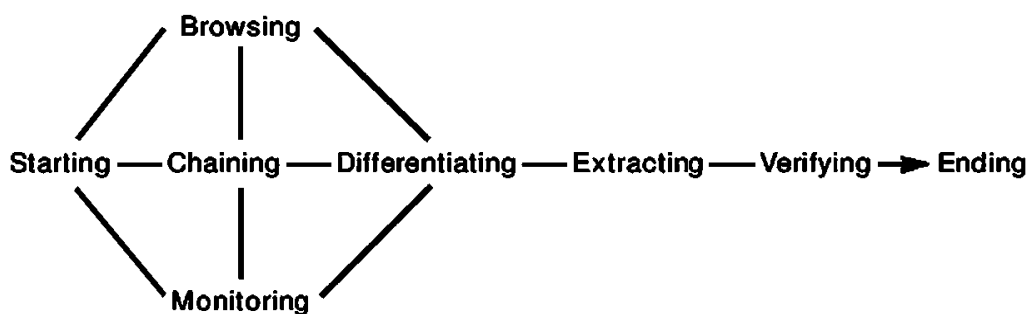


Figure 3. The stage process model of Ellis (Wilson, 1999).

2.3.2.4. Kuhlthau’s Model 1991

Kuhlthau (1991) supported Ellis’s work and added some other stages such as the information search process, the associated feelings, thoughts, actions, and the appropriate information tasks (Wilson, 1999). The model was called “Information Search Process (ISP)”. The stages in Kuhlthau’s model include Initiation, Selection, Exploration, Formulation, Collection, and Presentation. People participate in information seeking behaviour when they want to retrieve information about a particular task.

Kuhlthau’s model also describes uncertainty as the main force of information seeking. She describes the role of uncertainty as:

“Uncertainty is a cognitive state that commonly causes affective symptoms of anxiety and lack of confidence. Uncertainty and anxiety can be expected in the early stages of the ISP. The affective symptoms of uncertainty, confusion, and frustration are associated with vague, unclear thoughts about a topic or problem. As knowledge states shift to more clearly focused thoughts, a parallel shift occurs in feelings of increased confidence. Uncertainty due to a lack of understanding, a gap in meaning, or a limited construct initiates the process of information seeking.” (Kuhlthau, 1993, p. 111).

Kuhlthau et al. (1990) investigated 385 users in 21 different library environments. The users were from various academic backgrounds and stages such as college, high school students, and adults. Therefore, under these circumstances, the Kuhlthau’s model is valid across many different populations, ages, and academic backgrounds (Kracker, 2002).

Kuhlthau (2015) mentioned that her model investigated the cognitive factors (thoughts) and affective factors (feelings) as well as the affective-cognitive factors (mood) as ingredients, which are present in each stage in the information seeking process. People’s thoughts are responsible for the positive or negative feelings and moods are responsible for the range (broadening or narrowing) of possibilities in a search such as the definition of the topic and selection of information sources.

Kalbach (2009) stated that it is a very comprehensive model because it connects uncertainty with cognitive and physical factors. The new information also increases uncertainty in complex and difficult information environments (Kalbach, 2009).

Kuhlthau mentioned terms like feelings, thoughts, and emotions as important factors in each information stage. An important consequence of uncertainty is the rise of negative feelings such as doubt, anxiety, and confusion (Kracker, 2002). This research investigated different types of feelings before and after the information seeking process and their impact on the information seeking process.

With the recognition of the tasks and subtasks in this model, it is the first time that types of information, paths of information seeking, and relevance judgments have been investigated (Vakkari, 2005).

2.3.2.5. Sutcliffe and Ennis' 1998 Model

Sutcliffe and Ennis (1998) provided a framework for their cognitive model of information retrieval. They proposed that this model has two basic dimensions: a process theory for information seeking and knowledge representations. The first dimension is constructed from information retrieval activities including articulation, query formulation, results evaluation, problem identification, and form strategies. The second dimension includes the general knowledge framework that people poses (Sutcliffe and Ennis, 1998).

Sutcliffe et al. (2000) investigated students' information behaviour using MEDLINE. The students did not manage to retrieve relevant information, in contrast to experienced users who had better results. The students used more AND searching queries than OR queries unlike the experienced users.

This model is comprehensive and novel because it predicts for first time users' cognitive changes according to information problems, system characteristics and existing knowledge (Vakkari, 2005). The limitation of this model is that it does not explain in-depth the cognitive variables, but as Sutcliffe and Ennis (1998, p. 345) stated, "While this is an ambitious undertaking, and the current theory is preliminary and inadequate to deal with several aspects of observable user behaviour, it is at least a starting point".

2.3.2.6. Vakkari's Model 2001

Vakkari (2001) expanded Kuhlthau's model and provided a task based theory. He proved that there is a connection between students' mental stages, information seeking, searching strategies, relevance, and use of information (Vakkari, 2001). However, he narrowed the stages into three: pre-focus, post-focus and representation stages (Vakkari, 2001). The mental stages have been explored from the perspective that people are confused at the beginning of a seeking process, and after the acquisition of the appropriate information, their mental stages (their knowledge) would

be different. This study explored in-depth the differences in people's mental stages before and after the information seeking process. It investigated people's depth of knowledge before and after the information seeking process for each topic as well as people's degree of change of knowledge for each topic and people's degree of becoming informed for each topic.

Eleven students participated in his experiment. They attended a seminar about how to write their masters thesis. The data, collected, provided insights about their knowledge of the task, the information problem, the task stage, and the seeking strategies. They were asked to undertake three searches in the LISA database: at the beginning of the seminar, in the middle, and at the end. The purpose was to identify and investigate the three following stages: pre-focus, post-focus, and representation stages.

The mental term can be described as, *"A synonym for mental model is cognitive structure or conceptual structure. A mental model can be described as consisting of concepts and their relationships"* (Vakkari, 2001, p.41). Vakkari (2001) claimed that he tried to investigate and explain the actions in information retrieval and seeking. Mental stages or cognitive structures are obvious in Kuhlthau, and Vakkari's models but in different aspects. In the first model, feelings and thoughts are apparent but not very clear in each task stage, and in the second model the mental framework is used more as an auxiliary concept (Vakkari 2001,p.57), or as Vakkari stated:

"Kuhlthau describes the thoughts concerning the task on the trichotomies general narrowed focused and vague clearer clear. It seems that the distinctions are used in her model more as predicates of the stages in the information search process than to explain the types of information sought for or search strategies. However, Kuhlthau uses these constructs in both ways, emphasising the former. ... (Vakkari, 2001, p.49)... Vakkari uses the mental model as an auxiliary concept, which includes two dimensions. In the model differentiation refers to the number of concepts and integration to the number of interrelations between them" (Vakkari, 2001, p.57).

Spink et al. (2002), Pharo (2004), Ozmultu et al. (2004), Rieh and Xie (2006) and Xu (2007) claimed that this model was a major framework for information behaviour.

2.3.2.7. Hepworth's Model 2004

Hepworth (2004) developed a framework in order to explore and better understand the information seeking process. This framework has many categories and subcategories, and it can be applied in three stages: "the group," "the individual," and "the moment of interaction stage." The categories are:

- the sociological data (roles, norms, tasks),
- the psychological data (knowledge, cognitive, affective and style states),
- the behavioural data (behaviour),
- the source data (source character and behaviour).

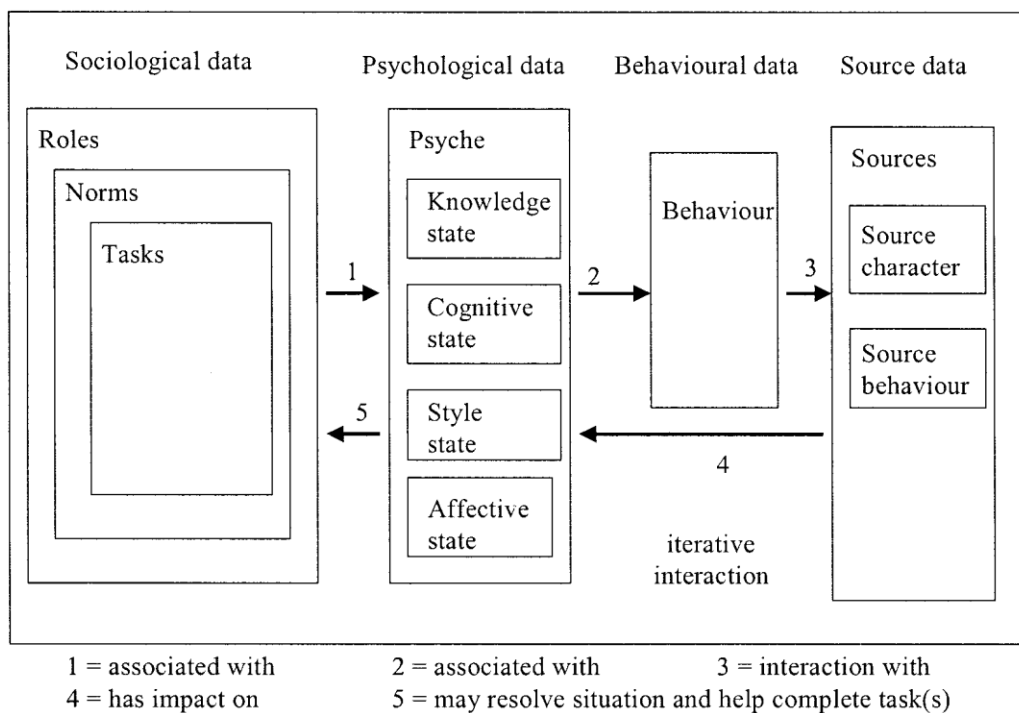


Figure 4. Hepworth's model (2004).

Hepworth's model (2004) is comprehensive and includes additional factors and elements about the individuals (roles, norms, and tasks). Psychological factors are cited in detail and confirm Wilson's (1999) and Ingwersen's (1996) frameworks.

The "activating mechanisms" and passive/active search of Wilson's model (1999) are analysed here as psychological data with the subcategories of style state and cognitive

state and can be either negative or positive. Ingwersen's also "current cognitive state" is categorised here as psychological factors (Hepworth, 2004).

The limitation of this framework as mentioned by the author (Hepworth, 2004, p.706) is that, "*Further research is required to test the usefulness of the framework in different contexts*". This research explored in-depth cognitive and psychological state factors as well as their influence on information seeking behaviour.

2.3.2.8. Foster's Model 2004

Foster (2004) investigated information seeking behaviour of people from different disciplines such as arts, humanities, social science and engineering. He explored people's information seeking behaviour, strategies and how people's information needs differ regarding each discipline.

He used semi-structured interviews to collect information seeking experiences from 45 interdisciplinary researchers. All participants were interviewed in their normal work places to "*enhance contextual richness and minimise fragmentation*" (Foster, 2004, p.230).

Foster (2004) recognised the complex nature of information seeking behaviour and he proposed a nonlinear, interdisciplinary model.

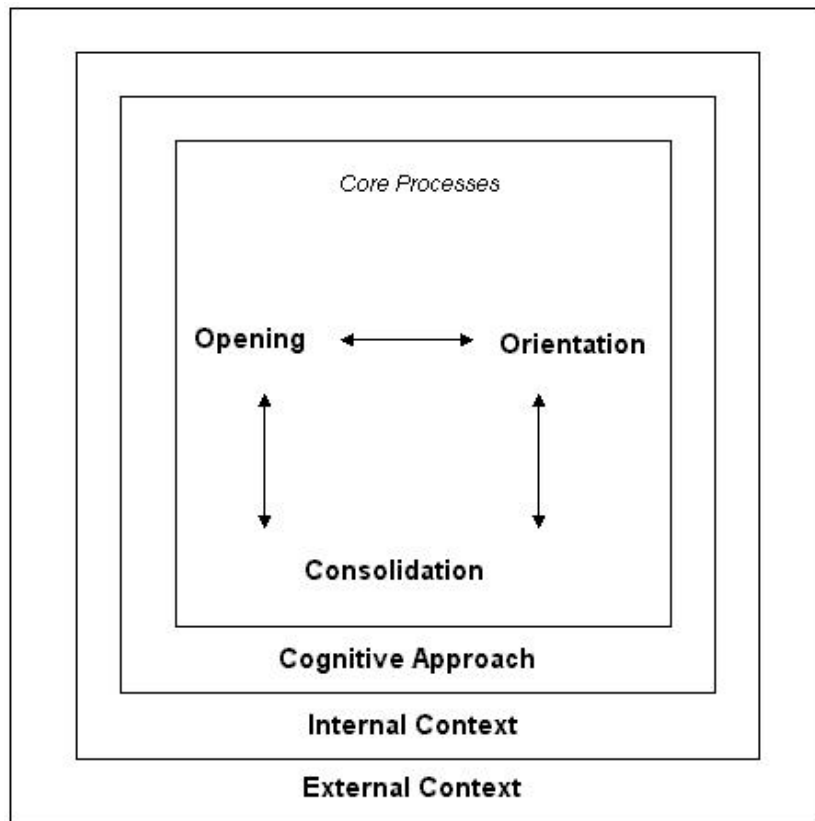


Figure 5. Foster's model (2004).

There are three categories of process: Opening, Orientation and Consolidation, which interact between the users' Cognitive Approaches, and their Internal and External Contexts.

Opening includes all the processes, which reduce or enhance the information resources such as browsing, keyword searching, networking, monitoring, and chaining serendipity. Orientation involves the problem definition, reviewing, identification of the keywords or the existing research; and Consolidation is about refining, shifting, verifying, and incorporation. The Internal Context involves factors that influence people's information seeking behaviour such as feelings, thoughts, coherence, and knowledge. On the other hand, External Context includes the time, task, navigation issues and access to sources. Finally, the Cognitive Approaches can be flexible and adaptable (mental agility and willingness to adapt to the different information and disciplinary cultures); holistic (grasping and incorporating concepts from diverse areas and bringing them together); nomadic (abandoning well-known and favoured

disciplines and sources in search of new material); and they can include openness (flexibility and adaptability in information-seeking) (Foster, 2004).

This model considered both internal and external context in conjunction with people’s cognitive approaches. It emphasises the complexity and flexible nature of the information seeking process (Foster, 2004). However, there were weaknesses in the data collection method (Foster and Urquhart, 2012). For this reason, Foster and Urquhart, in 2012 revised the above model using multiple coders. The revised model presented more clearly the changes between the internal and external contexts.

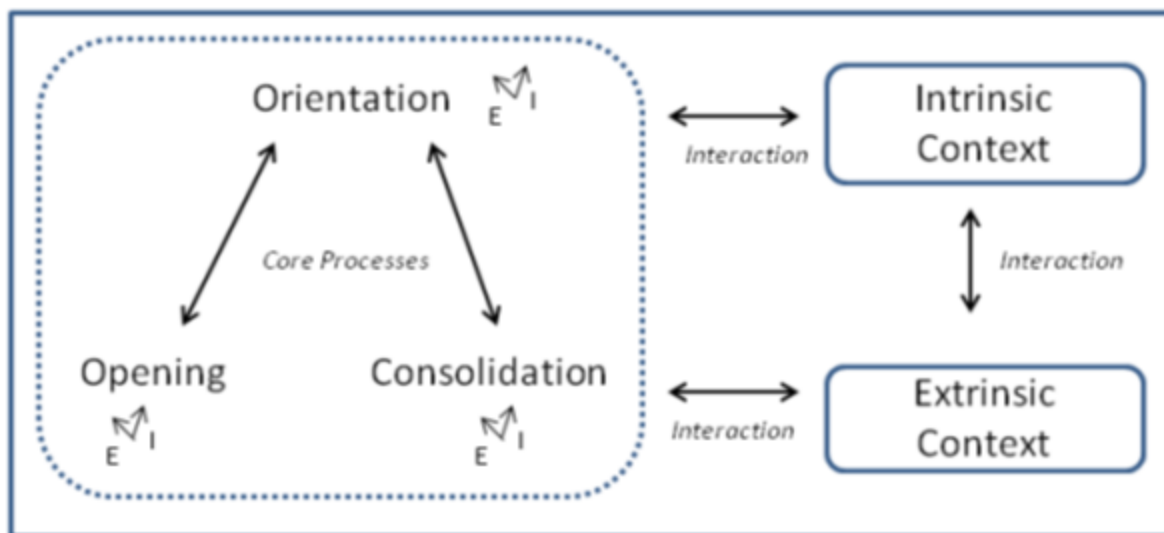


Figure 6. Foster’s revised model (2012).

Foster’s model supports the complex nature of the information seeking behaviour as well as the interactive processes, which take place in a dynamic way (Heinstrom, 2006; Robinson, 2010). The present study explored the intrinsic as well as the extrinsic context. It explored how cognitive and psychological state factors influenced the information seeking process as well as how time and other navigation factors such as vividness and network speed influenced in their turn this behaviour.

2.4. Information Retrieval (IR)

2.4.1. Overview

According to Ruthven (2009), information retrieval is an important aspect of information behaviour. Information retrieval is a process, which takes place in

representation, storage, seeking, finding, filtering, and presentation of new possible information in order to find information that the user desires (Ingwersen and Järvelin, 2005). Its aim is to explore and understand IR processes in-depth, in order to build such retrieval systems that could effectively help users retrieve information from the system (Ingwersen, 1992). Information retrieval models have tended to focus on either the system or the users. The traditional model of IR, however, tends not to focus on interactions between people, systems and other factors. On the other hand, cognitive approaches highlight the importance of cognitive factors and cognitive changes which take place during this interaction. However, the role of specific cognitive variables and their correlations with information retrieval have not been explored in depth.

2.4.2. Information Retrieval Models

There are different approaches to information retrieval, the system, user and cognitive approaches (Ingwersen, 1992). The system approaches put the system into the centre of the interaction. On the other hand, in the user approaches users have the main role. The cognitive approaches try to overcome these dimensions and divisions (Vakkari and Järvelin, 2005) and focus on the cognitive factors of both the system and the user (Larsen and Ingwersen, 2005).

The simplest model of information retrieval, the unidimensional (Spink and Cole, 2005a), represents the information in the form of text or category data. The binding between these is the matching function, which retrieves the appropriate documents or texts with the appropriate information (Ingwersen, 1992).

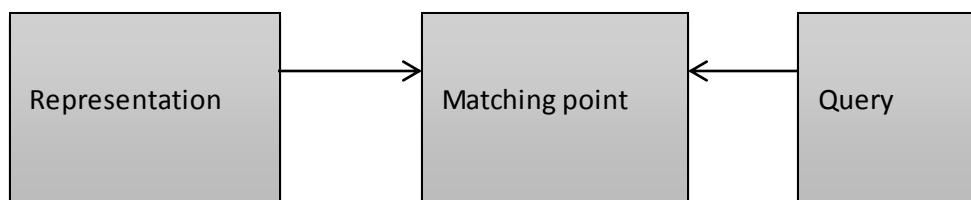


Figure 7. The simplest model of information retrieval (Ingwersen, 1992).

At the end, people try to find the most suitable information in the form of text or in other forms, but some texts are more relevant than others. As Ingwersen (1992) claimed, there are three major areas in the IR processes, which are involved in all IR theories

and models: aboutness, representation, and relevance. Aboutness is regarding the content bearing units in the text, generated by the author (Salton, 1968; Salton and McGill, 1983; Bruza et al., 2000).

The information about the text comes from the summarisation of the main ideas of the document. This represents a very traditional model of IR based on early pre TREC and TREC period. The representation of the text comes from people who try to understand, from their own point of view, the meaning of the information, combining it with their previous knowledge. This is called the assignment of representative information (Ingwersen, 1992).

Relevance has been characterised as, “*the measure or degree of correspondence or utility existing between a text or document and a query or information requirement as determined by a person*” (Van C.J Rijsbergen, 1990, p.24). People may not know what they will retrieve, a procedure, which is called retrieval uncertainty. Van C.J Rijsbergen (1990) claimed that, this is the main cognitive global idea in the field of information science. On the other hand, the weakness of this classical model is that it does not show directly the dynamic interaction.

Many other researchers also explored the terms of aboutness and relevance giving them the same or different meanings. For Schamber et al. (1990) relevance identified as topicality relevance, in which the documents meaning has the same information content with users information query. Cooper (1971) defined relevance as *topic-appropriateness* and Borlund and Ingwersen (1998) as *intellectual topicality*.

As it seems, there are two main research groups, which perceived the main idea of *aboutness* in different ways. Aboutness has also been combined with other variables (Da Costa Pereira et al., 2012).

This traditional model of IR, however, does not provide detail about behaviours and interactions between people, systems, and other important characteristics (Robbins, 2000). On the other hand, the aim of the user-oriented research was to understand users' IR and patterns of seeking information in natural environments (Ingwersen, 1992).

Ingwersen (1992, 1996) provided the cognitive IR approach. He believed that, people while searching information may alter their existing concepts or *maps* of information, and in the end, they may alter them or seek new ones. People may work upon various maps at the same time for the same text, document or information. Cognitive changes in conjunction with social and behavioural dimensions are apparent in IR behaviour (Ingwersen, 1992). Ingwersen mentioned (1992, p.131), “the knowledge states of individuals”, which include cognitive workspaces, actual states of knowledge, problem spaces, and states of uncertainty (Ingwersen, 1992). This model was the basis for his next model of polyrepresentation (Ingwersen, 1992, 1996). Ingwersen mentioned short-term memory (STM) and long-term memory (LTM), in which episodic and semantic memories are included. He also mentioned the categorical and situational classifications, which are included in LTM, and he provided the basis for memory recall. These classifications, however, come from a social point of view as *contexts* or as he claimed, “as a platform for structured questioning” (Ingwersen, 1992, p.130). He also synthesised attention, previous knowledge and experience in the process of categorization and memory recall. LTM is responsible for memory representations. He defined these cognitive mechanisms as a place, where mental representations are included (Ingwersen, 1992). LTM is responsible, as he claimed, for the understanding, perception, and interpretation of information (Ingwersen, 1992). He did not, however, investigate the cognitive mechanisms before LTM, which are responsible for the type of information, which should proceed to and finally be stored in LTM. Nor did he explore in-depth cognitive mechanisms like attention, and sublevels of memory like working memory and their correlations with information retrieval. These major variables are responsible for the process of information to STM and LTM. STM and working memory (WM) must be distinguished. STM includes only the temporal storage of information. On the other hand, WM is about the storage and manipulation of information (Baddeley, 2012). This study explored WM and how this influenced multitasking information behaviour while using the web.

2.5. Interactive Information Retrieval

2.5.1. Overview

Interactive information retrieval is the seeking of information through web technology and information systems (Ingwersen and Järvelin, 2005). Interactive IR research began before the appearance of the web. The last twenty years there has been a lot

of research in interactive information retrieval. Researchers have tried to explore and investigate the relationship between the user and the system. There is a major effort to understand human behaviour, how people interact with systems while searching information and building information behaviour models. Several attempts, for example, have been made to explore and incorporate cognitive aspects into these models.

Ingwersen (1992) also confirmed that IR processes involved many cognitive states, and there were relationships between users, IR systems, and information objects. In 1996, he also proposed a cognitive theory for interactive information retrieval.

Saracevic and Kantor (1988) also investigated in their experiment users' cognitive traits in natural environments. They explored users' context of queries, information problems and their formulation, people's cognitive characteristics, and finally they tested different searches of the same query. They wanted to investigate factors, which contribute to information seeking and retrieving behaviour and are related to cognitive aims and outcomes. An IS&R (interactive cognitive information seeking and retrieval) model was proposed by Ingwersen and Järvelin (2005), trying to combine cognitive, social, and individual characteristics of peoples information behaviour while they search and retrieve information. This study explored how people search using the web according to their working memory and flow levels.

2.5.2. Interactive IR Models

2.5.2.1. Bates 1989: Berry-Picking Model

Bates (1989) proposed that, when people search for information on the web, they may alter their searching strategies depending on their experience, and they may change (or not) their first information query. This is like a berry-picking process, a metaphor that implies people cannot find information from only one source. Therefore, they gather what they can from the first source and continue with other sources (Bates, 1989).

Berrypicking differs from traditional information retrieval searching in four ways (Bates, 2005): the nature of the query (queries are not static but they change during the seeking process); the nature of the overall search process (information is gathered in bits and pieces); the range of search techniques used (a variety of strategies are used

such as keyword matching), and the domain which is searched (the type of information e.g. text or figures).

Bates (1989) mentioned five strategies: 1) footnote chasing (the user finds information by reading the endnotes and footnotes in a particular article), 2) citation searching (the user looks at other authors who have cited a particular work), 3) journal run (the user sees the contents of multiple volumes of a particular journal title), 4) area scanning (browsing the shelves), and 5) author searching (the user finds articles or books written by a particular author).

She believed that users through the information seeking behaviour could have some cognitive changes. Through this process, users are also able to investigate and discriminate, which information is useful and relevant and which not. This model is in contrast to previous IR models, because it tried to investigate users' information behaviour, seeing the searcher and user as the same person. Bates's ideas about cognitive factors have been investigated by Du and Spink (2011), who proposed cognitive factors during the searching procedure such as cognitive coordination and its levels, and cognitive shifts and its levels. These factors, however, have not been explored in relation to cognitive and psychological state variables, something that this study did in-depth.

2.5.2.2. Ingwersen 1992, 1996: Cognitive IR interaction Model or Global Model of Polyrepresentation

Ingwersen explored many cognitive levels and their relationship between the user and the system in the interactive information retrieval (IIR). The idea of the multiple factors, the polyrepresentation, was linked to cognitive overlaps. Cognitive overlaps are the cognitive differences between users concerning the information texts. There are four cognitive factors, which influence users' information needs: a work task/interest; a current cognitive state; a problem space, including a state of uncertainty; and an information need (Ingwersen, 1996). The cognitive current state means that users have no awareness of what they want to seek (at the beginning of the information searching) (Ingwersen, 1996). Ingwersen tried to investigate and relate different aspects such as the user and the system, the information, the cognitive mechanisms, the cognitive overlaps, and the intermediary mechanisms (Ingwersen, 1996). The main

problem with that model, however, is that users' cognitive differences are general and not well distinguished (Robbins, 2000). In this study, however, users' cognitive differences were investigated in detail.

2.5.2.3. Saracevic 1996, 1997: Stratified Interactive IR Model

Saracevic believed that the user and the system are two separate entities, which are trying to interact (Rieh and Xie, 2006). Interaction proposed here as the, “*sequence of processes occurring in several connected levels or strata*” (Saracevic, 1997, p. 316). There are three levels for the user and the system. The user levels are the cognitive, affective, and situational. The cognitive level is about information, which is presented as texts or other forms and their representations. The affective level includes users' intentions, and the situational stage is about situational information problems.

The system has also three levels: engineering, processing, and content. The first level incorporates the hardware applications; the second level involves the software applications, the queries, and re-queries; and the last level presents the information content with the multiple representations and resources (Rieh and Xie, 2006). The user and the system interact among many levels and many variables such as searching information, browsing, understanding of new information, discriminating relevant or irrelevant information, and feedback.

Although this model is well organized, it does not provide details about the changes, their frequency, and the effect of them on an interactive IR environment. The present study, however, investigated in detail the interaction between the user and the system.

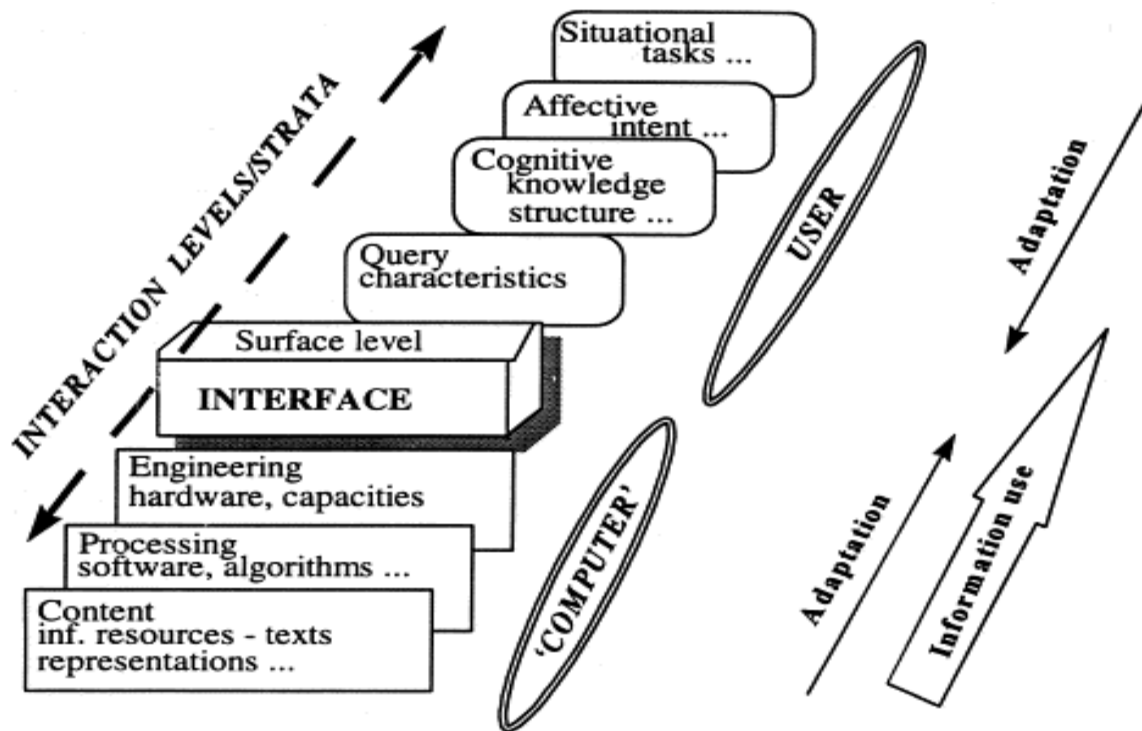


Figure 8. Saracevic's model for the IR process (Wilson, 1999).

2.5.2.4. Belkin 1996: Episodic Model of IR Interaction

Anomalous state of knowledge (ASK) is a central idea in Belkin's episodic model. Anomalous state of knowledge is about users' cognitive uncertainty (Belkin, 1980). Belkin believed that a user's problem is the knowledge level, which represents the cognitive uncertainty. The interaction with the system helps people to alter this stage of knowledge and proceed to more stable levels, which leads them to define and seek the appropriate and relevant information. Belkin et al. proposed (1982, p. 62) that:

"The ASK hypothesis is that an information need arises from a recognized anomaly in the user's state of knowledge concerning some topic or situation and that, in general, the user is unable to specify precisely what is needed to resolve that anomaly. Thus, for the purposes of IR, it is more suitable to attempt to describe that ASK, than to ask the user to specify her/his need as a request to the system".

The MONSTRAT model (Belkin et al., 1987) was based upon this theory, which also tried to explore the relationships between users and IR systems. The MONSTRAT

(MODular functions, Natural processes, STRATegic mechanisms) model has 10 major dimensions and 23 tasks, which are believed to be involved in an IR system in order to help users find the appropriate information (Brooks, 1986a, 1986b; Daniels, 1986). However, the episodic model of Belkin (1996) is far better than this model because it organises in a more structured way the dimensions of the MONSTRAT's model, and it distinguishes which items are repeated and how many times (Robbins, 2000). Except that, the MONSTRAT model is more a pre-search framework, and so it is very difficult to explore the on-going activities (Ingwersen, 1992). The weakness of this model is that it does not involve any other aspects except the cognitive, and it does not consider the outcomes of this interaction. The present study, however, explored not only cognitive but psychological state aspects too providing information about the outcome of their relationship while multitasking using the web.

2.5.2.5. Spink 1997: Interactive Feedback and Search Process Model

Spink (1997) found that feedback influenced a lot the interactive IR process. She found that in addition to feedback, there are also users' judgements, seeking strategies, mechanisms, and feedback loops, which are crucial for this interaction. The main idea here is that, users through the interaction with the systems incorporated feedback, which leads them to new searches and new queries, which in their turn provide and create new feedback. This model provides a more comprehensive idea of the interactive IR process (Du and Spink, 2011). With the feedback loops people try to investigate factors such as the content relevance, which could be either positive or negative; the magnitude relevance, which could be positive, negative or non-modification; the tactical; and terminology review (Spink, 1997). This model is considered the most comprehensive of all the models. The weakness of this model is that, it does not provide details about the underlying mechanisms of feedback loops and the possible cognitive variables. For that reason, it cannot be used in studies, in which the main user is also the searcher of information (Du and Spink, 2011).

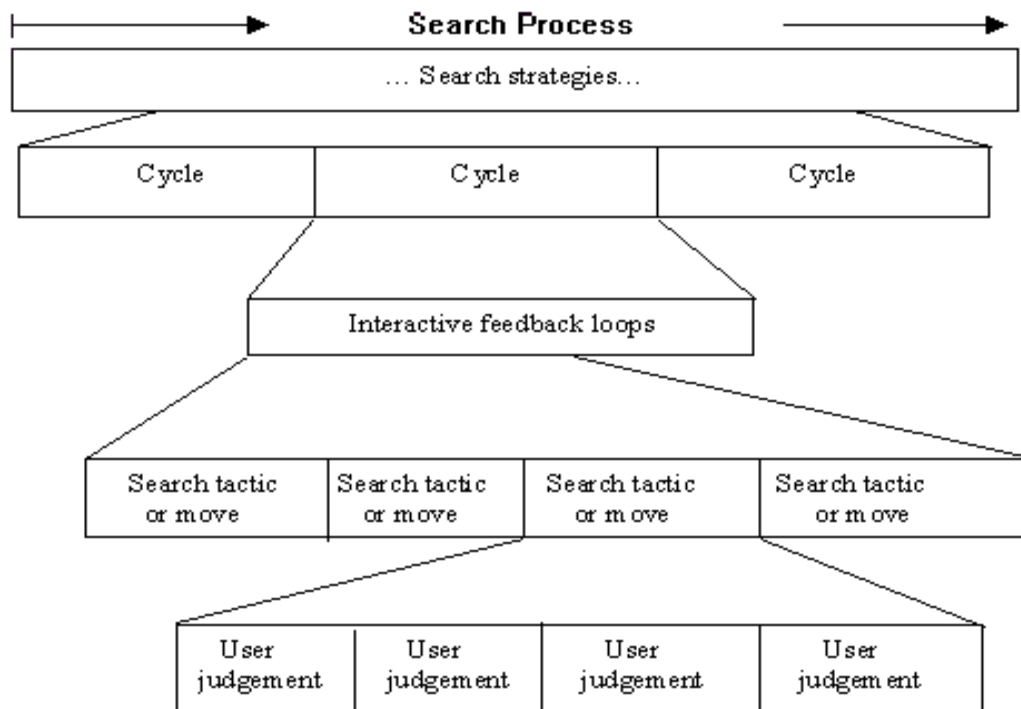


Figure 9. Spink's model of the search process (Wilson, 1999).

There have been some interactive IR models, which tried to explore the connecting link between the user, the information, and the system. For example Bates (1989) identified users' cognitive changes, Ingwersen (1992, 1996) mentioned cognitive overlaps, Saracevic (1996) highlighted the importance of cognitive and affective factors, Belkin (1996) also stated the impact of cognitive variables and Spink (1997) explored people's feedback loops. All these models are distinguished from the previous models of IR, because they presented users and systems as separate unities (Robbins, 2000). The main interest and effort of all these models in information retrieval and interactive information retrieval behaviour was to explore the cognitive variables, levels, stages of knowledge, and cognitive spaces, which lead to information need (Ingwersen and Järvelin, 2005), cognitive coordination, and cognitive shifts. All these models have provided many insights about the cognitive elements, but only from the aspects of knowledge. In order to find which variables are important and how they can positively or negatively affect the information retrieval interaction, it is argued that researchers should refer to psychological and cognitive theories as well as models about memory. Before all cognitive stages, aims, strategies, and outcomes, there are some cognitive mechanisms underlying and affecting all these factors. For example,

people must first successfully proceed and store information in working memory. As a consequence this research explored and identified for first time the role of working memory while multitasking while using the web, where IIR takes place.

2.6. Web Search

2.6.1. Overview

People use the web and web search engines a lot in order to explore, investigate and retrieve wanted information. Web search is the context of this research. As Bishop and Starr (1996, p.361) have claimed, "*we need to understand more about, which aspects of searching behavior are universal and which are situation-specific, if we are to design information systems to serve an increasingly heterogeneous user population with increasingly diverse sets of information needs*". There are many levels in this interaction such as the environmental, the human–computer interaction, the information searching, the categorisation level, and the coordination of all these information levels (Spink and Jansen, 2004).

2.6.2. Web Search Engines

Many researchers have also focused on the web seeking to understand better information retrieval (Wang et al., 2000). There have been experiments about web search systems, frameworks and designs (Shneiderman et al., 1997) as well as web search engines improvement in updating, indexing and display (Ding and Marchionini, 1996; Chu and Rosenthal, 1996; Meghabghab, 2001). Hoelscher (1998), Silverstein et al. (1999) and Jansen et al. (2000) investigated web seeking through different web search engines. The first group of participants used Fireball; the second group used Excite; and the last group the Alta Vista web search engine. Over 71% of web users used web search engines in order to find web sites (Jansen and Pooch, 2000).

Spink et al. (2000) examined one million web user queries using one web search engine, Excite. They concluded that web seeking was different from people's seeking actions in the traditional IR systems. Both are IR, but different. They found that people were not very comfortable using Boolean tools and browsing on the web easily. They mentioned that researchers need to understand more web seeking behavior, and that web IR systems are different from the design of the traditional IR systems.

People's behavior and interaction with the World Wide Web have also been explored. Hirsh (1998) for example studied how students found information on the web. The results showed that many factors participated such as the relevance of the topic, the students' interest, and how intrinsic the topic was. Bilal (2000) tried to investigate the effects of web search engines on children's cognitive and physical behaviors. The children designed eleven web search engines. The results showed that children designed high functional web engines with good visual characteristics. Wang et al. (2000) proposed a multidimensional model, in which three factors are connected: user, interface, and the World Wide Web. They suggested that all these factors affect people's cognitive, affective, and physical behaviors.

Atsaros et al. (2008) explored people's performance in two different types of web search engines. The first type was the general web search engine, which searched through the web, and the second type was the site-specific web search engine, which was given by web sites for local seeking. They used 20 queries in two general web search engines and 10 in specific web search engines. They tested the precision and the relative information retrieval. They found that sometimes the site-specific engines were better for the evaluation of the web page content than the general-purpose engines. The best general web search engine was Google (Atsaros et al., 2008).

Tümer et al. (2009) tested three web search engines: Google, Yahoo, Msn and a semantic search engine (Hakia). Participants searched for 10 queries using the three web search engines and for four similar to the meaning queries using the semantic search engine. The researchers tested the precision and the recall. They found that Yahoo had the best results for the most precise information. The semantic search engine had the lowest scores in the two conditions: precision and recall.

Vilar and Zumer (2011) explored how users perceive user interface usability. In their experiment they used three e-journal databases (Science Direct, Proquest Direct and Ebsco Host). Participants were asked to seek information for topics they desired in two databases at least. Their sessions were digitally recorded and analysed by the researchers. The findings revealed that users did a lot of probing as most databases were unknown to them. They searched the information topics they chose and only a few unexpectedly found irrelevant material. Many of them downloaded articles to read

them later and most of them allocated their attention to pictorial material. Finally, all users who were unhappy with the system they used, they were also dissatisfied with the results of their searching.

Salmeron et al. (2013) examined how students navigated and bookmarked web pages in Google's results list. The participants sought information for a given task on the web accessing only 10 preselected search results linked to real web pages retrieved from Google. The results from the navigation logs revealed that students followed the order suggested by the Google's results list. Moreover, students bookmarked web pages regarding the topic relevance and web reliability.

2.6.3. People's Characteristics and their Effects

People's experience, previous knowledge, and self-efficacy have also been investigated as well as their effects on web searching process and strategies (Hill and Hannafin, 1997; Hölscher and Strube, 2000). People's characteristics, cognitive aspects, gender factors, and their relations with information and tasks have also been explored (Kellogg and Richards, 1995; Navarro-Prieto et al., 1999; Hawk and Wang, 1999; Hupfer and Detlor, 2006; Rose, 2006).

Hawk and Wang (1999) used search transcripts and verbal protocols. They found 10 strategies for web seeking: surveying a web page, double-checking, exploring, link following, back and forward going, shortcut seeking, engine using, loyal engine using, engine seeking, and metasearching.

Hölscher and Strube (2000) explored the impact of user's search experience. They found that expert users started web seeking with their favorite web search engines. Expert users also used multiple strategies when they could not find relevant information. They tended to reformulate their search queries, revisit pages that have been found earlier, and use other search engines.

Blignaut and McDonald (2012) explored the effect of users' experience and socio-economic status on web searching performance. 655 participants completed a search task using Google. The results suggested that web experience did not relate to people's search performance in terms of number of mouse clicks. The socio-economic

status, however, was a significant predictor of efficiency for users with no or limited experience. Even though people with low socio-economic status made fewer clicks in order to find an answer on the web, this did not indicate a better performance in obtaining the correct information. Navarro-Prieto et al. (1999) investigated users' web experience too. They tested how novice and expert users searched information. They found that experienced users used more keywords as well as multiple strategies and were more flexible than novice users who did not use many strategies and started with a broad topic and gradually narrowed their search.

Slone (2004) tried to investigate the influence of people's age, experience of web seeking and explore the aims of web seeking processes. She observed and interviewed 31 participants in a library while they searched library catalogs. She divided participants into age categories. She found that age factors affected the quantity and quality of information as well as the seeking patterns. She found that people from all age groups, who had no experience, tended to have similar web attitudes. Children and older people tended to lack web-seeking experience. Situational goals drove the seeking processes.

Abeer et al. (2013) explored the relationship between web searching behavior and the education level. 64 participants searched information for topics related to their disciplines using any search tool they wanted. The researchers used pre and post questionnaires, think aloud protocol, and observation. The results showed that user needs, skills, and persistence enhanced as the education levels increased. This confirms the role of education level as a predictor of choosing the right techniques and search tools on the web. Ding and Ma (2013) assessed students' web searching competency regarding academic and daily life tasks. 141 participants completed a task-based online test to evaluate their web searching competency and performance. It has been found that many participants were unable to search the web with efficiency and the competency levels were higher for academic than for daily-life tasks.

Montgomery and Faloutsos (2001) gathered more than 20,000 Internet users' data from July 1997 to December 1999 trying to explore browsing trends and patterns. They found that in this period of time the number of pages and domains that users visited during a computer seeking session was stable whereas the time people searched on the web has increased.

Rieh and Xie (2001, 2006) analysed people's web paths and queries using a web search engine. Participants searched for six topics per session. They found that people reformulated their queries according to three factors: content, format, and resource. Users first interacted with their intentions on the affective level, then evaluated these outcomes on the cognitive level and finally took decisions about how the information problem could be solved on the situational level.

Tauscher and Greenberg (1997) analysed six week web seeking data of 23 people. They found that people revisited the same webpages and browsed a few related pages. Researchers mentioned the value of the web pages history system. It must provide more details about the previous visited pages, and the most frequently used pages should be on the top of the history list.

Kroustallaki et al. (2015) explored the effects of a short-term intervention to enhance students' web searching skills such as query formulation, information selection, and credibility evaluation. Two groups of students, the experimental and the control group, searched information for a task on the web using a popular search engine within twenty minutes. Participants in the control group sought information without receiving any training or other search instructions. Positive and negative affect was measured before, during, and after each search. The results showed that participants, who received help from the researchers during the search, experienced negative affect. The experimental group, however, presented significant growth in all searching skills.

Hamburger and Ben Artzi (2000) found that extroversion and neuroticism, the two personality characteristics, affect web use. They tested 72 participants and the frequency they used some web services (social services, information services, and leisure services). They found that extraversion for men was positively related to leisure services, and neuroticism was negatively affected information services. On the other hand, extraversion for women was negatively and neuroticism positively related to social services.

Nahl (1998) instructed undergraduate students to make structured self-reports while web seeking. They should also write down their thoughts and their feelings. Nahl found

that information behavior was connected with people's experience, familiarity, information structure and interest. Palmquist and Kim (2000) investigated the effects of cognitive styles and experiences on undergraduate students' web seek experiences. The results showed that cognitive styles affected only novice users' web performance. Kim and Allen (2002) also explored personal differences in web seeking process. They tested participants' cognitive styles first, and then they analysed participants' web seeking engines and task outcomes. They found that web-seeking strategies were affected by users' effectiveness in particular tasks, and that web engines structure affected people's ability to achieve different tasks successfully or not.

Baker et al. (2010) investigated students' cognitive–affective states using three different computer learning environments. They used a variety of data collection such as quantitative field observation, self-report, and different types of learning environments such as dialogue tutor, problem-solving game, and problem-solving-based Intelligent Tutoring System. They found that boredom was present across learning environments and negatively influenced learning. Confusion and engaged concentration were experienced by most students within all three learning environments.

Spink et al. (2010) explored web interactions and technoliteracy of children in the early childhood years. The term technoliteracy refers to children's' knowledge of everyday technology. Young children conducted web searches and their searches were recorded. It has been found that young children engaged in complex web searches and their searches included keyword searching and browsing, query formulation and reformulation, relevance judgments, successive searches, information multitasking, and collaborative behaviours. Park (2008) constructed a model in which multiple factors seemed to prioritise and coordinate people's ability to manage multiple information tasks. The results showed that gender and age affect differently each person when multitasking and seeking information while using the web (Park, 2008). Task elements, time, and emotion are significant factors, which affect people's prioritising abilities and thoughts (Park, 2008). There is also a strong combination and link between prioritise and coordination. This is a very important model because it provides for the first time a framework for various factors, which are combined in the

multitasking web seeking process. The weakness, however, as Du (2010) in her PhD thesis and Du and Spink (2011) in their article stated is that, Park did not consider in detail the cognitive coordination mechanism in the multitasking interaction. This study, however, investigated in detail specific cognitive and psychological state factors and their impact on multitasking information behavior while using the web.

2.6.4. Web Search Models

Previous web search models have highlighted different factors which may influence information seeking while using the web. For example, Wang et al. (2000) mentioned the importance of cognitive, affective, and physical factors. Ford et al. (2001) as well as Knight and Spink (2008) explored the impact of cognitive styles on seeking strategies. Du (2010) combined cognitive coordination and cognitive shifts during multitasking while using the web. However, how particular cognitive and psychological state variables as well as task and artefact characteristics influence the information seeking process while using the web and the outcome of this procedure is less well understood.

2.6.4.1. Wang, Hawk, and Tenopir 2000

They tried to build a framework in order to understand information searching interaction between people and web search systems. Their aim was to investigate this interaction and process providing details and a multidimensional model.

In their experiment participants completed questionnaires about web experience, anxiety and cognitive styles. Then they searched on the web for two information problems. They found that there were many factors, which influenced web-seeking process. There were cognitive, affective, and physical factors (Wang et al., 2000). Cognitive characteristics affect people's interpretation of information, and cognitive styles affect their strategies as well (Wang et al., 2000). The present study explored in-depth cognitive and psychological state factors which influence the web seeking process.

This model considers both the user and the system. Wang et al. (2000) believed that a successful web-seeking model should incorporate people's mental stages and web designs in order for web engines to be more effective and helpful.

2.6.4.2. Choo, Detlor and Turnbull 2000

Their research was focused on experts' use of internet for daily activities, issues, topics, and information. They identified four stages of information seeking: undirected view, which is characterised by starting and chaining actions; formal seeking, which is about particular information; conditioned viewing, which is differentiating, browsing and monitoring; and informal search (Choo et al., 2000). Browsing web pages took place in all these levels (Choo et al., 2000). With this model, they tried to highlight information behavior and build new bridges either enhancing people's information seeking strategies and paths or providing information about web search engines and systems characteristics (Choo et al., 2000).

This model is comprehensive and tries to connect content relativity and communication. It provides levels and stages of information seeking process. The weakness, however, is that it addresses only the seeking processes of experts and managers and not those of ordinary people. The present study highlighted and explored factors which affect information seeking while using the web.

2.6.4.3. Ford, Miller, and Moss 2001, 2005

In their model, they tried to incorporate many variables. Self-efficacy and gender seemed to influence people's seeking ability. Self-efficacy influenced people's retrieval ability. They investigated 64 Master students, 44 females and 20 males. They found that males were more confident and able to seek the right information (Ford et al., 2001).

Cognitive styles also affected information retrieval. They found that verbaliser cognitive style negatively worked in contrast to holistic and an analytic style, which had no effect on retrieving process (Ford et al., 2005). People with a verbaliser cognitive style concentrate more on web images and pictures, and they have difficulties to keep their aims. Older adults were connected with low levels of Boolean seeking in contrast to younger, who had higher levels. Females were connected with the analytic cognitive style and males with the holistic (Ford et al., 2005).

In 2005, Ford et al. reported links between low levels of Boolean searching and older individuals; between analytic cognitive style and female gender; between high levels

of Boolean searching and younger individuals; and between holistic cognitive styles and male gender.

This model is detailed, but it also has some limitations. As Ford et al. (2005) state more experiments need to be done with more participants in natural environments using different web search engines. In this study people used different web search engines to find the desired information and specific psychological variables were explored in-depth.

2.6.4.4. Knight and Spink 2008

Cognitive styles remain to challenge and influence researchers. In this model, cognitive styles are of major importance proving their influence on web seeking processes. People start web seeking from an information need they have. Cognitive styles affect people's strategies. According to Knight and Spink (2008), there are two main activities in the information seeking behavior: browsing and searching actions. This is a macro model of information seeking behavior (Knight and Spink, 2008).

People start seeking information on the web. People's self-perceptions, perceptions about the system, and expected interactions between them influence the seeking strategies.

The strength of this model is that it explored the consequences of cognitive styles in strategies and seeking queries (Du and Spink, 2011). It describes not only the interactions between people and web systems but also between people and information. Seeking strategies and cognitive affections have been explored, but the outcomes of the existing knowledge and cognitive stages have not been described (Du and Spink, 2011). This study explored in-depth the differences in existing knowledge after the information seeking behavior. It investigated people's depth of knowledge before and after the information seeking process for each topic as well as people's degree of change of knowledge for each topic and people's degree of becoming informed about each topic.

2.6.4.5. Du 2010

Du (2010) combined for first time cognitive coordination and cognitive shifts while multitasking using the web. She found that, there are some levels in cognitive

coordination, which influence web-seeking processes. The sublevels of cognitive coordination, which influence the task strategies and task manipulation, are: task, mechanism, and strategy coordination. These sublevels influence the cognitive shifts, which could be either holistic or state. Holistic shifts are the general changes of knowledge for one topic, and state shifts are the changes during the interaction between the user and the system

She found some seeking activities such as serendipity browsing, multiple search sessions, and seeking levels between original and evolving information problems (Du, 2010). She proposed the new MCC (multitasking, cognitive coordination and cognitive shift) web search model. This new model is comprehensive because it includes cognitive coordination and its outcomes as well as cognitive shifts, are crucial for any web seeking process.

The main purpose of this research was to create a new model, explore, and investigate cognitive and psychological state variables. Between multitasking and cognitive coordination there are some cognitive variables such as working memory, which influence cognitive coordination and cognitive shifts. Working memory is responsible for the quality and quantity of information that people attend, process, and store in their memory as well as for people's change of knowledge.

Flow, explained in the PAT model, was obvious during the multitasking seeking process while using the web. Tasks and artefact characteristics were measured. All these variables enhanced the understanding about web seeking process. Under these circumstances, it is a very useful model for scientists who search and study web search information behavior. This new framework could predict according to cognitive and psychological state variables at some level the performance on web searching as well as the factors, which may reduce it. This could help researchers in their studies and web companies as well knowing how web interact with users to build more effective web systems.

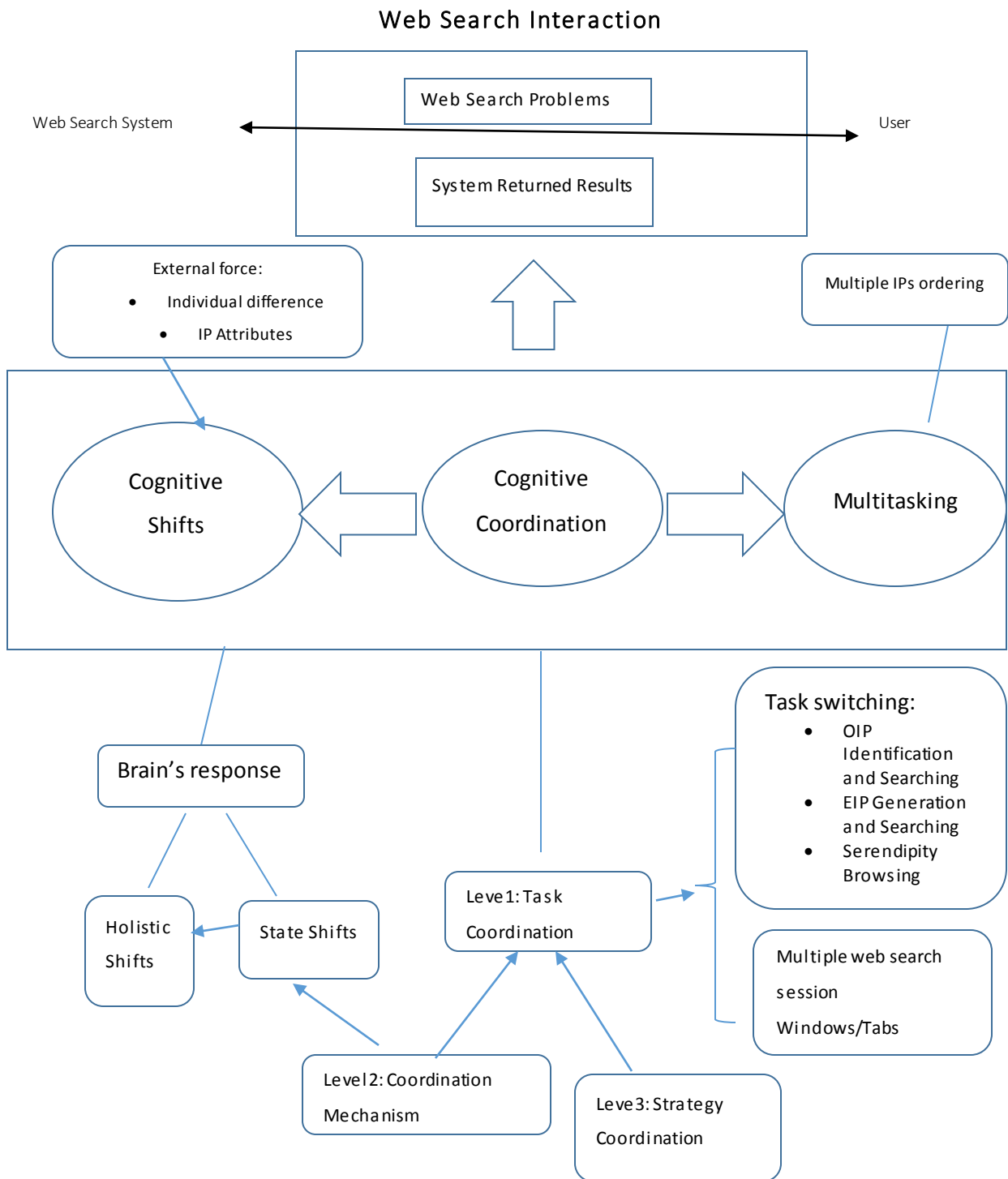


Figure 10. Du's Model (Du, 2010).

2.7. Cognitive Coordination

Coordination can be observed in many fields such as biological and computational. There have been many definitions, but the main idea is that coordination is people's ability to handle their actions effectively (Malone and Crowston, 1994).

As Malone and Crowston (1994, p.90) suggested, "*Coordination is managing dependencies between activities*". This means that people have to find the characteristics of their activities and then to investigate their cognitive processes.

Ma (2008) provided an IR coordination model. She suggested that coordination is an underlying mechanism between users and IR systems. Information retrieval is a process of coordination between users and IR systems. This relationship has been developed through seeking strategies and knowledge of coordinating mechanisms (Du, 2010). Three types of information are responsible for this relationship: perceptual, linguistic evidence, and exploration of seeking web logs. The limitation of this model is that it describes coordination only from a communication point of view between users and systems, and it does not explain the underlying cognitive mechanisms of it (Du, 2010).

When people seek for information while using the web, they have to coordinate not only information, but also seeking strategies and various tasks. This procedure depends on multiple variables such as people's knowledge about the topics, cognitive styles which guide the seeking strategies, and cognitive strategies. These variables have been mentioned by many researchers from the field of information science (Spink et al., 2006; Park, 2008; Du and Spink, 2009).

Miyata and Norman (1986) proposed two different aspects of coordination: internal and external. Internal aspects incorporate people's knowledge, seeking strategies, cognitive styles, conscious, and subconscious control. External aspects include all the external factors from the environment. Interruptions can also be internal and external. Internal interruptions are people's irrelevant thoughts when they seek information, and external interruptions refer to environmental factors.

Park (2015) explored the nature of multitasking information task behaviour while using the web and how people coordinate multiple information tasks. Participants searched on the web for four information tasks for one hour. He used different data collection techniques such as web search logs, think aloud data, interviews, questionnaires, and post-search interviews. He found that when people searched information for a difficult task or when they did not find the required information, they did not complete the task but they proceed to another one. Those participants who decided in the beginning which strategies to follow such as which keywords or search system engine to use, performed better than those who did not plan their actions. People tend to coordinate their strategies not only to better find information but also to effectively switch between tasks with less mental effort.

Freed (2000) found that coordination of the tasks and task prioritisation under time pressure are influenced by four factors: urgency (available time to perform a task); importance (cost of not performing the task); duration (how long it takes to complete a task); and switching cost (the cost of switching to another task).

Regarding task switching and task performance, Dual-process theories are about people's processing mechanisms of information (Shiffrin and Schneider, 1977; Epstein, 1994; Epstein and Pacini, 1999; Evans, 1989, 2006). All these theories have in common two systems: System 1 and System 2 (Evans, 2008). Many terms describe these two systems, but generally, System 1 is unconscious, automatic, quicker, and has a lot of capacity in contrast to System 2, which is controlled, conscious, slower, and has limited capacity. Emotion is connected with the first System (Epstein, 1994). System 2 is a procedure, which is helped by System 1 and all its components such as memories. Working memory is linked to System 2, and that is the reason why this system is slower and has limited capacity. Some dual-process theories include individual differences and their effect on task performance (Evans, 2008).

Du (2010) found three coordination levels: task, mechanism, and strategy level. According to her, task coordination level is the basic level; then is the mechanism coordination level (e.g. feedback, self-learning regulations); and the most important, the strategy level. This level has two sublevels: global and specific strategy level. The task coordination level is the evaluation of the information problems. The mechanism

coordination level is people's feedback about their seeking procedure. The specific strategy level is about the query reformulation, and the global strategy level involves people's plans about the entire seeking process. The cognitive coordination levels occur sequentially (Du, 2010).

This study investigated in-depth participants' cognitive coordination levels, depending on different working memory and flow results and explored the transition steps from one coordination level to another for each participant. Coordination patterns emerged for participants according to their working memory and flow results.

2.8. Cognitive Shifts

Cognitive shifts have been described as the changes that can be mentioned in an action or utterance (Jacobs, 2002). Cognitive shifts depend on various characteristics and individual differences such as cognitive styles, traits, and experience (Wang et al., 2000; Palmquist and Kim, 2000; Ford et al., 2001).

Researchers have found cognitive shifts in information problems (Robins, 2000), information searching stages (Santon, 2003), and information seeking strategies (Xie, 2000). Spink and Dee (2007) explored participants' cognitive shifts after they conducted online investigations for information problems. They reported cognitive shifts in information seeking strategies and tasks knowledge. These shifts were only positive and contributed to people's knowledge. They concluded that cognitive shifts are an important element for effective interaction in IR environments (Spink and Dee, 2007).

Xie (2000) investigated cognitive shifts in-depth. He analysed data from 40 participants from different library types (academic, special, public). He found three cognitive shift levels: interactive intention shifts, planned shifts in current tasks, and shifts of information-seeking strategies. Cognitive shifts contributed to the change of methods and/or resources. People may alter their methods and resources in order to improve and enhance their information seeking strategies. He also mentioned that cognitive shifts could only be positive.

Spink (2002) investigated cognitive shifts in information problems and information-seeking stages. In her study participants searched information for their information tasks using the Inquirus web search engine. The results showed that participants experienced different levels of cognitive shifts depending on their information tasks, information seeking stages, and personal knowledge. Rieh and Xie (2006) explored cognitive shifts depending on web query reformulations. In their experiment, participants submitted six or more queries per session. They gathered query logs from 313 search sessions. They found three facets of query reformulation: the content, format, and resource with nine sub-facets. Moreover, they observed eight patterns of query reformulations: specified, generalised, parallel, building block, dynamic, multitasking, recurrent, and format reformulation.

Kuhlthau (1991) in her model mentioned that people are involved in information seeking behaviors in order to find information about a specific task. She also suggested that, through uncertainty, people engaged to information seeking. People pass from information uncertainty to knowledge shifts and positive feelings (Kuhlthau, 1991). Saracevic's (1996) Stratified Model also provides different cognitive shifts between different levels in an IR interaction.

Wu (2011) explored researchers' information seeking and retrieval behavior. Participants searched information for their thesis or for project surveys. It has been found that users shifted between different cognitive states (search for a topic and evaluation of the results) and needs (when users chose the topic and then they started to seek information).

Du (2010) identified two types of cognitive shifts: holistic and cognitive states shifts. Holistic shifts are general changes in knowledge about an information problem, and cognitive state shifts are the changes during the interaction between the user and the system.

There are five cognitive states shifts: topic, (people switch between their tasks and goals); strategy, (people shift their seeking strategies); evaluation, (participants criticize the system's validity and affectivity); view, (people examine a specific opened web page and its relation to the information problem); and overview, (people focus on the whole seeking action) (Du, 2010). Du (2010) found that different participants had different cognitive shifts, and each participant might have different shifts for each information problem. She has not found, however, how individual differences and task characteristics may influence these shifts. This study explored in detail participants' cognitive shifts according to their working memory and flow results. This research enhanced the knowledge about multitasking while using the web.

2.9. Personal Dimensions in Information Seeking Behaviour

There are many factors involved in the information seeking and retrieving process. The following section is a brief overview of the most widely recognised and will be discussed in more detail later as well as the contributions of individual authors.

From the field of information science according to Hepworth's (2004) framework these include sociological data (roles, norms, and tasks), psychological data (knowledge, cognitive, affective, and style states), behavioural data (behaviour), and source data (source character and behaviour). Lazonder and Rouet (2008) also described factors which affect information seeking activity: contextual variables (time and other conditions on activity), individual variables (the language skills, the existing knowledge and the familiarity with the task), and resource variables (the amount and type of information). Wilson (1999) mentioned psychological, cognitive, and affective factors, which influence the information seeking procedure. Kuhlthau (1991) also explored terms like feelings, thoughts and emotions and regarded these as important factors associated with information seeking. The stage of information seeking and uncertainty can enhance various negative feelings such as doubt, anxiety, and confusion (Kracker and Wang, 2002). Vakkari (2001) identified connections between students' mental stages, information seeking, search strategies, relevance, and the use of information.

There are therefore, five main dimensions highlighted by information scientists: the affective (feelings, emotions, moods), cognitive (cognitive styles, working memory, attention, the users' experience, developmental stages, and aging factors), psychological states (flow, motivation), personality (extraversion, agreeableness, conscientiousness, neuroticism, and openness), and sociological factors (self-efficacy). From the field of psychology important factors have been associated with information seeking behaviour. These are similar to those in information science: the affective, cognitive, psychological states, personality dimensions, and sociological factors. However, there are some differences. In the psychological affective factors, for example, there are moods and emotions, but not feelings. In the psychological cognitive category, there is attention but not users' experience. The following table provides the most important variables in their categories.

Information Science (IS)										
Psychology (PSY)		Cognitive	Affective	Psychological States		Personal Dimensions.	Sociological Factors (Roles, Norms)	References		
	Cognitive	IS	Cognitive Styles Working Memory Experience Developmental Stages Aging					Social Cogn. Theory : Self-efficacy	IS	Ford et al., 2005; Palmquist and Kim 2000; Wang et al., 2000; Spink, 2010; König et al., 2005; Bühner, et. al., 2006; Hambrick et al., 2010; Marchionini, 1997; Hawthorn, 2000; Hepworth, 2004; Wilson, 1999.
		PS	Cognitive Styles Working Memory Attention Aging Developmental Stages						PSY	Engle et al., 1999; Baddeley and Hitch, 1974; Kane et al., 2001; Bandura, 1986; Tucker and Warr, 1996; Alloy et al., 1999; Huey et al., 1996; Kemper, 1992.
	Affective			IS	Emotions Feelings				IS	Wang et al., 2000; Nahl, 2005; Damasio, 1994; Scherer, 2001; Picard, 2003.
				PSY	Emotions Moods				PSY	Illies and Palmon, 2004; Gasper and Zawadzki, 2012; Bless et al., 1996; Armitage et al., 1999.
	Personality Dimensions						Extraversion Agreeableness Conscientiousness Neuroticism Openness		IS	Amichai Hamburger et al., 2002; Heinström, 2003.
								PSY	Costa et al., 2001; Humphreys and Revelle, 1984.	
Psychological States					IS	Motivation Flow		IS	Keller, 1987; Cocea and Weibelzahl, 2007; Csikszentmihalyi, 1990; Novak et al., 2000; Finneran and Zhang, 2003.	
					PSY	Motivation Flow		PSY	Wigfield et al., 2012; Humphreys and Revelle, 1984; Shin, 2006; Massimini and Carli, 1988.	

Table 1. Personal Dimensions in information seeking behaviour.

The factors that were not explored in this research are discussed in brief below. Working memory and flow, however, they were investigated in-depth in this study, and are discussed later in detail.

2.9.1. Factors that were not explored in this Study

Feelings, emotions and moods are in the affective category. Feelings are the conscious, subjective, and private results of emotions (responses to situations). There are, “the mental representations of the physiological changes that characterise emotions” (Damasio, 2001). This means that people’s personal experiences and personality affect the types of feelings. Feelings are connected with web seeking behaviour and task difficulty. Therefore, positive feelings may improve a person’s information seeking behaviour during and after the seeking process (Meghabghab, 1995; Bilal, 2000; Kracker and Wang, 2002; Nahl, 2005; Bilal and Bachir, 2007; Tenopir et al., 2008; Gwizdka and Lopatovska, 2009; Yeykelis et al., 2014).

Emotions have been identified as another important factor for information seeking behaviour (Kuhlthau, 1993; Kracker and Wang, 2002; Vuorela and Nummenmaa, 2004; Fredrickson and Branigan, 2005; Kim, 2008; Arapakis et al., 2008). Both sciences suggest that, emotions influence people’s cognitive performance, decision-making, and they are correlated with people’s aims and motivations (Damasio, 1994; Armitage et al., 1999; Picard, 2003). Positive emotions help people to broaden their attention while they seek information. Negative emotions, such as anxiety, negatively influence the seeking process and they are correlated with task difficulty.

Moods last longer than emotions and may not be associated with a specific situation (Weiss, 2002). Moods influence web seeking behaviour (Mackie and Worth, 1989; Bless et al., 1996; Gasper and Zawadzki, 2012). Different moods provoke different information processing styles. People with positive moods tend to have a heuristic information processing style. Positive moods let them know that the current information seeking process is safe, they do not ask many questions, and they rely on their existing knowledge because they feel comfortable. On the other hand, people with negative moods feel that the information seeking process may be flawed, they ask more questions, and they try to critically analyse the situation (Schwarz, 1990; Bodenhausen et al., 1994; Bless et al., 1996). An attempt was made to minimise the

impact of mood by creating a neutral setting. Feelings were investigated before and after the information seeking process. However, the analysis did not show that they had a significant influence.

In the cognitive category, cognitive styles also affect information behaviour in different ways (Plass et al., 1998; Boles et al., 1999; Palmquist and Kim, 2000; Sadler-Smith, 2001; Ford et al., 2002; Graff, 2003; Massa and Mayer, 2006; Park and Black, 2007; Frias-Martinez et al., 2008; Thomas and McKay, 2010; Jablokow and Vercellone-Smith, 2011; Yuan et al., 2011; Lo et al., 2012; Vercellone-Smith et al., 2012; Belk et al., 2013; Belk et al., 2013; Huang et al., 2014). Both sciences suggest that cognitive styles have multiple effects on information seeking behaviour, including negative, none, and some evidence of correlation. Graff (2003) did not find any connections between cognitive styles and task performance in online seeking activities. The same results have been found by other researchers regarding the effect of cognitive styles on people's performance on web based learning activities (Sadler-Smith, 2001; Massa and Mayer, 2006). Other researchers, however, have found correlations between cognitive styles and learning outcomes on web based learning activities. Better performance has been shown when the learning environments follow their cognitive styles (Plass et al., 1998; Boles et al., 1999; Thomas and McKay, 2010; Jablokow and Vercellone-Smith, 2011; Vercellone-Smith et al., 2012; Huang et al., 2014). There are therefore conflicting data about the impact of cognitive styles on information seeking behaviour. It seems that, further research is needed in order to explore and understand better the effects of different cognitive styles on information seeking performance. This research did not explore in detail the impact of cognitive styles, however, the results did not indicate that other variables had influenced the results.

Another factor in cognitive category is attention. Attention is related to working memory, information behaviour, and performance. Attention determines how much and which information is held in working memory during the information seeking behaviour, and it determines the focus on specific information and number of items, which are going to be held (Festinger, 1957; Mills, 1965; Lowin, 1969; Baddeley and Hitch, 1974; Garavan, 1998; Downing, 2000; Jonas et al., 2001; Kane et al., 2001; Cowan, 2001; Mc Elree, 2006; Cowan et al., 2007; Dehaene and Changeux, 2011; Oberauer and Hein, 2012). As Cowan (2001) proposed people can attend four chunks

at the same time. Other researchers suggested that, people can attend only one item (Garavan, 1998; Mc Elree, 2006). Attention was not explored in this research in detail as this was not the scope of the study, however, the measure of working memory capacity did indicate users attention.

Developmental stages are also not included in the cognitive category in this study. They indicate that people have different cognitive, information processing, and retrieval abilities, depending on the developmental stage they have reached. These have been related to cognitive changes and processes. The information processing strategies and skills depend on each developmental stage (Rose, 2006; Spink and Cole, 2007; Spink, 2010). In this study it was assumed that participants were at a similar level because they had achieved a similar level of academic performance.

Users' experience has been included in the cognitive category in this study. Experienced users seem to need less time to seek information, achieve better outcomes and use more information seeking strategies than non-experienced web users (Carroll and Carrithers, 1984; Marchionini, 1997; Navarro-Prieto et al., 1999; McGrenere and Moore, 2000; Ford et al., 2002, 2005; Brand-Gruwel et al., 2005; Tabatabai and Shore, 2005; Chevalier and Kicka, 2006; Bruder et al., 2014).

Finally, the aging variable has been related to cognitive declines. Both sciences support the idea that aging negatively affects information seeking behaviour and performance. Aging has been related to decrease of many cognitive variables such as working memory, attention, and inhibition (Panek et al., 1984; Zacks and Hasher, 1988; Balota and Duchek, 1988; Kemper, 1992; Filley and Cullum, 1994; Grady et al., 1994; Salthouse, 1996; West and Bell, 1997; Reuter-Lorenz et al., 1999; Stuss and Alexander, 2000; Hawthorn, 2000; Park et al., 2002; Suthers et al., 2003; Fisk et al., 2004; Bopp and Verhaeghen, 2005; Poynton, 2005; Raz et al., 2005; Fabiani et al., 2006; Mattay et al., 2006; Riecker et al., 2006; Williamson and Asla, 2009; Cappell et al., 2010; Drag and Bieliauskas, 2010; Schneider-Garces et al., 2010; Passow et al., 2012; Govaere et al., 2012; Mishra et al., 2013; Reuter-Lorenz, 2013; Bruder et al., 2014).

The psychological states category of this research consist of motivation and flow. Both science fields provide evidence that motivation is connected with information seeking behaviour (Humphreys and Revelle, 1984; Deci and Ryan, 1985; Keller, 1987; Csikszentmihalyi, 1997; Clark and Mayer, 2003; Beck and Jessup, 2004; Illies and Reiter-Palmon, 2004; Jonas et al., 2005; Cocea and Weibelzahl, 2007; Keller, 2008; Wigfield et al., 2012; Huang et al., 2014). Motivation is about people's interest in being informed, satisfaction, and feelings of success relating to their information seeking process and outcome. However, high motivation for a long period can have negative results leading to fatigue as well as seeking irrelevant information. Flow is connected with motivation (Massimini and Carli, 1988), so from that perspective the measure of flow in this study could indicate the levels of motivation.

In the personality dimension category, five personality dimensions have been thought to influence information behaviour: neuroticism, extraversion, openness to experience, competitiveness and consciousness (Humphreys and Revelle, 1984; McCrae and John, 1992; Carroll, 1993; Eysenck, 1994; Ackerman and Heggestad, 1997; Costa et al., 2001; Amichai-Hamburger et al., 2002; Demetriou et al., 2002; Heinström, 2003; Chamorro-Premuzic and Furnham, 2004; Moutafi et al., 2005; Jensen, 2006; Boyle et al., 2008; Friedman and Schustack, 2009; Schultz and Schultz, 2009; Fayombo, 2010; Rose et al., 2010; Myers et al., 2010; Zebek et al., 2011; Tan and Tang, 2013).

In the sociological factors category is self-efficacy a component from the social cognitive theory, which is recognised in Wilson's 1996 model of information behaviour. Both sciences support Bandura's theory about self-efficacy and its positive results in information seeking behaviour and performance. The importance of roles and norms has also been highlighted (Bandura, 1986; Bandura and Jourden, 1991; Wilson and Walsh, 1996; Brown et al., 2001; Britner and Pajares, 2006; Bates and Khasawneh, 2007; Rains, 2008; Tella, 2009; Chen and Feeley, 2014; Bronstein, 2014). Psychologists have also related self-efficacy to mental effort, effort management, cognitive performance, and cognitive process, enhancing motivation (Schunk and Gunn, 1986; Pintrich and De Groot, 1990).

There are therefore a multiplicity of factors/variables that may influence information behaviour. Some of them have been explored. Feelings were measured in the pre and

post questionnaires. Users explained how they felt before and after the web seeking procedure. Emotions and moods were not been explored in detail, however, the existence of particular feelings, which have been identified, could indicate the nature of user's emotions and moods. User's experience was measured in the pre-questionnaires.

Cognitive styles, personality dimensions and self-efficacy were not explored. They could have influenced the study, however, the diversity of the results was not significant and did not indicate a significant influence of other intervening variables.

Attention was not explored in detail, for example using eye tracking and this was beyond the scope of this study. However, an aspect of attention was incorporated in working memory. Working memory results did provide some detail about people's attention levels. A more detailed exploration about attention and its impacts on working memory in a multitasking environment on the web could, however, be another separate experiment in the future.

Users were in the same range of age and developmental stage, which indicated that there were not cognitive differences regarding these factors. From the psychological states category motivation was explored through flow. It was expected that people, who experienced flow would also have high levels of motivation in contrast to people who did not experience flow. It has been found that flow is a positive mediator for motivation. Massimini and Carli (1988) found that teenagers who experienced flow, felt happier, creative, motivated, excited and had the control of their actions. Furthermore, flow is the psychological state where people are fully immersed in a feeling of involvement. Therefore, it is expected that they were also motivated.

2.9.2. Factors that were explored in this Study

2.9.2.1. Working Memory

It is therefore difficult and possibly impossible without extended periods of time with respondents to develop a research intervention that would measure all the variables that could influence a person's information behaviour. This study therefore chose to focus on working memory, flow, cognitive state and cognitive coordination shifts, task and artefact characteristics partly because several of these factors were relatively unexplored and there was an opportunity to build on and compare findings with previous research.

It can be seen that some information scientists have focused on memory. Memory has been identified more thoroughly by Ingwersen (1992, 1996). Ingwersen mentioned short-term memory (STM) and long-term memory (LTM). He did not, however, explore the cognitive mechanisms before LTM, which are responsible for the type and amount of information, which should proceed to and be stored in LTM. He did not explore, in-depth, working memory which is responsible for the process of information to STM and LTM.

Working memory is a limited capacity cognitive system, which is responsible for the storage and processing of information, decision making, and planning (Oberauer et al., 2002). Many psychologists described working memory as the ability to retain a specific amount of information while intervening with other information or tasks (Engle et al., 1999; Miyake and Shah, 1999; Miyake et al., 2001; Conway et al., 2002; Kane et al., 2004; Colom et al., 2005a, 2005b; Conway et al., 2005).

The three-component model of Baddeley and Hitch (1974) proposed that working memory has three systems: visuo-spatial sketchpad, phonological loop, and the central executive. The visuo-spatial sketchpad is the system that maintains the visual information; the phonological loop maintains the vocal information; and the central executive is responsible for the decision-making process and attention. Baddeley (1986) added a new component, the episodic buffer, which maintains episodically some components of working memory and long-term memory, bringing both memories in touch. All these components are coordinated through the central executive system. Baddeley and Hitch (1974) used the concurrent task, in which participants recalled

verbally a sequence of verbal digits. It was expected that as the digits would increase, they would take more space from the limited working memory and in the end it would be impaired. In their first study, participants accomplished a visually grammatically test while they were tested in the concurrent task. When the digits increased, the response time was also increased. They found that there is not one system in working memory but three. Their assumption was that, the central executive system might organise the needs for the multiple tasks that require attention the same time.

Oberauer et al. (2002) proposed a two dimensions framework for working memory: content and cognitive dimensions. The first dimension includes working memory for visuo-spatial and numerical materials. The second dimension has three sublevels: simultaneous storage and processing, supervision, and coordination (Oberauer et al., 2002). On the other hand, there are some researchers who proposed that working memory is an entire system (Just and Carpenter, 1992; Engle et al., 1999).

Researchers from the field of information science found that in multitasking environments working memory was a performance predictor (König et al., 2005; Bühner et al., 2006; Juvina and Oostendorp, 2006; Hambrick et al., 2010; Colom et al., 2010). Bühner et al. (2006) tried to investigate the role of working memory in a multitasking situation. In their research, participants completed questionnaires about working memory and attention. After that, they multitasked. The researchers used Oberauer's (2002) model of working memory. They found that the coordination system of working memory predicted multitasking speed, but not multitasking errors. The storage system predicted multitasking errors, but not multitasking speed. Supervision seemed to have no effect on multitasking performance. These results suggested that multitasking errors might be correlated with the limited capacity of working memory (storage). Butler et al. (2011) tested participants' working memory, as they had to recall a series of words, which were presented with an equation. The results showed that working memory capacity had no effect on how people chose which task to perform first. However, participants with low working memory capacity had more errors in word recall, especially under time pressure. It seems that people with low working memory can also multitask, but their performance is lower than participants' performance with high working memory.

Working memory capacity is the number of items that people can recall during a complex working memory task (Barett et al., 2004). Baddeley (1986) proposed that working memory capacity is limited. It was proposed by Miller (1956) that people can maintain and repeat seven plus or minus two items or chunks (letters or words). Other researchers suggested that adults could only recall 3 or 4 verbal chunks (Gilchrist et al., 2008). Working memory capacity is, “the controlled attention of working memory” (Engle et al., 1999). This means that people’s different levels of working memory reflect individual different abilities of “controlled, sustained attention in the face of interference or distraction” (Engle et al., 1999, p. 104). High span people tend to allocate their attention to relevant information and coordinate information better than low span people, who tend to allocate their attention to task-irrelevant information and not coordinate information successfully (Engle et al., 1999; Corbetta and Shulman, 2002; Gazzaley et al., 2005; Polk et al., 2008; Andersen and Muller, 2010).

Gulbinaite et al. (2014) explored individual differences in working memory capacity. They measured people’s attention to relevant and irrelevant information by tagging target and distractors with different frequencies. They found that people with high working memory capacity suppressed their attention to irrelevant stimuli, whereas people with low working memory capacity enhanced their attention to irrelevant stimuli.

On the other hand, many researchers suggested that working memory capacity could be expanded through practice and exercise. If people exercise seeking and retrieving information in a specific domain of knowledge, then they may repeat these procedures quicker and expand their working memory capacity (Ericsson and Kintsch, 1995; Klingberg et al., 2005; Westerberg et al., 2007; Green and Bavelier, 2008; Dahlin et al., 2008; Perrig et al., 2009; Shipstead et al., 2010; Takeuchi et al., 2010; Morrison and Chein, 2011; Boot et al., 2011; Diamond and Lee, 2011; Houben et al., 2011; Shipstead et al., 2012; Penner et al., 2012). Klingberg (2010, p. 317) mentioned that, “the observed training effects suggest that working memory training could be used as a remediating intervention for individuals for whom low working memory capacity is a limiting factor for academic performance or in everyday life” .

Dunning et al. (2013) categorised 810 children aged 7–9 years into three groups: adaptive working memory training, non-adaptive working memory training with low

memory loads and no training. They found that children's working memory was enhanced one year after training. Children with low working memory have difficulties in reading and mathematics (Passolunghi and Siegel, 2001; Gathercole et al., 2003; Passolunghi, 2006; Wang and Gathercole, 2013), and in all related areas of the academic curriculum (Swanson and Sachse-Lee, 2001; Geary, 2004).

Melby-Lervag and Hulme (2013) explored the training effects of working memory on children with attention-deficit/hyperactivity disorder. They categorised children into two groups: treated group and untreated control group. The results revealed that there were reliable short-term improvements in working memory skills.

Autin and Croizet (2012) examined if working memory capacity can be improved through metacognitive interpretation of task difficulty. They tested 12 children. Half of them prior the working memory span experiment completed a difficult task, where the researchers explained to them that the task difficulty was normal and did not connect to any self-limitation. The results showed that their working memory capacity had been enhanced. Researchers suggested that a healthy and supportive psychological environment, where researchers can explain that task difficulties are not related to self-incompetence, could enhance working memory capacity (Autin and Croizet, 2012). Penner et al. (2012) explored the same hypothesis. They conducted working memory tests over eight weeks with participants while they received training. They used the training tool BrainStim (Penner et al., 2006), which tests: spatial orientation, through remembering visual or verbal instruction; visual object memory, where people have to remember which cards are when where they turned over; and numbers memory, where people have to remember a sequence of digits while the numbers increased. They found that their working memory capacity has been improved.

Working memory capacity is an essential component for web navigation, web browsing, and information seeking because only then people are able to process the information and the contents of texts, understand them, and keep only the necessary and relevant information (Toldy, 2009). Working memory externalisation is beneficial for people because it relieves working memory (Zhang, 1997; Van Nimwegen et al., 2004). Externalisation occurs when information becomes available in the interface, and it is not necessary for people to remember it (Van Nimwegen et al., 2004). Working

memory has two elements: internal (stored in memory) or external representations. On the web, there are many types of externalisation such as help-options or wizards (Van Nimwegen et al., 2004). Van Nimwegen et al. (2004) used two forms (internalisation and externalisation) for a problem solving. Participants conducted a distraction task in order for researchers to measure their working memory results. Researchers also measured participants' knowledge of the problem. They found that externalisation did not provide better performance. Only at the beginning, internalised participants took more steps than externalised participants did. On the other hand, internalised participants performed more complex seeking strategies and were able to continue after an interruption in contrast to externalised participants, whose performance after the interruption eliminated. Furthermore, internalised participants remembered more items because they built stronger correlations and had better strategies.

Working memory capacity is a predictor and mediator for many other cognitive activities such as language comprehension (Daneman and Merikle, 1996), reading comprehension (Daneman and Carpenter, 1980) and vocabulary comprehension (Daneman and Green, 1986), which are crucial for information seeking behaviour. Individual differences are mediators for working memory capacity (Just and Carpenter, 1992; Miyake et al., 1994; Ericsson and Kintsch, 1995; Shah and Miyake, 1996; Baret et al., 2004). For all these cognitive activities, motivation is also an important predictor. The level of motivation leads people to read deeply, comprehend and process better any information (Baldwin et al., 1985; Schiefele and Krapp, 1996; Hidi, 2001; Unsworth and McMillan, 2012).

When working memory is loaded with more than seven items such as in multitasking situations, this called working memory load. Performance and cognitive outcomes may be low because attention decreases, and much irrelevant information pass into working memory without filtering (Lavie, 2005; Lavie and De Fockert, 2005). Working memory is crucial for maintaining attention and cognitive control (Pratt et al., 2011). Cognitive load theory (Sweller et al., 1998; Paas et al., 2003) investigates the cognitive processes and instructional designs. Cognitive load theory is based on the fact that there is a limited working memory with two separate processing systems (for visual and auditory information), and there is an unlimited long-term memory (Sweller et al.

1998; Paas et al. 2003; Sanjram, 2013). When people expand their limited working memory processing capacity, then this leads to cognitive overload. In order for people to learn and transfer acquired knowledge, they need to process the information from working memory to long term memory (Roberts, 2009).

There are three types of cognitive load: intrinsic cognitive load, germane cognitive load, and extraneous cognitive load. Intrinsic cognitive load is the interaction of individual differences with the nature of the instructional materials. Individual differences are people's past knowledge or experiences (Roberts, 2009). Therefore, if people have experienced the same situation or problem before, then the intrinsic cognitive load will be low. Interactivity can also be enhanced when multiple pieces of information are dependent on each other and should proceed at the same time in order to attain a good understanding such as the understanding of sentences in a paragraph (Sweller et al., 1998).

Germane cognitive load can be raised from the construction of schemas. Schemas are functions, which provide the structure and storage of knowledge. Schemas categorise information in long-term memory in order to become experience and help people to reduce working memory load in new situations (Sweller et al., 1998). Extraneous cognitive load (Sweller et al., 1998) is the way in which information is presented to people. For example, difficult or complex diagrams may impose extraneous cognitive load. The effects of cognitive load are degradation of performance, multiple errors in performance, and failure to learn.

Cognitive load theory maybe significant in a web environment according to dual-coding and dual-channel assumptions (Mayer, 2001). The dual-coding assumption is about the different representations of information: verbal (e.g. written or spoken text) and visual material (e.g. pictures, graphics or maps), which are processed and represented in different, but interconnected systems (Paivio, 1986). The dual-channel assumption is about the different procedures of information in working memory, and they have been mentioned earlier (visuospatial and phonological subsystems) (Baddeley, 1986). People attend information relevant to their already existing knowledge visual or verbal, and they make associative connections between them. These procedures require

cognitive resources, which are limited in working memory. When these procedures expand these limits, the cognitive load is present.

Law et al. (2012) explored working memory load during multitasking. Participants memorised either good or poor plans for multitasking and then they were assessed on task completion and on the extent to which they changed their original plans. It has been found that participants were able to change their plans and reorder their online route. Participants with a poor plan at the beginning had comparable performance to those with better plans. This means that online planning does not overload working memory as it can use other resources such as acquired everyday skills.

Researchers (Hancock and Warm, 1989; Hancock and Desmond, 2001; Ackerman, 2011; Matthews et al., 2012; Szalma and Teo, 2012; Guastello et al., 2013) have related cognitive fatigue to increased cognitive workload. People start developing fatigue from the time they spent on a particular task while performing other tasks at the same time.

Interruptions have been found to negatively influence people's cognitive demands and cognitive load. People's cognitive performance is impaired by prevalent interruptions (Evaristo et al., 1995; Speier et al., 1999; Altmann, 2004; Loft et al., 2008). Drews and Musters (2015) explored the relationship between individual differences in working memory and interruptions. They found that people with low working memory capacity were more prone to the negative effects of interruptions than people with high working memory. Furthermore, people with low working memory performed the same as people with high working memory when they used the strategies people with high working memory used, but this performance was impaired when there were interruptions.

Working memory has been related to emotions (Gray et al., 2002; Aoki et al., 2011). Many researchers have found no correlations between working memory and emotions (Kensinger and Corkin, 2003; Döhnel et al., 2008; Neta and Whalen, 2011; Lindstrom and Bohlin, 2011; Grimm et al., 2012). Other researchers have found that positive emotions may positively affect working memory tasks (Perlstein et al., 2002; Mikels et al., 2008; Becerril and Barch, 2011). Moods have been found to demonstrate

limitations of cognitive capacity, whereas irrelevant thoughts distract people from their goals increasing cognitive load and decreasing task performance (Eysenck et al., 2007; Levens and Phelps, 2008). When people allocate their attention to tasks, which are neutral or non-emotional, then their working memory decreased (Williams et al., 1996), whereas attention to emotion related tasks leads to increased task performance (Anderson and Phelps, 2001; Ohman et al., 2001).

Li et al. (2010) tested how emotions affect working memory tasks with high or low working memory load. They used negative or positive inducing situations first, and then participants completed the working memory tests. They found an interaction between working memory and emotion only when working memory load was increased. They suggested that this selective procedure might be guided by attention. Baddeley (2013) mentioned that fear and anxiety negatively affect working memory by capturing and biasing attention to other similar distracting stimuli. People with depression tend to recall negative thoughts in contrast to people with neutral emotions. The solution for negative emotions such as fear and anxiety is to fight the threat, which is the distracting stimuli, but the solution for depression is to find ways act against it.

Carpenter et al. (2013) explored the effect of positive feelings on working memory and decision making in older adults (aged 63-85). Participants completed a computer task in which they could win money if they chose from “gain” decks, and lose money if they chose from “loss” decks. It has been found that people with positive feelings chose better and earned more money than people with neutral feelings. Adults in the positive-feeling condition enhanced their working memory capacity.

Yoon et al. (2014) explored the effect of irrelevant information on working memory. They categorised participants into three groups: social anxiety, depression and control group. Participants remembered two lists of words and then they were instructed to ignore one of the lists. Participants then chose whether a word belonged to the relevant list or not. It has been found that people in the depression group faced greater difficulties discriminating irrelevant emotional words from working memory.

Yeh et al. (2015) explored the effect of stress on working memory in game situations. 34 students tested in a computer based task. The results showed that stress enhanced

working memory performance leading to creativity during gaming. High levels of stress can contribute to working memory performance but too high levels can create negative emotions.

Working memory and its relation to cognitive styles has also been explored. Riding et al. (2001) related the results of 12 years old participants in working memory tests to holistic-analytic cognitive styles. They found that analytics were related more to working memory capacity than holistics. Analytics performed better when they had high working memory capacity and worse when they had low working memory capacity. Holistics were not affected by working memory capacity. It has been shown that analytics and verbalisers are affected by working memory capacity because they use more complex strategies (Riding et al., 2003; Grimley and Banner, 2008). People's prior knowledge of the text contents has been found to be related to working memory (Kaakinen et al., 2003). Some researchers believed that prior knowledge and working memory is the same thing because prior knowledge controls the capacity of working memory (Ericsson and Delaney, 1999). As Ericsson and Delaney (1999, p.268) mentioned, "Long Term- Working memory is an integral part of the skilled procedures for performing the tasks in the associated domain of activity". They continued and said, "Long Term- Working memory reflects a complex skill acquired to meet the particular demands of ..Domain relevant skills, knowledge, and procedures for the task are so tightly integrated...that the traditional assumption of a strict separation between memory, knowledge and procedures is not valid for skilled performance" (Ericsson and Delaney, 1999, p.257). However, there are some researchers who suggested that these two elements are separate (Just and Carpenter, 1992; Baddeley and Logie, 1999). Baddeley and Logie (1999) argued that long-term memory contributes to working memory performance, but there are separate systems through to neuropsychological evidence.

Ericsson and Kintsch (1995) proposed the long-term working memory (LT-WM) model. They reviewed the literature review about short-term and long-term memory in multiple activities such as e-mental calculation, everyday activities, medicine, and chess. They distinguished two different components of working memory: ST-WM (short term-working memory) and LT-WM (long term-working memory). They mentioned the importance of LT-WM examining the literature review and finding strong evidence such

as the “interruptions imposed by switching between different tasks, by memory testing during processing, and by memory performance after processing has been completed” (Ericsson and Kintsch, 1995, p. 240). The first concept (ST-WM) involves all the tasks with no prior knowledge that require driven attention. On the other hand, LT-WM provides quick access to prior knowledge, especially for familiar and well-known tasks. For example, when people have knowledge for a task, then LT-WM is activated, providing access to people’s knowledge and eventually understanding of the task. When people have no knowledge of the task, then LT-WM cannot be activated. In this situation, ST-WM is only available, which requires more time and resources in order people to understand the task (Ericsson and Kintsch, 1995; Kintsch, 1998).

Cowan (1995, 1999) presented the embedded process model. According to this model, a limited amount of LTM information is available anytime regarding the focus of attention. Attention can be either automatic or driven and may activate the LTM information. This model, however, did not examine in-depth the elements of LTM, which are available during problem solving (Woltz and Was, 2006).

Oberauer (2002) proposed that information in WM is accessible in different levels. He conducted the same experiments with Cowan (1995, 1999). Participants memorised sets of digits. There were two subsets: the active set, which had to be accessed as input for arithmetic tasks; and the passive set, which was independent from the concurrent task and had to be remembered too. He found three stages of representations in working memory: the activated part of long-term memory, a capacity-limited region of direct access, and a focus of attention. He assumed that one chunk of information can be attended at any time. However, there are limited additional chunks, which can be activated immediately and become the focus of attention. He believed that there is LTM information, which is not limited like WM, and can be activated any time, as Ericsson and Kintsch (1995) described in their model. However, this is “an inadequate test of the broader notion that the cognitive workspace must include available background knowledge related to immediate task demands to explain complex forms of cognition, such as language comprehension and problem solving” (Woltz and Was, 2006, p. 699).

Kaakinen et al. (2003) examined 47 participants. Participants read and recalled two texts for which they had different levels of knowledge, while their eye movements were recorded. Researchers also explored participants' working memory capacity levels. They found that people with high working memory capacity and prior knowledge did not require extra processing time for encoding information into memory, in contrast to participants with low working memory capacity, who needed more time in order to process and encode relevant information. Participants with high working memory capacity could use better their prior knowledge than participants with low working memory capacity. These findings supported the LT-WM theory of Ericsson and Kintsch (1995), which suggests that individual differences in working memory capacity are related to the proper or not use of long-term memory.

Hambrick and Engle (2002) investigated domain knowledge and working memory capacity. Participants with different levels of working memory capacity (low, average, or high), age (18 to 86 years, who divided into three groups: young, middle age, and older), and knowledge about the game of baseball (low vs high) listened simulated radio broadcasts for baseball games, and then they answered some questions. Their findings supported the model of Ericsson and Kintsch (1995). They found that domain knowledge was an important component of working memory according to the performance in domain-relevant cognitive tasks (Hambrick and Engle, 2002). Participants with high working memory capacity had more positive results from their previous knowledge than participants with low working memory capacity.

Working memory can be influenced by many factors. Stress is a negative mediator. It has been found that stress can reduce working memory capacity (De Quervain et al., 2000, 2003; Kuhlmann et al., 2005; Elzinga and Roelofs, 2005; Oei et al., 2006; Buchanan et al., 2006; Lupien et al., 2007; Smeets et al., 2008; Schoofs et al., 2008; Wolf, 2008). Aging has also been found to decline working memory performance (Grady et al., 1994; Verhaeghen and Salthouse, 1997; Reuter-Lorenz et al., 1999; Park et al., 2002; Bopp and Verhaeghen, 2005; Fabiani et al., 2006; Riecker et al., 2006; Passow et al., 2012; Mishra et al., 2013; Klaassen et al., 2014).

To sum up, it seems that working memory is a crucial cognitive system for information seeking behaviour and cognitive outcome. It is responsible for the attention, quality,

and quantity of information, which is going to be stored and processed during the information seeking behaviour. It is correlated with many other variables such as emotions and cognitive styles. Both sciences, Psychology and Information Science, mentioned its importance for information behaviour and performance. It is important to explore this variable in this research into this multitasking environment and relate it to other variables, trying to identify its impact on web seeking. Prior knowledge is also an important element not only for text comprehension, but also for working memory. Prior knowledge is related to working memory capacity and cognitive performance. For these reasons, this aspect was considered in the current study.

2.9.2.2 Flow

Csikszentmihalyi (1990) defined flow as a function of “skill” and “challenge”, a *state* (Csikszentmihalyi, 1990; Hoffman and Novak, 1996; Webster et al., 1993), where people are fully immersed in a feeling of involvement. Skills are the abilities of people to solve tasks, and challenge is the degree of which people find it difficult or not to solve them (Shin, 2006). It can also be characterised as, “a balanced ratio of challenges to skills” (LeFevre, 1988, p. 307). Flow has nine dimensions such as clear goal, feedback, balance of challenge and skills, concentration, focus, control, loss of self-consciousness, transformation of time, and autotelic nature (Csikszentmihalyi, 1997).

Oinas-Kukkonen (2000, p.80) presented web flow as “an optimal perceived user experience which improves a web user’s orientation and navigational use, as well as vice versa, and which is predicted by balanced user skills and the feeling of the web to be enjoyably challenging, the feeling of being in control of web use, and the perceived ease of use and usefulness of the web”. Psychological positive outcomes of flow have been investigated from both sciences. From information science, Chen et al. (2000) explored 304 web users’ opinions about flow through an open-ended questionnaire. They found that flow could be connected with positive psychological outcomes such as enjoyment, loss of self-consciousness, and awareness. In psychology, in Clarke and Haworth’s (1994) experiment 35 participants answered questions about flow in a diary when they previously received signs from a pre-programmed watch. They found that people who experienced flow in their everyday life situations scored higher in the psychological measures of wellbeing than those,

who did not experience flow. Massimini and Carli (1988) also tested Milanese teenagers for one week. They found that teenagers, who experienced flow, felt happier, creative, motivated, excited and had the control of their actions.

Flow has been found from both sciences to provoke positive task outcomes and performance on the web. From the field of education, Shin (2006) investigated students in virtual classes. The results have shown that flow is a predictor of self-satisfaction and task performance.

From the field of information science, Hoffman and Novak (1996) observed that web consumers had more positive behaviours and learning outcomes when they experienced flow. People with flow would investigate and explore more web pages and would repeatedly visit them. Novak et al. (2000) concluded that flow elements are: high levels of skill and control; high levels of challenge and arousal and focused attention; and that they are enhanced by interactivity and telepresence. Novak et al. (2003) found that flow could also be obvious in task-oriented activities. They used data from 1,312 respondents, who filled at least one of the nine surveys that conducted with the 10thWWW User Survey. This is an independent survey, which is done by the Graphic, Visualisation, and Usability Centre of Georgia Institute of Technology, and its purpose is to search for the trends on web use, user attitudes, and usage patterns.

Websites designs have been found to affect flow levels (Palmer, 2002; Newman et al., 2004; Koufaris and Hampton-Sosa, 2004; Chou et al., 2005). Internet system quality and design quality have also been investigated (Ivory and Hearst, 2002; Subramony, 2002; Luarn and Lin, 2003; Hsu and Lu, 2004; Flavian and Guinaliu, 2006). Ilsever et al. (2007) mentioned that internet systems' quality, content visibility, design quality, user's satisfaction, and user's concentration are positive factors for flow.

Finneran and Zhang (2003) constructed the PAT model (person, artefact, and task), in which these three variables are flow's antecedents in computer environments. They divided personal characteristics into: state and trait. State represents people's moods and is dynamic in contrast to trait, which represents people's personality.

People are more likely to experience flow if they have: autotelic nature, exploratory behaviour, absorption, time distortion, loss of self-consciousness, balance between skills and challenges, clear task goal, people's perception that they can use the artefact, feedbacks, and playfulness. Flow is also more likely to be obvious when the artefact has vividness and responsiveness, and when the task is autonomous, goal-directed, enables more variety, has an appropriate level of complexity, and fits with the artefact (Finneran and Zhang, 2003). This model identifies the importance of separating the task from the artefact within a computer-mediated environment (Finneran and Zhang, 2003). Artefact and task characteristics were measured.

Mills and Fullagar (2008) found a connection between flow and intrinsic motivation. They collected data from an online survey of 690 students. Ho and Kuo (2010) confirmed that flow and computer attitude have positive learning outcomes. In Van Schaik and Ling (2012)'s experiment, 114 undergraduate psychology students participated. It was a 2x2 between-subjects experimental design with variables: artefact complexity (high and low) and task complexity (high and low). Participants searched information for tasks, and at the end, they completed a flow scale. The researchers pointed out that, flow affected task performance, and task performance affected flow on task outcome.

Guo and Poole (2009) tested flow in online shopping environment. They found that flow's preconditions (feedback mechanism, challenges, skill, and clear goal) were affected by web site complexity. Skadberg and Kimmel (2004) observed flow while people browsed the web. Participants completed a survey, which measured flow factors. They noted that, when people experience flow, they tend to learn more while browsing, and as a result, they have positive outcomes.

All these experiments from both science fields have been shown that, flow is an important mediator for positive psychological outcomes and performance, when people search information on the web. It is also affected by people's, task and artefact characteristics. For this reason, this study explored in detail flow and its relationship with working memory, cognitive coordination and cognitive shifts.

Below is a figure with the variables that were investigated in this study.

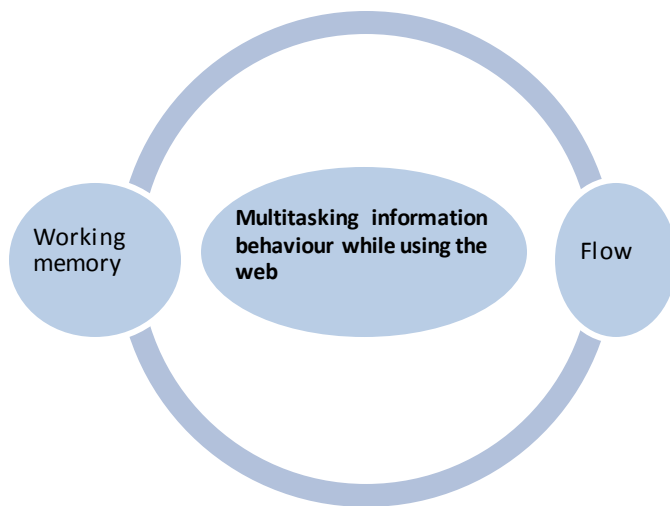


Figure 11. Variables under investigation in this study.

The purpose of this research was to form a new model of multitasking. From the previous model of Du (2010), it seems that web-seeking behaviour includes multitasking, cognitive coordination, and cognitive shifts. This research explored further this behaviour and investigated people's cognitive and psychological state variables. It investigated participants' transition steps from one coordination level to another according to their working memory and flow results, and participants' cognitive shifts were explored in-depth. It formed a more integrated model, providing an insight into how multiple and different between them aspects affect web seeking behaviour.

2.10. Preliminary Theoretical Model

A preliminary theoretical model was proposed, which indicated the relationship between multitasking while using the web, working memory and flow influenced by the PAT model.

Environmental factors were limited by providing a quiet place for the study, however, other external factors could not be eliminated e.g. there were windows in the place in which the study was conducted, noise from outside environment. Demographic factors were controlled in this research because it was intended to select participants with similar age and educational levels. Task and artefact characteristics were measured. The intention therefore was to investigate in-depth the lower part of the model, in particular, the connection between working memory, flow levels, cognitive coordination and cognitive shifts. Below is the preliminary model.

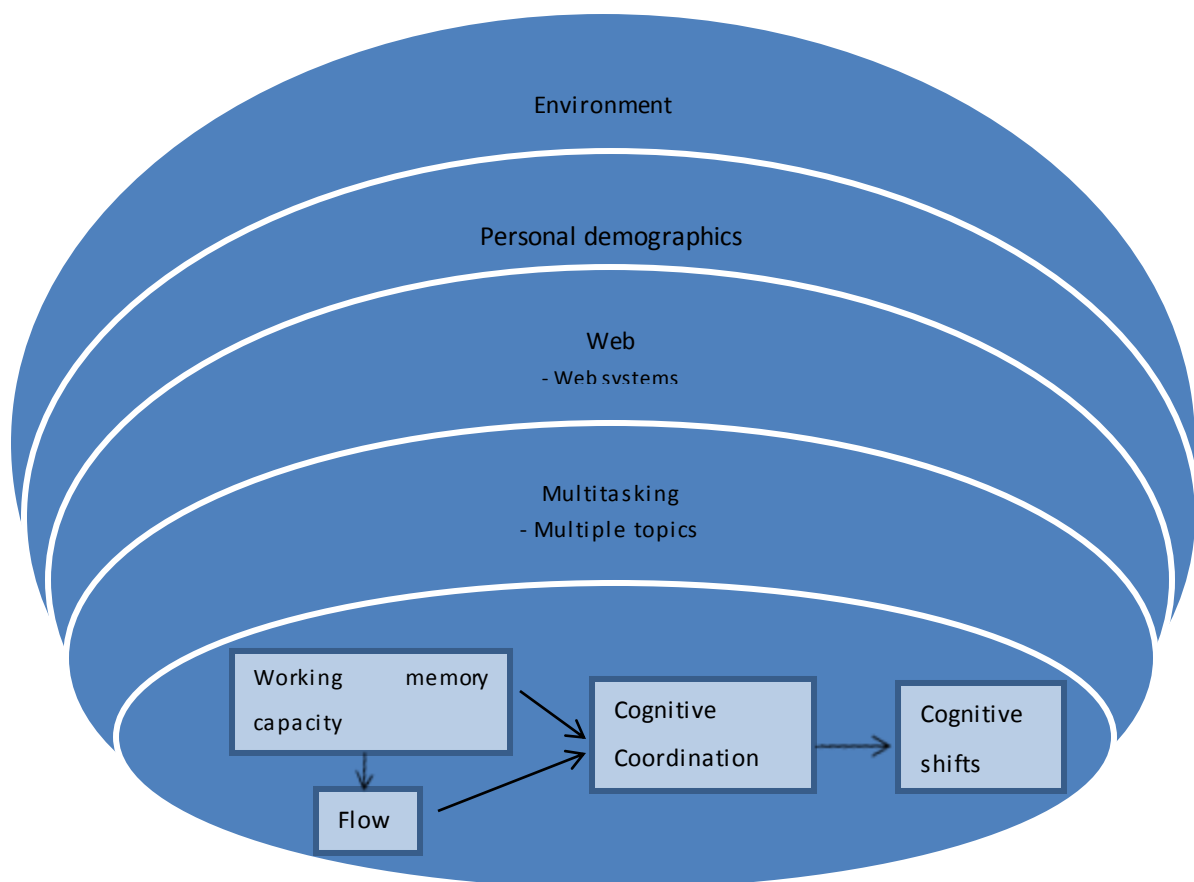


Figure 12. Preliminary model of this study.

Chapter 3 Research Methodology

3.1. Research Philosophy

Research philosophy provides the context in which the relationships between data and research methods can be explored and analysed (Collis and Hussey, 2003). The choice of research philosophy is very important because it determines which research design is the best for the study, and which research methods researchers are going to use (Easterby-Smith et al., 2008).

Easterby-Smith et al. (2008, p. 56) mentioned three reasons of why it is very important and useful to explore the philosophical issues: *“First, it can help to clarify research designs; second, knowledge of philosophy can help the researcher to recognise which designs will work and which will not; and third, it can help the researcher identify and even create designs that may be outside his or her past experience; and it may also suggest how to adapt research designs according to the constraints of different subject or knowledge structure”*.

Proctor (1998) mentioned that it is very important to connect research aims, research questions, methods, and research philosophy. There are two main research philosophies, which may lead research design and methods selection: positivism and interpretivism (Galliers, 1991; Dainty, 2007). These two research philosophies have different approaches regarding the main assumptions: epistemology, logic, and ontology of research. Epistemology describes the ways with which researchers will obtain knowledge about reality (Easterby-Smith et al., 2008). Logic is about the context of research in action. This could be either deductive or inductive. Deductive research approach moves from general ideas to specific situations. Inductive approaches are the exactly opposite (Collis and Hussey, 2003). Ontology is researchers' subjective views about the nature of reality (Easterby-Smith et al., 2008; Bititci and Ates, 2008). The following sections highlight some of the most important research philosophies.

A range of ontologies were considered. The positivist orientation was the most appropriate for this research rather than interpretivist ontologies such as associated with post positivism or constructivism.

The positivist approach is characterised by testing research questions and hypotheses from the existing knowledge and models. As Saunders et al. (2007, p.103) mentioned,

“Positivists ...use existing theory to develop hypotheses”. The basic idea of this research philosophy is that objective and single reality exists, it is independent, and it is not related to humans and can be achieved by reality observation and not by researchers’ beliefs. Researchers can obtain this objective knowledge about reality only if they observe without interfering (Comte, 1971; Denzin and Lincoln, 2011).

The main hypothesis is to diminish any subjective point of view by using statistics, mathematics, and “formal logic” (Hempel, 1965). This means that researchers may search causal relations between variables, only if they manipulate reality using one independent variable and integrate the results into an existing model or theory. Collis and Hussey (2003, p. 52) stated that, *“Positivistic approaches are founded on a belief that the study of human behaviour should be conducted in the same way as studies conducted in the natural sciences”*.

This approach is deductive. Some positivistic research methodologies are: experimental studies (in controlled and structured environments), longitudinal studies (over an extended period), and cross-sectional studies (across different groups) (Easterby-Smith et al., 2008). Alhalalat (2005) mentioned that case studies could exist as research materials in positivist approach. Positivism tries to generalise across population reflecting an objective reality and identifying causal factors (Denzin and Lincoln, 2011). Researchers identify a research topic and then they propose their hypotheses (Carson et al., 2001).

The main disadvantage of this research philosophy is that it is difficult to observe people objectively without considering their beliefs, thoughts, and attitudes. Positivists cannot explore these data. Positivist serves the idea that, reality can be explored only using the facts. For researchers who want to investigate feelings and thoughts, this is not the appropriate research philosophy (Hirschheim, 1985; Galliers, 1991; Bond, 1993; Payle, 1995).

Whereas, for the post positivists reality is not rigid and people are involved in research. This research philosophy is called post positivism because it challenges the traditional philosophy of positivism. Post positivism claims that causes may affect outcomes (Creswell, 2009). The main aim is to discover the causes that influence outcomes. It

is a reductionist philosophy because its intention is to minimise the ideas into a small number. Post positivists believe that there is an objective reality, which can be captured through observation.

Researchers start with a theory, then they collect the appropriate data, which may, or may not, support the theory, and in the end, they make revisions, which may lead to additional quantitative methods. The main idea is that absolute knowledge for the world can never been found (Creswell, 2009), and that the evidence of research is always fallible. However, researchers should be guided each time by the evidence they have gathered (Robson, 2011). Methods and conclusions should be examined in order to avoid any bias. Researchers should try to provide statements, which may explain the causal relationships and understand that socio-political factors have an influence on how knowledge is perceived. It is common for quantitative studies to use this research philosophy (Robson, 2011).

On the other hand, interpretivism indicates that only through subjective observation can reality be explored and understood. Researchers investigate variables in their natural environment. Human behaviours cannot be easily interpreted because there are inner feelings, thoughts, and attitudes, which cannot be observed, and researchers cannot give them a general meaning (Collis and Hussey, 2003). The objective reality is only one dimension of reality. There are cultural beliefs, gender and culture variables that influence reality (Proctor, 1998). A single reality cannot be fully understood because of the “hidden variables” (Denzin and Lincoln, 2011).

This research philosophy assumes that, people influence reality and give to it personal meanings. Under this perspective, there can be many realities (Denzin and Lincoln, 2003). Researchers try to interpret these multiple reality meanings, which may lead to investigation of people’s personal experience (Hatch and Cunliffe, 2006; Saunders et al., 2007). It is very important to explore people’s feelings and inner thoughts and emphasize people’s points of view (Eriksson and Kovalainen, 2008).

The main qualitative research methods which used in this type of research philosophy, are: case study, action research (researchers involve and influence the study), ethnography (participants’ observation), participative enquiry (participants’ active

involvement within their own group), feminist perspectives (researchers focus on female), and grounded theory (build a theory from data) (Collis and Hussey, 2003).

The main limitation of this research philosophy is the qualitative methods. Mays and Pope (1995, p.109) stated that, *“qualitative research is merely an assembly of anecdote and personal impressions, strongly subject to researcher bias; secondly, it is argued that qualitative research lacks reproducibility – the research is so personal to the researcher that there is no guarantee that a different researcher would not come to radically different conclusions; and, finally, qualitative research is criticised for lacking generalisability”*.

The main purpose of post modernists is to examine the complexities of social interactions rather than provide explanations (Robson, 2011). As Lather (1991, p. 21) mentioned, *“Philosophically speaking, the essence of the postmodern argument is that the dualisms which continue to dominate Western thought are inadequate for understanding a world of multiple causes and effects interacting in complex and non-linear ways, all of which are rooted in a limitless array of historical and cultural specificities”*.

Post modernists believe that truth cannot be discovered by using natural science methods. People are conscious and give multiple meanings to reality. People’s behaviour is dependable on those meanings and beliefs. For that reason, researchers should interpret and analyse these behaviours (Robson, 2011).

Post modernism is used in qualitative methods because it tries to analyse people’s beliefs and subjective experiences through multiple theoretical positions. Jameson (1988, p. 121) said that, *“There is something quite naïve, in a sense quite profoundly unrealistic, and in the full sense of the word ideological, about the notion that reality is out there simply, quite objective and independent of us, and that knowing it involves the relatively unproblematic process of getting an adequate picture of it into our own heads”*.

The main aim is to reveal the truth. Scheurich (1997, p. 66) said that, “*the modernist assumption that there is a reality out there that the researcher can accurately capture or represent, given the use of improved research methods, is a great challenge*”.

Finally, social constructivist is used in qualitative approaches. It has been developed by Berger and Luekmann (1967), Lincoln and Guba (1985), Crotty (1998) and Neuman (2000). Social constructivists believe that people try to understand the world. They give to it multiple subjective meanings, which researchers try to identify. Researchers also focus on specific social and historical contexts and try to understand them (Creswell, 2009).

Researchers know that their own backgrounds may influence the interpretation of results and so they put themselves into research in order to understand how their subjective interpretation flows from their experiences. The aim is to develop inductively a new theory (Creswell, 2009).

3.1.1. Research Philosophy for this Study

Primarily this research was based on the positivist orientation. It was believed that there is a single truth and a research topic was proposed with the appropriate hypotheses. The main aim of this research was to explore and investigate causal relationships and consequences of personal variables in conjunction with cognitive coordination levels, cognitive shift levels, task, and artefact characteristics during multitasking while using the web. In particular, the relationships between working memory, flow and multitasking information behaviour were investigated.

Methodologically, a mixed methods approach was used combining qualitative and quantitative data to discover the phenomenon which was investigated. The quantitative data helped to reveal relations between variables in a positivistic way whereas the qualitative data gave an insight of what people thought to some extent. Some qualitative data such as people’s verbal thoughts were quantified to some extent to provide cognitive state categories.

3.2. Research Design

Burns and Grove (2003, p.195) mentioned that, “*a research design is a blueprint for conducting a study with maximum control over factors that may interfere with the validity of the findings*”. Polit et al. (2001, p.167) stated that, “*a research design is the researcher’s overall for answering the research question or testing the research hypothesis*”.

Research design involves the methods and the strategies with which the data of a study are collected. Research design involves three types of design: qualitative, quantitative or mixed methods. Qualitative research designs are inductive and try to explore and observe the world through case studies, ethnography (participants’ observation), participative enquiry, and grounded theory (Collis and Hussey, 2003). Below is a brief description of the two most important qualitative strategies: case studies and grounded theory.

According to Merriam (1988), a case study technique, which is used in qualitative method design, gives to researchers the opportunity to focus and understand in-depth behaviours in an only person. With this technique, researchers are able to use multiple ways of data collection such as diaries, observation, interviews, and many other quantitative or qualitative techniques. Case study is an approach which offers to researchers the ability to explore a phenomenon in-depth gathering data from multiple sources. Under this perspective, the phenomenon can be understood better considering all the aspects and not only one.

Glaser and Strauss (1967) discovered grounded theory. Glaser and Strauss (1967, p. 2) defined grounded theory as, “*the discovery of theory from data systematically obtained from social research*”. It is used in qualitative method design and through the interplay of data and theory; a new theory can be developed. This is an inductive procedure because the emergent data are continuously correlated with previous data until associative patterns emerge (Glaser and Strauss, 1967). It is an appropriate method for exploring social relationships and provides understanding for factors, which have been previously little explored (Crooks, 2001).

On the other hand, quantitative designs are deductive and try to examine the relationships between variables. These designs involve tests, experiments or surveys, trying to generalise research's results by avoiding researcher's personal beliefs and bias (Lincoln and Guba, 1985).

Survey methods, for example, are used in quantitative method designs and includes cross sectional and longitudinal studies with questionnaires or structured interviews. The intention is to generalize the results from a sample to a population (Creswell, 2009). Surveys are used in positivism in order to achieve systematic observation and consistency (Bititci and Ates, 2008).

Experimental research, which is used in quantitative method design, tries to define if a specific treatment can influence an outcome (Creswell, 2009). Researchers provide a treatment to one group only, and then explore both groups' outcomes. Experiments can be either true, if a researcher randomly assigns participants to treatment conditions, or quasi, when researchers do not use random assignments (Creswell, 2009). There is also the non-experimental strategy, which is the same as the experimental research, but in this situation, researchers do not aim to change the outcome with a treatment (Robson, 2011).

Mixed methods research combines both qualitative and quantitative designs. It uses both types of data. It aims to explore a phenomenon and overcomes the weaknesses of each design separately (Creswell, 2009). This research design may be sequential, transformative or concurrent. In the following section, the mixed methods design is discussed in detail. Phillips (1976, p. 93) stated that, "*The research design constitutes the blue-print for collection, measurement and analysis of data. It aids the scientist in allocation of his limited resources by posing crucial choices: Is the blueprint to include experiments, interviews, observations, and the analysis of records, simulation, or some combination of these? Are the methods of data collection and research situation to be highly structured? Is an intensive study of a small sample more effective than a less intensive study of a large sample? Should the analysis be primarily qualitative or quantitative?*". Below is a table from Creswell (2009), in which the basic characteristics of each research approach are described.

Qualitative, Quantitative, and Mixed Methods Approaches			
Tend to or Typically...	Qualitative Approaches	Quantitative Approaches	Mixed Methods Approaches
Use these philosophical assumptions	Constructivist, advocacy/participatory knowledge claims	Post-positivist knowledge claims	Pragmatic knowledge claims
Employ these strategies of enquiry	Phenomenology, grounded theory, case study, ethnography and narrative	Surveys and experiments	-Sequential, -Concurrent -Transformative
Employ these methods	Open-ended questions, emerging approaches, text or image data	Close-ended questions, numeric data, predetermined approaches	Both open and close ended questions, both approaches, and both qualitative and quantitative data and analysis
Use these practises of research as the researcher	<ul style="list-style-type: none"> -Positions him or herself/engaging himself or herself -Collect participants' meanings -Focuses on a single phenomenon -Brings personal values into a study -Studies the context of participants -Validates the accuracy of findings -Makes representations of the data -Creates agenda for change or reform -Collaborates with the participants 	<ul style="list-style-type: none"> -Tests or verifies theories or explanations -Identifies variables to study -Relates variables in questions or hypotheses -Uses standards of validity and reliability -Observes and measures information numerically -Uses unbiased approaches -Employs statistical procedures 	<ul style="list-style-type: none"> -Collects both quantitative and qualitative data -Develops a rationale for mixing Integrates the data at different stages of inquiry -Presents visual pictures of the procedures in the study -Employs the practices of both qualitative and quantitative research

Table 2. Qualitative, quantitative, and mixed methods approaches (Creswell, 2009, p.17).

3.2.1. Research Design of this Study

Qualitative methods are emerging methods using qualitative data, which are analysed through themes and patterns interpretations as well as text and image analysis (Creswell, 2009). On the other hand, quantitative methods are predetermined and use statistical analysis and interpretation. Mixed methods are a combination of these two methods using statistical and text analysis and across databases interpretation (Creswell, 2009). Johnson and Onwuegbuzie (2004, p. 17) offer a similar definition, "*mixed methods research is formally defined here as the class of research where the researcher mixes or combines quantitative and qualitative research techniques, methods, approaches, concepts or language into a single study.*"

There are certain types of research problems that need specific research methods. For example, when a research topic is about the identification of the variables that influence an outcome or about the understanding of the results of an intervention and the presumed outcomes, then quantitative approach is the most suitable. If the research problem needs to be explored in-depth because there is very little evidence in this research area, then qualitative method is more useful through its exploratory character. Mixed methods can be used, when researchers want to use both qualitative and quantitative methods. These methods absorb more time for analysing qualitative and quantitative data, and researchers should be familiar with both forms of research (qualitative and quantitative) (Creswell, 2009).

This study used a mixed methods research design. It used theory either deductively (quantitative research) or inductively (qualitative research). It investigated cognitive (working memory) and personal state (flow) variables. The researcher, using quantitative methods, explored the relationships between these variables. The results from the quantitative data were then compared to the results from the qualitative data and used to develop an integrated framework. This research used both the strengths of qualitative and quantitative methods in order to explore in-depth multitasking information behaviour while using the web.

This study also used a mixed methods pilot study. During the pilot study, the researcher discovered one problem regarding the pre-interview, which was resolved (see page 105). Pilot studies can be used to better perform well-grounded knowledge

development and build theory that is more tangible. Through pilot studies, researchers can obtain contextual sensitivity. They may also be more aware of the dynamic relationships between research variables (Baptista Nunes et al., 2010).

Pilot studies have been defined as the small studies before the main experiment, which are "*small scale version[s], or trial run[s], done in preparation for the major study*" (Polit et al., 2001, p. 467). The purpose is to collect background information, define a research approach, and conclude to efficient research instruments. Researchers can limit any problems that may arise during the research (Baptista Nunes et al., 2010). De Vaus (1993, p. 54) stated, "*Do not take the risk. Pilot test first*". Pilot studies can bring to surface any disabilities of the research method or materials. Through pilot studies, researchers can test their materials such as questionnaires and tests and decide if they are going to use them or if they have to make any essential corrections. Researchers then change any problematic situation and reform any questions, so as in the main study to use the most appropriate tools. It is very important for researchers to pilot their questions (Plowright, 2011). This research used pre and post questionnaires in order to identify people's cognitive shifts. Therefore, it was important to pre-test these questionnaires in order to eliminate possible problems. Sampson (2004, p. 399) also mentioned the fact that it is, "*often only when data is evaluated that any gaps in a research design begin to show up, hence a running a pilot can save time invested in unfeasible projects, particularly in the context of today's social science, which is frequently strictly time-bounded and pressurized*".

Baker (1994) mentioned that the appropriate sample size for the pilot studies should be the 10 -20 % of the sample size for the main experiment. In this research, four participants took part in the pilot study. Participants' total number for the main experiment was 30. Therefore, the number of participants was considered to be sufficient.

3.3. Planning Mixed Methods Procedures

Mixed methods are characterised by four important factors: timing, weighting, mixing and theorising (Creswell, 2009).

- **Timing:** Researchers have to consider, which data will be collected first: either the qualitative or the quantitative. They also need to decide whether this collection could be sequential or concurrently. When the data are gathered the same time, both qualitative and quantitative data are collected concurrently. When qualitative data are collected first, this means that researchers try to investigate a topic and then generalise these data to a larger sample. The sequential option depends on researchers' intentions (Creswell, 2009).
- **Weighting:** Researchers may emphasize qualitative aspects more than quantitative data or the weighting could be equal. This depends on researchers' interests about what they want to investigate (Creswell, 2009). If researchers want to investigate any possible relationships between variables, they will use quantitative data. If they want to explore a phenomenon, then they will use qualitative data.
- **Mixing:** Researchers could mix qualitative and quantitative data at the end of the research or may connect and compare them between two phases. The mixing is "connecting" when both data are collected and correlated between two phases. If data are collected the same time, and researchers merge the qualitative with the quantitative data, then this is the integrating mixing. The other type is the embedding mixing, in which researchers use only one type of data and have the other type only for supporting information (Creswell, 2009). For example, researchers can use quantitative data for their experiments and only a few qualitative data in order to support the findings from the quantitative data.
- **Theorising:** If researchers base their studies on a previous framework, then the theories that will be developed can be either explicit or implicit (Creswell, 2009). When researchers use either qualitative or quantitative data, they are based on a theoretical framework. When researchers use mixed methods, then the choice of the theoretical framework may be more difficult because it depends on researchers' preference of qualitative or quantitative point of view.

Timing	Weighting	Mixing	Theorizing
No sequence Concurrent	Equal	Integrating	Explicit
Sequential-Qualitative first	Qualitative	Connecting	Implicit
Sequential-Quantitative first	Quantitative	Embedding	

Figure 13. Aspects to consider in planning a mixed methods design (Creswell et al., 2003).

In addition to these four factors, which help to organise the procedures in a mixed methods research, there are several mixed methods types, which describe how researchers collect their data. According to Tashakkori and Teddlie (1998), Morse (1991), and Creswell and Plano Clark (2007), there could be six types:

- **Sequential explanatory strategy:** quantitative data are collected and analysed first. The qualitative data follow, trying to support the results from the quantitative data. The aim is to explain quantitative results by using interviews in order to understand better the results. As Creswell (2009, p. 211) mentioned, *“Weight typically is given to the quantitative data and the mixing of the data occurs when the initial quantitative results informs the secondary qualitative data collection”*.
- **Sequential exploratory strategy:** qualitative data are collected and analysed first followed by the collection and analysis of the quantitative data. *“The purpose of this strategy is to use quantitative data and results to assist in the interpretation of the qualitative findings...the primary focus of this model is to initially explore a phenomenon”* (Creswell, 2009, p. 211). Creswell (2009, p. 212) also stated, *“This model is especially advantageous when a researcher is building a new instrument..it is useful to a researcher who wants to explore a phenomenon”*.
- **Sequential transformative strategy:** this mixed methods type could start either with the qualitative or quantitative data depending on researchers’ intentions.

- **Concurrent triangulation strategy:** researchers collect both qualitative and quantitative data concurrently and then compare their results.
- **Concurrent embedded strategy:** researchers start with the primary data. The other type of data is embedded into them. The primary data serve one type of research question, and the secondary type of data answer other types of research questions, which may provide information to the primary research question.
- **Concurrent transformative strategy:** this is a mixed method type, which uses characteristics from both concurrent triangulation strategy and concurrent embedded strategy. Researchers use as guideline a model or framework, which is the basis. According to this model, data will be divided to primary or not.

This study used the sequential exploratory strategy. The weight was given to the qualitative data followed “*by a quantitative data collection and analysis that builds on the results of the qualitative phase*” (Creswell, 2009, p. 211). The quantitative data “*assisted in the interpretation of the qualitative findings*” (Creswell, 2009, p. 211). The aim of this research was to explore a phenomenon, the multitasking information behaviour on the web in conjunction with psychological variables as well as task and artefact characteristics, and build a new model highlighting the underlying cognitive procedures of this behaviour.

3.4. Research Methods of this Study

Frey et al. (1991) mentioned that research methods are the strategies, which researchers use in order to gather the necessary information and data for building and testing theories. As Creswell (2009, p. 15) said, “*Research methods involve the forms of data collection, analysis, and interpretation that researchers propose for their studies*”.

There are multiple ways to collect data and information. Researchers have to consider research methods in the light of the “*degree of predetermined nature, their use of closed-ended versus open-ended questioning, and their focus on numeric nonnumeric data analysis*” (Creswell, 2009, p. 15).

The combination of multiple data material is called triangulation, which means the use of different strategies to approach the same topic of investigation. Researchers may use multiple research methods in order to investigate the under exploration phenomenon. Many researchers have used several research instruments in their studies, trying to cross correlate their results and enhance the reliability and validity of them (Saracevic et al., 1990; Byström, 1999; Wang et al., 2000; Ingwersen and Järvelin, 2005; Du and Spink, 2011).

People's information behaviour is a multidimensional procedure, which involves several characteristics. For this reason, it is important to use various research methods in order to capture as much information as possible.

In this study, a combination of multiple quantitative and qualitative data was used. The quantitative data were:

- Pre and post questionnaires with close-ended questions.
- Automated Operation Span Task (Unsworth et al., 2005).
- Flow State Scale of 36 items (Jackson and Marsh, 1996).
- Web search logs.

The qualitative data were:

- Pre and post questionnaires with open ended questions.
- Pre-interview.
- Observations.
- Think-aloud protocols.
- Audio-visual data.
- Critical Decision interview.

3.5. Data Collection Procedure

Thirty University students participated; 10 psychologists, 10 accountants and 10 mechanical engineers. The procedure went through the ethical approval process. The data collection tools used were: pre and post questionnaires, a pre-interview, a

working memory test, a flow state scale test, audio-visual data, web search logs, think aloud data, observation, and the critical decision method. The research had two phases. In the first phase, 34 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 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 two broad categories for each discipline, which each one involved two topics: two for which participants had prior knowledge and two for which participants had no or little prior knowledge. All participants searched information on the web for four topics: two for which they had prior knowledge and two more without prior knowledge.

3.5.1. Time Constraints

Time is an important mediator for information retrieving and seeking process. It influences users' concentration, choices about strategies, outcome and performance. People may choose different seeking strategies when they feel that they are under time pressure (Kuhlthau, 2004). Slone (2007) mentioned that people might not get the appropriate information they want when they are under time pressure.

In this study, time constraints was measured. Participants had one hour to seek information for the four information problems. In the previous study of Du (2010), participants had one hour to solve three information problems. However, she did not find any correlation between time constraint and information seeking. For this reason, in this study, participants had the same time for more information topics in order to examine this variable.

The results might provide insights about information seeking patterns, the reasons why people switched between different information topics, and the reasons why they chose specific strategies. Each participant might have different reactions under time pressure.

the topic in the lists that was more related to it. Therefore, the pre-presented lists of topics helped the researcher with their categorisation.

These pre-interviews determined the four information topics that participants searched on the web in the main experiment.

3.5.3. Study Participants

This study was exploratory, and hence 34 participants were initially chosen for this research in order to explore the study objectives and propose a model. This reduced to 30 participants because four were not able to meet the 85% accuracy criterion of the working memory test. This number was regarded to be appropriate for qualitative and quantitative studies.

The experiment was conducted in Greece and in the UK. Thirty Greek University students participated; 10 psychologists and 10 accountants from Greece, and 10 mechanical engineers from UK. In order to recruit participants, several methods were used. The researcher approached the professors of the City University of Seattle in Greece four months prior the experimental phase to describe the purpose and the procedures of the research and to ask for permission to recruit participants. Then, the professors informed the undergraduate and postgraduate students of the Department of Psychology about the experiment. The researcher also sent emails to postgraduate research students from the School of Science and the Department of Information Science at Loughborough University, describing the study and asking for potential participants. There was a lunch as a reward for each student at the end of the main experiment. Appendix A provides a copy of request for participation in the research.

3.5.4. Information Topics

This research investigated multitasking information behaviour while using the web in conjunction with working memory capacity levels. It is important to consider participants' prior knowledge of the topics. The researcher conducted short pre-interviews where participants chose from two lists several topics about their discipline that they would like to search on the web and for which they had firstly, prior knowledge and secondly, no or little prior knowledge. Then, the researcher developed two broad

categories from the participants' answers, which each one involved two topics: two topics with prior knowledge and two topics with little or no prior knowledge.

Enabling the participants to choose the information problems, made the experiment more realistic than if the researcher chose for them. Moreover, if the researcher chose the topics, then it would be an important issue about participants' motivation and levels of flow. The experiment would lack reality, and the study would not be naturalistic. In this study, the aim was to explore realistically how users seek information on the web and provide insights about multitasking information behaviour while using the web.

There were no treatment or control of how participants had to find information on the web or which web systems and web sites they chose. The aim was to observe the information seeking patterns. Questionnaires, interviews, and web logs were used to gather information about cognitive shifts and cognitive coordination levels as well as task and artefact characteristics. According to the PAT model (Finneran and Zhang, 2003), people are more likely to experience flow if they have goal directed tasks in contrast to web browsing. In this study, the researcher guided participants to search for four information problems rather than browse generally on the web. Moreover, when people are free to choose the information seeking strategies, they are able to experience flow. In this study, participants were advised to follow any strategy they want in order to find the wanted information.

Participants were able to follow any possible pattern and use any source in order to solve the topics. Finneran and Zhang (2003) mentioned that task complexity might have positive or negative influence on flow. A complex task could lead to high levels of flow because it engages many challenges. On the other hand, a high complex task could also lead to high levels of anxiety. In this study, the researcher analysed at the beginning and at the end of the experiment the task levels of complexity. Before the experiment, participants were asked in the pre questionnaires about each task's level of complexity, and at the end in the post questionnaires, they were asked again about how complex or not each task was after the information seeking.

An artefact must have telepresence, an essential component for better interaction between users and systems. Telepresence characteristics are vividness and

responsiveness. Vividness involves image, audio, video, experiential, or a combination of all these factors and responsiveness is the speed of an information system. If the speed is too low, the flow will also be low (Finneran and Zhang, 2003). After the experiment, participants provided details about how vivid or not each web search engine was and about the web system's responsiveness.

3.5.5. Automated Operation Span Task (Unsworth et al., 2005)

As mentioned previously in the literature review, working memory capacity (WMC) is related to reasoning ability and fluid intelligence. Moreover, WMC different levels indicate people's individual differences in difficult and complex cognitive activities such as text comprehension, arithmetic or learning of complex skills. People's individual differences in WMC have also related to the control of cognitive processes (Lewandowsky et al., 2010).

Working memory tests use the complex-span paradigm. Complex-span tasks procedure is about interleaving a memory component (for example participants have to remember a set of items in the order of presentation) with a secondary processing task (to judge if the equations are correct) (Lewandowsky et al., 2010).

The automated operation span (AOSpan) is a computer-administered operation span task. In the AOSpan, participants are asked to solve simple maths problems while trying to remember characters. In the first phase, participants familiarised with the characters (Unsworth et al., 2005). A character appeared on the screen, and participants were required to recall the characters in the same order in which they were presented. After the presentations, a matrix was appeared with 12 possible characters. Participants were required to choose the right characters, which were presented earlier in the right order. This recall phase was untimed. After the characters' recall, the computer provided feedback about the number of characters that recalled correctly (Unsworth et al., 2005).

In the second phase, the participants familiarised themselves with the mathematics portion of the task. They were required to solve simple maths problems. Participants were asked to solve the problems as quickly and as accurately as possible. When participants had completed the problem, they clicked the mouse (Unsworth et al.,

2005). On the next screen a digit, which might be the possible answer, appeared. Below there were two boxes: true or false. Participants had to either click the mouse in the true box, if they thought the answer was correct or click in the false box if the answer was false. Participants completed 15 practise trials. At the end of these trials, participants' mean response time was computed. This time limit was used in the main experiment in order for participants to solve the maths operations (Unsworth et al., 2005).

In the third, participants performed both the characters' recall and the maths problems. Each math problem was followed by a brief presentation of a character. Three to seven math problems-character pairs were presented per set. Initially, the participants completed three practice trials. Then they were instructed to solve the maths problems and remember the characters. The aim was to solve the maths problems as quickly and as accurately as possible within 15 to 20 minutes.

At the end, the program indicated five results: total Ospan score, total number correct, maths errors, speed errors, and accuracy errors. The total Ospan score was the perfectly recalled sets. The total number correct was the total number of the characters, which were recalled in the correct order. The math errors were the total number of task errors. The speed errors referred to when participants ran out of time. The accuracy errors were errors depending on the maths operations (Unsworth et al., 2005).

The AOSpan has both good internal consistency (alpha .78) and test–retest reliability (.83). It is valid and easily conducted in laboratory settings. This test is a valid measurement of working memory capacity, and it has been used widely in multiple experiments (DeCaro et al., 2008; Blair et al., 2009; Johnson and Gronlund, 2009; Clarkson et al., 2011; Youmans et al., 2011; Weitz et al., 2011; Banas and Sanchez, 2011; Hayes et al., 2012).

Participants took this test in the first phase. The researcher analysed participants' results and kept for the main experiment only those participants, who met the 85% accuracy criterion. The results from these tests were related to web seeking patterns,

cognitive coordination and its levels, and cognitive shifts and its levels. These results were also related to flow results.

3.5.6. Flow State Scale (Jackson and Marsh, 1996)

Flow has nine dimensions: clear goal, feedback, balance of challenge and skills, concentration, focus, control, loss of self-consciousness, transformation of time, and autotelic nature (Csikszentmihalyi, 1997). Flow positively influences psychological outcome, task outcomes, and performance during web searching.

The nine dimensions of flow experience was measured using Jackson and Marsh's (1996) 36-item Flow State Scale (FSS). This instrument is the most appropriate for measuring flow because it is comprehensive, and its reliability and validity have been tested (Tenenbaum et al., 1999; Davis and Wiedenbeck, 2001; Novak et al., 2003). There are 36 questions. Response options are given on a 5-point Likert scale from 1 (strongly disagree) to 5 (strongly agree). These questions involve participants' experiences about how they felt and what they thought when they searched information using the web. There are no right or wrong answers. The average reliability of the 36-item FSS is $M = 0.83$, and the internal consistency coefficients for all the subscales are satisfactory ($\alpha > .70$) (Jackson and Marsh, 1996).

Participants completed this test at the end of the experiment. The results from this test were related to web seeking patterns, cognitive coordination, and cognitive shifts levels of each participant according to his/her working memory results.

3.5.7. Pre and Post Questionnaires

Pre and post questionnaires provided many details and information about participants' background. In this study, pre-questionnaires developed in order to gather information about participants' age, gender, affiliation, student status, and web experience. The pre questionnaires involved open-ended and close-ended questions. The open-ended questions also helped the researcher to identify the nature of the information problems and their complexity.

In order to capture people's change of knowledge, the researcher used multiple questions. According to Saracevic's Stratified Model (1996), users and computers

have their own elements while interacting. User characteristics have three levels: the cognitive, affective, and situational. The cognitive level incorporates people's cognitive processes and results such as relevance inferences or changes in the state of knowledge. Questions about people's change of knowledge were involved in the pre and post questionnaires. The affective level maintains peoples' intentions, beliefs, feelings, and motivations. There were questions about peoples' intentions and feelings before and after the search. The situational level is about how people judge each problem according to its utility (Saracevic, 1996). There also were questions about how people order and switch between the problems. There also were similar questions in the critical decision interview.

In order to identify people's holistic changes of knowledge, in the pre-questionnaires there were questions about people's depth of knowledge for each information topic and people's degree of becoming informed for each topic.

Post questionnaires helped the researcher to identify participants' cognitive shifts. There were questions about each task's level of complexity, each web search engines characteristics (vividness and responsiveness), the order of the information topics, and the reasons for switching between them. In order to identify people's holistic changes of knowledge, in the post-questionnaires there were questions about people's depth of knowledge for each information topic after the information seeking process, people's degree of becoming informed for each topic after the information seeking process and people's degree of change of knowledge for each topic. There also were questions about: peoples' intentions, and feelings.

The post questionnaire also incorporated the Short Subjective Instrument (SSI). This was a 7- point Likert scale, which measured the cognitive load. It is subjective, reliable, valid, sensitive to small changes, and an unintrusive technique, which can indicate people's cognitive load (Gopher and Braune, 1984; Paas et al., 1994; Gimino, 2002). High cognitive load might affect people's performance as well as cognitive coordination and cognitive shifts levels. These relationships were investigated.

The pre and post questionnaires helped the researcher to identify possible similarities or differences between thoughts and changes of knowledge for each participant

according to his/her working memory results before and after the information seeking behaviour. These results were analysed and compared to the results from other research methods. The researcher identified what cognitive coordination, cognitive shifts, and flow levels each participant had according to his/her working memory results.

3.5.8. Think-Aloud Protocols

In this methodology, participants have to verbalise aloud their thoughts while undertaking a specific task. The Think Aloud Method has been used widely in psychology and information science field. This process enlightens the cognitive procedures, information seeking strategies, and reasoning (Smith, 2006; Du and Spink, 2011). From the psychology field many researchers have used this method in Cognitive Psychology (Crutcher 1994), Behaviour Analysis (Austin and Delaney 1998), and Cognitive Science (Simon and Kaplan, 1989).

The Think Aloud Method has been approved as a valid method for identifying mental and cognitive procedures in real time while people perform a complicate task (Eriksson and Simon, 1993). Spink et al. (2006) used think aloud data while participants searched on the web. Yang (1997) also used this method in order to investigate users' information seeking patterns.

This method is valuable because it provides information in real time, and it is accurate, however, it has disadvantages. The disadvantages of this method are that participants may not verbalize their real feelings or thoughts because they are not able to identify each feeling or thought or because they do not know how to do that. This may lead to not reliable and validate results (Ingwersen, 1992). Verbal protocols may also reflect the results of the cognitive process and not the cognitive process itself (Eriksson and Simon, 1993).

Branch (2000) mentioned that, it is difficult for participants to perform a task and speak at the same time. However, this problem can be solved by using retrospective data. Branch (2000) and Fonteyn et al. (1993) stated that asking subjects questions about the cognitive process at the end of the experiment may provide valuable information that make think aloud data easier to understand and interpret.

Despite the disadvantages, think aloud data provided rich information about participants' cognitive procedures. Moreover, these disadvantages were diminished with post questionnaires and interviews, which were used in this study.

In this study, participants were asked to verbalize their thoughts and feelings. The main purpose was to give rich data about information seeking behaviour. The Think Aloud Method was used in combination with other research materials such as post questionnaires, observations, interviews, and web analytics in order to diminish the disadvantage of this tool. It provided details about participants' cognitive coordination, cognitive shifts, and flow levels.

3.5.9. Web Search Logs

Web search logs have been used widely in order to give additional insights about participants' actions and strategies (Wang et al., 2000; Jansen and Pooch, 2000; Spink et al., 2006; Du and Spink, 2011). In this study, the Camtasia Studio software captured participants' seeking behaviours. This software gave the opportunity to capture participants' web seeking patterns, participants' time on each web page, and pages' sequence. It recorded participants' actions, movements, and voices. These qualitative audio-visual data were analysed and compared to the think aloud and observational data. The aim was to better understand information seeking behaviour. Camtasia Studio software is the best method for capturing all these data providing reliability and avoiding human bias (Goodwin, 2005).

3.5.10. Observations

Gorman and Clayton (2005) defined observation as a method which "*involves the systematic recording of observable phenomena or behaviour in a natural setting*" (p. 40). Direct observation allows researchers to collect data in real time, in a specific environment, and in a specific time without participating (Spink, 2004). This procedure may provide important information as well as affect researchers' objectiveness (Adler and Adler, 1994). It may be difficult and participants may need more time to behave naturally, when they know that they will be observed, but this method allows observers to concentrate and gather more data (Krathwohl, 1997; Du and Spink, 2011). One strategy to improve validity of this method is to include participants' feedback and the use of "low inference descriptors" (Adler and Adler, 1994). Another important variable

is time. It is important for researchers to have "*prolonged, personal contact with events in a natural setting*" (Chatman, 1984, p. 426). It is necessary for researchers to "*gain at least a comfortable degree of rapport, even intimacy, with the people, situation, and settings of research*" (Jorgensen, 1989, p. 21).

In this study, the researcher observed participants while they sought information on the web. The observer was not involved in the information seeking process and adopted a low profile. The aim was to compare the data from the observation to the think aloud and audio-visual data. The researcher was able to identify, in real time, the participants' actions.

3.5.11. Critical Decision Method (CDM)

The Critical Decision Method (CDM) is a semi-structured interview technique, with which researchers can gather information about participants' decisions when they performed their tasks. As Horberry and Cooke (2010, p. 11) said, "*The Critical Decision Method (CDM) is a structured interview process that can be used to elicit information and knowledge from experienced operators about their decision-making, understanding and problem solving processes during non-routine critical incidents*".

In this technique, there are specific questions, which help researchers to obtain detailed data about each phase of the experiment. These questions follow participant's actions, trying to reconstruct the experiment and identify details that even participants could not mention. This type of interview is used mostly for non-routine or difficult incidents, providing comprehensive points of view from participants' perspectives (Hutchins et al., 2004).

The main questions that this technique tries to answer are: *what, how, and why*. What actions have been taken, how and which strategies people used, and why they chose these particular strategies. Participants must find and select an incident. This incident has to be the most challenging and difficult. For this reason, a brief review of previous incidents may be required. Then, participants describe the whole incident from the beginning to the end. Then, researchers repeat the incident again, matching participants' terminology of incident, content, and sequence. Participants have to attend in order to provide any details, clarifications, and corrections. Then, participants

repeat one more time the incident providing a possible timeline (Crandall et al., 2006). Participants make a timeline of the incident, describing specific actions, decisions, and strategies. The next step is for researchers to understand the participants' actions. In this stage, more deepening questions are required about the participants' thoughts and feelings. These are the probe questions (Klein et al., 1989; Hoffman et al., 1995). Finally, there are the "What if" questions. Researchers ask participants if they would like to change any action (Horberry and Cooke, 2010). Below is a table with the probe questions (Klein et al., 1989).

Probe Type	Probe Content
Cues	What were you seeing, hearing, smelling?
Knowledge	What information did you use in making this decision and how was it obtained?
Analogues	Were you reminded of any previous experience?
Standard scenarios	Does this case fit a standard or typical scenario? Does it fit a scenario you were trained to deal with?
Goals	What were your specific goals and objectives at the time?
Options	What other courses of action were considered or were available?
Basis of choice	How was this option selected/other options rejected? What rule was being followed?
Mental modeling	Did you imagine the possible consequences of this action? Did you imagine the events that would unfold?
Experience	What specific training or experience was necessary or helpful in making this decision? What training, knowledge, or information might have helped?
Decision making	How much time pressure was involved in making this decision? How long did it take to actually make this decision?
Aiding	If the decision was not the best, what training, knowledge, or information could have helped?
Situation assessment	If you were asked to describe the situation to a relief officer at this point, how would you summarize the situation?
Errors	What mistakes are likely at this point? Did you acknowledge if your situation assessment or option selection were incorrect? How might a novice have behaved differently?
Hypotheticals	If a key feature of the situation had been different, what difference would it have made in your decision?

Table 3. Sample of CDM probe questions (Klein et. al., 1989).

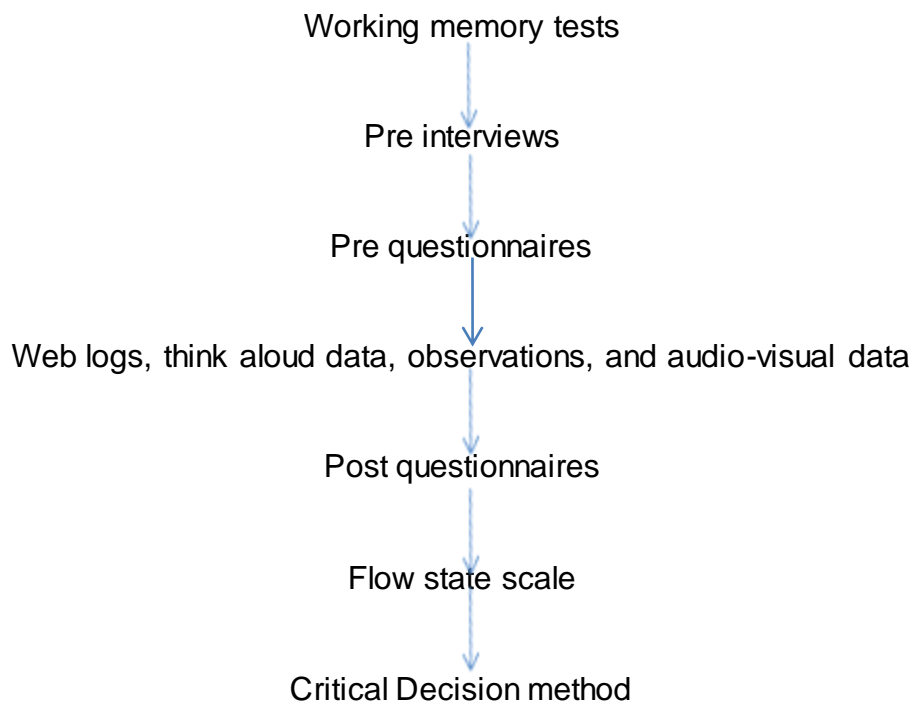
Du (2010) identified the levels of cognitive coordination (coordination of tasks, strategies, and mechanisms) using only the data from the think aloud method and the utterance search segments (web search logs). Cognitive shifts of knowledge were investigated through the pre and post questionnaires. She used a 5-point Likert scale

in the pre and post questionnaires in order to identify the holistic cognitive shifts of knowledge. Cognitive state shifts were explored through the web search logs analysis.

The cognitive coordination and cognitive shifts levels of knowledge in this study were measured by the think aloud method, the pre and post questionnaires, the web search log analysis, and the Critical Decision Method. It seemed necessary to add a more thorough cognitive tool in order to explore in-depth these variables (cognitive coordination and cognitive shifts). It was hoped that the Critical Decision Method would indicated new characteristics of cognitive coordination and cognitive shifts and possibly provide new sublevels.

Thus the Critical Decision Method was able to give insights to already gathered data. It was used in order to identify web-seeking patterns, strategies, and reasons for choosing these strategies, levels of new knowledge, cognitive shifts, and thoughts. The interviews were recorded using the Camtasia Studio Software.

The flowchart of the research methods in this study was:



Flowchart 1. Flowchart of the research methods of this study.

All these multiple data material helped the researcher to investigate in-depth multitasking information behaviour. The aim was to provide a new more integrated

framework of multitasking information behaviour while using the web, helping not only researchers of information science to understand this behaviour, but also web designers to develop more effective web products.

3.6. Data Analysis

3.6.1. Thematic Analysis

Thematic analysis is a method with which researchers can organise, analyse and report patterns and themes within their data. The main advantage of this method in contrast to other methods of analyses such as content analysis is that thematic analysis is more flexible and pays more attention to the qualitative interpretation of the data. However, this advantage may turn into a disadvantage, and researchers will not be able to decide which aspects to interpret (Braun and Clarke, 2006). Another difference of thematic analysis is that codes are not predetermined, but emerge as researcher analyse the data (Marks and Yardley, 2003). Furthermore, thematic analysis can be used in large amount of data and provide similarities and differences between them.

Thematic analysis involve six stages: familiarising with data, generating initial codes, searching for themes, reviewing themes, defining themes, and producing the report. The procedure does not follow a linear process, but researchers can move back and forward many times during the process (Braun and Clarke, 2006).

Through the first step, researchers read and re-read the data, transcribing if it is necessary any idea they have. Researchers have to become familiar with the depth and breadth of their data (Braun and Clarke, 2006). Any verbal data has to be transcribed. This research used many verbal data.

The second step is to code all the basic units of the text that seem important such as words, phrases, sentences, paragraphs, sections, chapters, and books and place them into initial codes. Coding is determined from the aims of researchers and what they want to investigate. Coding can be done manually or through software. This study used the NVivo software for coding.

After this stage, researchers put all the codes into broader contexts, the themes. It can be possible one theme to involve multiple and different between them codes. Visual representations of a thematic map can be useful (Braun and Clarke, 2006). At the end, there will be the main themes and subthemes. Researchers have to review the themes and check, if the extract of each theme form a coherent pattern and if the thematic map reflects the real meaning from the data (Braun and Clarke, 2006).

Researchers, being confident about their themes, define and name them in order to analyse them. The last stage includes the final analyses of the selected or compelling extracts. Researchers relate these data to research questions and literature review (Braun and Clarke, 2006).

Some criteria have to be addressed in a good thematic analysis. Braun and Clarke (2006) summarize 15 criteria in the following table.

Process	No.	Criteria
Transcription	1	The data have been transcribed to an appropriate level of detail, and the transcripts have been checked against the tapes for 'accuracy'.
Coding	2	Each data item has been given equal attention in the coding process.
	3	Themes have not been generated from a few vivid examples (an anecdotal approach), But instead the coding process has been thorough, inclusive and comprehensive.
	4	All relevant extracts for all each theme have been collated.
	5	Themes have been checked against each other and back to the original data set.
Analysis	6	Themes are internally coherent, consistent, and distinctive.
	7	Data have been analysed - interpreted, made sense of - rather than just paraphrased Or described.
	8	Analysis and data match each other - the extracts illustrate the analytic claims.
	9	Analysis tells a convincing and well-organized story about the data and topic.
	10	A good balance between analytic narrative and illustrative extracts is provided.
Overall	11	Enough time has been allocated to complete all phases of the analysis adequately, Without rushing a phase or giving it a once-over-lightly.
	12	The assumptions about, and specific approach to, thematic analysis are clearly Explicated.
Written report	13	There is a good fit between what you claim you do, and what you show you have Done - i.e., described method and reported analysis are consistent.
	14	The language and concepts used in the report are consistent with the epistemological Position of the analysis.
	15	The researcher is positioned as active in the research process; themes do not just 'Emerge'.

Table 4. A 15-point checklist of criteria for a good thematic analysis (Braun and Clarke, 2006).

In this study, pre and post questionnaire data, observation, think aloud, and interview data as well as web seeking logs were analysed using thematic analysis.

3.6.2. Quantitative Analysis

In this study, there were two quantitative instruments: working memory test and flow state scale. The purpose was to compare participants' working memory results to their flow levels.

Regression analysis was used to compare the two variables and test for differences between the two working memory groups (high working memory and low working memory) and flow groups (high flow and low flow). A Pearson product-moment correlation coefficient was also computed to assess the relationship between working memory and flow. This test measures the strength of a linear association between two variables.

A Wilcoxon signed rank sum test, a nonparametric test, was used to compare scores that come from the same participants. It is suitable for evaluating the data from a repeated-measures design where the prerequisites for a dependent samples t-test are not met. Wilcoxon signed rank sum test is used to test the null hypothesis that the median of a distribution is equal to some value.

A Wilcoxon signed rank sum test was conducted to measure differences in the degree of change of knowledge for both groups for both types of information topics. It was also used to measure differences regarding task complexity for both working memory groups, flow groups and disciplines before and after the web seeking process for both types of information topics.

The use of the Mann-Whitney U test is more appropriate than the t-test when the data is not normally distributed. It is used when two different groups of participants perform both conditions, and it does assume that the two distributions are similar in shape. The Mann-Whitney U test was performed in order to capture statistically possible differences between all groups regarding their multitasking information behaviour (mean number of queries, mean number of opened tabs and mean number of web search sessions).

The Mann-Whitney U test was also used to identify statistical significant differences between the groups for information topics with and without prior knowledge. The Mann-Whitney U test was performed in order to evaluate possible differences between the three disciplines, the two working memory groups and the two flow groups regarding vividness, the degree of change of knowledge, task complexity, the degree of becoming informed before and after the information seeking process for the four topics, the degree of depth of their knowledge before and after the seeking process for the four topics, and the number of cognitive state and cognitive coordination shifts.

3.6.3. Integrated Analysis

In mixed methods design, researchers gather both qualitative and quantitative data. In order these data to be related, integrated analysis is needed (Caracelli and Greene, 1993; Creswell, 2003).

Caracelli and Greene (1993) mentioned four integrative strategies: (a) *data transformation*, in which one type of data is transformed into another for further analysis, for example, qualitative data convert to quantitative coding; (b) *typology development*, in which the categories that are developed from one set of data is applied to another; (c) *extreme case analysis*, in which the revealed findings by one analysis are explored again using other methods; and (d) *data consolidation/merging* in order to create new variables for further analysis.

Two major routes for integration are obvious: combination and conversion of data. Combination is the analysis of numerical and categorical data, which are used for statistical analysis and can be combined with qualitative data such as data from surveys and interviews. The data can be collected sequentially or at the same time (Bryman, 2006). Conversion, on the other hand, is the alteration of one type of data to another; qualitative data can be coded to quantitative data or quantitative data can be analysed through a narrative analysis of the events (Tashakkori and Teddlie, 1998; Elliott, 2005). The disadvantage of this approach is that through the data combination, possible anomalies or contradictions may arise. The solution is to gather more data in order to resolve these contradictions (Erzberger and Kelle, 2003).

This study used this analysis because it involved both qualitative and quantitative data. The qualitative data were combined with the quantitative data in order to explore in-depth multitasking information behaviour while using the web. The software, which was used, was NVivo. Through this software, qualitative data could be quantified measuring either the frequency of codes by documents or the words in the coded segments per code (Creswell, 2009).

This approach may give the most exciting outcomes especially for those researchers, who use the grounded theory approach (Strauss, 1987). Furthermore, as Bazeley (2006, p. 68) mentioned, “when data are matched in the way described, instances where individuals go against a trend can be readily identified and explored in detail. These cases might be outliers on a statistical measure, deviant cases in qualitative terms, or cases where there is an apparent contradiction in the data from the different sources”.

3.7. Verification of Methodology

Another important issue was to check the validity of the qualitative and quantitative methods as well as the research procedures. In mixed methods designs, researchers have to report the validity and reliability scores of each quantitative instrument as well as include strategies that will be used in order to enhance the validity of the qualitative instruments (Creswell, 2009).

3.7.1. Validity

There are two types of validity threats in quantitative experiments: internal and external. The first type is experimental processes or participants experiences that may threaten researchers’ interpretations about the population in the experiment. External validity threats are about false inferences from past or future situations, or from the sample data to other people (Creswell, 2009).

In this study, one possible threat of internal validity could be obvious: regression. Regression threat is about participants, who have extreme scores and may influence the process of the experiment. The solution is not to enter these participants into the experiment (Creswell, 2009). In this study, participants, who did not meet the 85% accuracy criterion of the working memory tests, did not participate in the main

experiment. If extreme scores occurred in the flow state scale, then these results could be triangulated with the post questionnaire, think aloud, observation, and interview data. Furthermore, the validity of each quantitative instrument was investigated as highlighted earlier.

Qualitative validity means that researchers find the same results from different aspects. One validity strategy is triangulation. This study used multiple research materials in order to triangulate the qualitative data from one source.

3.7.2. Reliability

When there is consistency between different researchers, then qualitative reliability has been achieved (Creswell, 2009). There are some strategies in order to achieve reliability such as checking transcripts and constantly comparing the data with the codes in order to avoid any drift in the definition of codes (Gibbs, 2007).

This research used many of these strategies in order to achieve the best level of reliability. The researcher checked the transcripts in order to minimize the possibility of mistakes and compared the codes to themes avoiding any drift in the meaning of the code.

3.7.3. Generalisability

It is more proper to discuss qualitative *particularity* rather than generalisation. Researchers do not use qualitative generalisation widely because the main aim of the qualitative researches is not to generalise the results. The main aim of qualitative studies is to study in detail and describe in particular the under investigation phenomenon (Creswell, 2009). With this detailed analysis and description, researchers can make judgments and use the research's findings to other contexts (Zhang and Wildemuth, 2009).

In this study, the interpretation of the data results, the description of the research strategies, and instruments as well as the detailed analysis of the coding procedure contributed to the use of these methods from other researchers in other future contexts.

Quantitative studies are usually thought to be generalisable. The requisitions are that participants have to randomly been assigned to groups, experiments have to involve enough participants and use statistical analysis in order to justify that the results are not by chance (Cronbach, 1975). As Lauer and Asher (1988, p. 155) said, "*over a large number of allocations, all the groups of subjects will be expected to be identical on all variables*". Cronbach (1975) also mentioned that findings from experimental studies about social phenomena could not be easily generalised. For that reason, researchers should add qualitative methods in order to describe in detail the complex sociological phenomena and provide grounded hypotheses.

Chapter 4 Results

4.1. Demographic Data

Thirty participants, 20 from Greece and 10 from Loughborough University in the UK participated in this study. From the total of 30 participants, 10 were psychologists, 10 were accountants and 10 studied mechanical engineering at Loughborough University.

The study participants included eleven females and nineteen male students. Most study participants were in their 20s (26) with the remaining in their 30s (4). All were full-time students. The study included 16 Bachelor participants, eight Master students and six PhD students. A table with the participants' demographic characteristics is included in Appendix B, B.1.

4.2. Working Memory Data

In the first phase, 34 participants took the Automated Operation Span Task (AOSPAN) working memory test. The researcher then excluded four participants, who got less than 85% in the time pressured mathematical calculation test. Fifteen participants were in the high sector above the mean of 27.7 and 15 in the lower sector below the mean. The people in the higher sector were regarded as having high working memory capacity and those in the lower sector as having low working memory capacity. The maximum score was 61 and the standard deviation was 17.2.

Table 5 shows the number of study participants in each discipline according to their working memory capacity.

Participants in disciplines	Low working memory capacity	High working memory capacity
Psychologists	6	4
Mechanical engineers	2	8
Accountants	7	3
Total	15	15

Table 5. Number of participants in each discipline according to their working memory capacity.

4.3. Flow

The Flow State Scale (FSS) of Jackson and Marsh (1996) consists of 36 items (questions) measured on a 5-point scale. By scoring across all 36 constructs a mean score for each participant was calculated. They were then divided into two groups: high flow group (mean scores above 4) and low flow group (mean scores below 4). The number of participants in each flow group according to their working memory (WM) is provided in Table 6.

Working memory groups	Low flow group	High flow group
Low working memory	7	8
High working memory	8	7

Table 6. Number of participants in each flow group according to their working memory capacity.

Table 7 shows the number of people in each flow group regarding their disciplines.

Disciplines	Low flow group	High flow group
Psychologists	5	5
Mechanical engineers	6	4
Accountants	4	6

Table 7. Number of participants in each flow group regarding their disciplines.

4.4. Flow and Working Memory

Regression analysis was used to compare the two variables and test for differences between the two working memory groups and flow levels. No significant difference was found ($b=-.006$, $t= -.853$, $r= -.159$, $p>.05$).

A Pearson product-moment correlation coefficient was also computed to assess the relationship between working memory and flow. These results confirmed the results from the linear regression analysis. There was no correlation between the two variables ($r = -.159$, $n=30$, $p=.401$). This means that having different working memory levels did not affect the flow levels of the participants.

4.5. Web Search Systems

All study participants reported using the web for information seeking (16 participants for 11 plus years, 10 from between six to 10 years, and four from one to five years).

The participants used multiple web search engines for seeking information. Table 8 shows the different web search engines employed by each participant.

Participants	Web search systems
1	Google scholar, Google, YouTube
2	Google, Intranet city.u.gr, Google scholar,
3	Google
4	Google, Google scholar
5	Google, Google images, Twitter
6	University's library, Scopus, Web of Science, Google, Wikipedia, Google Scholar, University's webpage
7	Google, YouTube, Google video, Google scholar
8	Google
9	Google, YouTube
10	Google, Google scholar, Google news,
11	Lboro library, Google,
12	Google scholar, Google, YouTube
13	Google, YouTube, Wikipedia
14	Google, Lboro library, YouTube, Google images
15	Google, YouTube,
16	Google, Google Scholar, Lboro library
17	Google, YouTube
18	Google, YouTube, Wikipedia
19	Google, Google news, Google images, Google scholar
20	Google, Google images
21	Google
22	Google, Google images
23	Google, Wikipedia
24	Google
25	Google
26	Google, YouTube, Google images
27	Google, YouTube
28	Google
29	Google
30	Google

Table 8. Web search systems that used during the web searches.

4.5.1. Characteristics of Web Search Systems

As mentioned in the literature review, an artefact must have telepresence in order for people to have high levels of flow. Telepresence involves vividness and responsiveness (Finneran and Zhang, 2003).

In order to measure these two variables, participants rated on a 7-point Likert scale, in the post questionnaires, the degree of vividness for each web search system they used during the information seeking process and the degree of the network speed during the experiment, which was considered to be regarded as “responsiveness”.

4.5.1.1. Working Memory Groups: Vividness and Responsiveness

Table 9 shows the overall Likert scores of vividness and responsiveness for each working memory group.

Working Memory Groups	Likert scores of web search systems' vividness	Likert scores of network speed
Low working memory	5.5	5.3
High working memory	5.5	5.5

Table 9. Likert scores of vividness and network speed for each working memory group.

The Mann-Whitney U test was performed to evaluate possible differences between the two groups. As the data was skewed (not normally distributed) this was the most appropriate statistical test. No significant difference was found regarding the vividness and network speed ($U=104$, $Z=-.383$, $p>.05$ and $U=.97$, $Z=-.670$, $p>.05$).

4.5.1.2. Disciplines: Vividness and Responsiveness

Table 10 shows the overall Likert scores of vividness and responsiveness for each discipline group.

Disciplines	Likert scores of web search systems' vividness	Likert scores of network speed
Psychologists	6	6.3
Mechanical engineers	5	5.3
Accountants	6.1	6

Table 10. Likert scores of vividness and network speed for each discipline group.

Although most participants from the three disciplines thought that the web search systems had high vividness and the network speed was high, there were some differences.

The Mann-Whitney U test was therefore performed in order to evaluate those possible differences between the three disciplines. No significant difference was found regarding the network speed. However, there were significant differences between the accountants and the other disciplines regarding vividness. In both cases of mechanical engineers ($U=20.5$, $Z= -2.482$, $p <.05$, $r=-.55$) and psychologists ($U=16$, $Z=-2.790$, $p<.05$, $r=-.62$) it was apparent that the accountants experienced a higher degree of vividness (see Table 11 and 12).

Ranks				
	Disciplines	N	Mean Rank	Sum of Ranks
Vividness means	Mechanical engineers	10	7.55	75.5
	Accountants	10	13.45	134.5
	Total	20		

Table 11. Mann-Whitney results for mechanical engineers and accountants regarding vividness.

Ranks				
	Disciplines	N	Mean Rank	Sum of Ranks
Vividness means	Psychologists	10	7.10	71
	Accountants	10	13.90	139
	Total	20		

Table 12. Mann-Whitney results for psychologists and accountants regarding vividness.

4.5.1.3. Flow groups: Vividness and Responsiveness

Table 13 shows the Likert scores of vividness and responsiveness for each flow group.

Flow groups	Likert scores of web search systems' vividness	Likert scores of network speed
Low flow	5	6
High flow	6.3	6.6

Table 13. Likert scores of vividness and network speed for each flow group.

The Mann-Whitney U test was performed in order to evaluate possible differences between the two groups. Neither vividness nor network speed were found to be statistically significant ($U=102.5$, $Z= -450$, $p >.05$ and $U=87.5$, $Z=-1.08$, $p >.05$).

The PAT model (Finneran and Zhang, 2003) suggested that artefacts characteristics might affect flow levels such that people with high scores of vividness and responsiveness would have high flow levels whereas people, who have low scores of vividness and responsiveness, would also have low flow levels. The above results confirmed that assumption only for the group with high flow. People with high flow felt that vividness and network speed were high. People with low flow levels, however, who should have low levels of vividness and network speed, also experienced high levels of vividness and network speed.

4.6. Multitasking Information Behaviour while using the Web

As stated in the literature review, multitasking information behaviour is the: “*description of the variables, including the ordering and switching between multiple information problems searching tasks, the generation of evolving information problems including serendipity browsing activities, and multiple search sessions*” (Du, 2011, p. 98).

A web search session is “*the entire sequence of queries through the interaction with the web search systems in the windows/tabs when searching on a particular information problem*” (Du and Spink, 2011). As it seems, web search sessions include: the topic, the queries, the web search engines and the opened windows/tabs (Du, 2010).

The researcher identified these behaviours through the analysis of the post questionnaires and the web search logs. The following sections provide the results of the multitasking information behaviours.

4.6.1. Information Topics

As stated previously, the researcher conducted short pre-interviews where participants chose from two lists several topics about their discipline that they would like to search 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 two broad categories for each discipline, which each one involved two topics: two for which participants had prior knowledge and two for which participants had no or little prior knowledge.

The two broad topics for the accountants, for which they had prior knowledge, were: international accounting standards and qualified accountant-tax related issues; the other two categories, for which they had little or no prior knowledge, were: financial accounting and law. For the mechanical engineers the two categories, for which they had little or no prior knowledge, were aeronautical marine and automotive, and the two other categories with prior knowledge were materials and design. Finally, for the psychologists, the two categories with prior knowledge were: cognitive and social psychology; and the other two categories with little or no knowledge were: counselling and clinical psychology. Table 14 shows the categories for each discipline.

Disciplines	Categories with prior knowledge	Categories with little or no prior knowledge
Psychologists	<ul style="list-style-type: none"> • cognitive psychology • social psychology 	<ul style="list-style-type: none"> • counselling psychology • clinical psychology.
Mechanical engineers	<ul style="list-style-type: none"> • materials • design 	<ul style="list-style-type: none"> • aeronautical marine • automotive
Accountants	<ul style="list-style-type: none"> • international accounting standards • qualified accountant • tax related issues 	<ul style="list-style-type: none"> • financial accounting • law

Table 14. Categories for web seeking per discipline.

4.6.2. Characteristics of Information Topics

4.6.2.1. Task Complexity and Working Memory Groups

Each participant rated the level of complexity of each information task in the pre and post questionnaires. The complexity of information tasks according to Finneran and Zhang (2003) may have positive or negative influence on flow. A complex task could lead to high levels of flow because it may be considered a challenge. However, it may also considered to be daunting and thus lead to anxiety. In the pre-questionnaires, participants pre-judged the complexity of the topics, while in the post questionnaires they rated the complexity of the topics with hindsight having completed it.

Table 15 shows the Likert scores of complexity for each list of information topics (IT with or without prior knowledge) rated on a 7-point Likert scale, where 1 means no complexity and 7 means very complex, before and after the seeking procedure, for participants according to their working memory capacity.

		Likert scores before web seeking process	Likert scores after web seeking process
Low working memory group	Topics with prior knowledge	3.7	3.6
	Topics without prior knowledge	4.9	4.6
High working memory group	Topics with prior knowledge	4.5	4.4
	Topics without prior knowledge	4.7	4.4

Table 15. Likert scores of tasks' complexity before and after the web seeking process for each working memory group for both types of information topics.

A Wilcoxon signed rank sum test was conducted to measure any differences for both working memory groups after the web seeking process for both types of information topics. The test showed a statistically significant change for the participants assigned to the low working memory group ($Z = -2.158, p = .031$). Participants with low working memory capacity felt that task complexity at the end of the procedure was higher for topics without prior knowledge than for topics with prior knowledge (see Table 16).

Ranks				
Task complexity after web seeking		N	Mean Rank	Sum of Ranks
Topics with prior knowledge.	Negative Ranks	9	11.11	100
	Positive Ranks	18	15.44	278
Topics with no prior knowledge.	Ties	3		
	Total	30		

Table 16. Wilcoxon's results for low working memory group for topics with and without prior knowledge after the web seeking.

4.6.2.2. Task Complexity and Disciplines

Table 17 shows the overall Likert scores of task complexity before and after web seeking for both types of topics for the three disciplines.

		Likert scores before web seeking process	Likert scores after web seeking process
Psychologists	Topics with prior knowledge	4.1	4.5
	Topics without prior knowledge	4.2	4.9
Mechanical engineers	Topics with prior knowledge	4.5	4.7
	Topics without prior knowledge	5.1	4.7
Accountants	Topics with prior knowledge	3.8	3
	Topics without prior knowledge	5.2	3.8

Table 17. Likert scores of task complexity before and after web seeking for both types of topics for the three disciplines.

A Wilcoxon signed rank sum test was also conducted in order to explore any significant differences for all disciplines before and after the web seeking for both types of topics. The test only showed a statistically significant change for accountants ($Z=-2.492$, $p=.013$). They felt that task complexity at the end of the information seeking procedure was significantly less for topics without prior knowledge (see Table 18).

Ranks				
Task complexity for topics with no prior knowledge.		N	Mean Rank	Sum of Ranks
After - Before web seeking	Negative Ranks	13	10.92	142
	Positive Ranks	5	5.8	29
	Ties	2		
	Total	20		

Table 18. Wilcoxon's results for accountants for topics without prior knowledge before and after the web seeking.

Think aloud data and the analysis of the post questionnaires confirmed these results. Because information accounting topics were regarded as being more straightforward, it was easy for accountants to find information for topics without prior knowledge.

4.6.2.3. Task Complexity and Flow

Table 19 shows the overall Likert scores of task complexity before and after the web seeking for both types of topics for the two flow groups.

		Likert scores before web seeking process	Likert scores after web seeking process
Low flow group	Topics with prior knowledge	4.1	4.6
	Topics without prior knowledge	4.9	4.8
High flow group	Topics with prior knowledge	4.1	3.7
	Topics without prior knowledge	4.6	4.2

Table 19. Likert scores of task complexity before and after the web seeking for both types of topics for the two flow groups.

The table shows that the task complexity decreased after the information seeking for both types of information topics for the two groups, with the possible exception for the low flow group for topics with prior knowledge. The Wilcoxon test, however, did not find any statistical differences before and after the web seeking for either type of topics or flow groups.

Regarding the PAT model and task complexity, Finneran and Zhang (2003) suggested that task complexity might have positive or negative influence on flow. A complex task can lead to anxiety and low levels of flow. Task complexity, however, may lead people to experience high levels of flow because it engages and challenges them.

In this study, both flow groups had mostly means of complexity for both types of topics above 4 on a 7-point item Likert scale. This means that both groups felt that the topics were fairly complex. This confirms the suggestion of the PAT model. People with high flow felt that the task complexity engaged challenges whereas people with low flow felt that task complexity lead them to anxiety. Think aloud data and the analysis of the post-questionnaires confirmed these results.

4.6.3. Order of Information Topics

Twenty-one participants switched the order of the information topics and only nine followed the order that has been given to them. The most important findings were that:

- Working memory and flow levels did not influence the order of the information topics (five and four people with high and low working memory respectively as well as five and four people with high and low flow levels did not change the order of their information topics).
- Disciplines also did not affect the order of the information topics undertaken (from the nine participants who did not switch the order: three were mechanical engineers, two were psychologists and four were accountants).

In the post-questionnaires, participants were asked for the reasons of their behaviour. Of the twenty-one participants, who switched the order of the information topics, most said they did so for reasons relating to their degree of interest and level of knowledge. They preferred to start with an information task, for which they had knowledge and which found more interesting. For example,

- Participant 17: "I started with the information topic for which I have more knowledge",
- Participant 9: "I chose the information topics regarding my interest and my knowledge".

Other reasons included boredom and tiredness. For example, Participant 17 also mentioned, "I get bored of some information topics and I could not find information easily".

Two participants, Participant 11 and Participant 15 said that it was a random switch of order without any particular reason. Finally, Participant 3 said, "I switched the order because the network speed was low sometimes and it could not load the web pages. Therefore, I decided to move on and save time".

4.6.4. Types of Information Topics

From the web search analysis it seemed that, there were three types of information searching undertaken: for the original information topics, for the evolving information topics and the serendipity browsing.

1. Original Information topics (OIT): The original information topics were the first information topics from the broad categories, which participants chose in the pre-interview (OIT1, OIT2, OIT3, OIT4).
2. Evolving Information topics (EIT): The evolving information topics were related to the original information topics, generated by each participant (EIT1, EIT2, etc.).
3. Serendipity Browsing (SB): Participants browsed with serendipity (SB1, SB2, etc.).

Evolving Information topics (EIT) are “a type of information problem that was produced during the successive web searching...Compared to an original information problem (OIT) which was consciously set by the study participants, the generation of an evolving information problem had an attribute of improvisation. It could be conscious or unconscious” (Du, 2011).

For example, Participant 19 started with the original information topics: Cad programs followed by the evolving information topics: solidworks cad, 3-D printers, water 3-D printers kick-starter. Participant 12 started with the original task of Circuit analysis and continued with the evolving information topics of load flow analysis, electrical circuit analysis, Megrew Hills series power systems, and transient stability analysis. From the analysis of web logs, it seemed that all participants, except two, generated evolving information topics. There were, in total, 259 evolving information topics. Only four participants browsed with serendipity.

4.6.4.1. Working Memory Groups

Table 20 below shows the number of evolving information topics for each working memory (WM) group. People with high and low working memory generated almost the same number of evolving information topics.

Woking memory groups	Number of evolving information topics
Low working memory	131
High working memory	128
Total	259

Table 20. Number of evolving information topics for each working memory group.

4.6.4.2. Disciplines

Table 21 shows the number of evolving information topics for each discipline group.

Disciplines	Number of evolving information topics
Psychologists	91
Mechanical engineers	123
Accountants	45
Total	259

Table 21. Number of evolving information topics for each discipline group.

The accountants had a significant lower number of evolving information topics whereas mechanical engineers had the highest. 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 undertake detailed searches.

On the other hand, psychologists generated more evolving information topics and they changed keywords many times, keeping the main context the same, because it was more difficult to find the information they wanted. This may mean the participants lacked skills to use the right keywords or that the psychological information topics were more complex and theoretical in nature compared to the accounting information topics, or both.

The mechanical engineers, however, generated more evolving information topics because, as it seemed from the web logs, they were keen to expand and explore the information topic provided. From the analysis of the interviews it was also indicated

that this discipline is more often updated, so the participants were keen to explore new facts.

4.6.4.3. Flow Groups

Table 22 shows the number of the evolving information topics for each flow group. The low flow group had slightly lower number of evolving information topics than the high flow group. However, there was no significant difference between the two groups ($U=108$, $Z=-188$, $p>.05$).

Flow groups	Number of the evolving information topics
Low flow	124
High flow	135
Total	259

Table 22. Number of the evolving information topics for each flow group.

4.6.5. Multiple Web Search Sessions

4.6.5.1. Working Memory Groups

The mean number of queries, the mean number of opened windows/tabs, and the number of web search sessions for each working memory group are shown in Table 23.

Working memory groups	Mean number of queries	Mean number of opened windows/tabs	Number of web search sessions
	Mean	Mean	Sum
Low working memory	6.2	2.5	199
High working memory	7	3	207
Mean	7	3	14

Table 23. Mean number of queries, mean number of opened windows/tabs and number of web search sessions for each working memory group.

The Mann-Whitney U test was performed in order to evaluate possible differences between the two groups. Regarding the mean number of queries, no significant differences were found between the two working memory groups ($U=108.5$, $Z= -.167$, $p>.05$). No significant differences were also found between the two working memory

groups regarding the opened tabs ($U=90.5$, $Z=-.947$, $p >.05$) or regarding the web search sessions ($U=107$, $Z=-.229$, $p>.05$).

4.6.5.2. Disciplines

Table 24 shows the mean number of queries, the mean number of opened windows/tabs, and the number of web search sessions for each discipline.

Disciplines	Mean number of queries	Mean number of opened windows/tabs	Number of web search sessions
	Mean	Mean	Sum
Psychologists	6.7	3	143
Mechanical engineers	7	3	169
Accountants	5	2	94

Table 24. Mean number of queries, mean number of opened windows/tabs and number of web search sessions for disciplines.

Mann-Whitney U tests were performed to identify any significant differences between the disciplines and the above factors. The tests identified four significant differences:

1. The mechanical engineers created more queries than accountants ($U=7$, $Z=-3.289$, $p<.05$). Table 25 shows that mechanical engineers had the highest mean rank.

Ranks				
	Disciplines	N	Mean Rank	Sum of Ranks
Mean number of queries	Mechanical engineers	10	14.80	148
	Accountants	10	6.20	62
	Total	20		

Table 25. Mann-Whitney results for mean number of queries for mechanical engineers and accountants.

2. The mechanical engineers opened more windows/tabs than accountants ($U=19.5$, $Z=-2.402$, $p<.05$) (see Table 26).

Ranks				
	Disciplines	N	Mean Rank	Sum of Ranks
Mean number of opened tabs	Mechanical engineers	10	13.55	135.5
	Accountants	10	7.45	74.5
	Total	20		

Table 26. Mann-Whitney results for mean number of opened tabs for mechanical engineers and accountants.

3. The mechanical engineers had a higher number of web search sessions ($U=7, Z=-3.266, p <.05$) (see Table 27).

Ranks				
	Disciplines	N	Mean Rank	Sum of Ranks
Number of web search sessions	Mechanical engineers	10	14.8	148
	Accountants	10	6.2	62
	Total	20		

Table 27. Mann-Whitney results for number of web search sessions for mechanical engineers and accountants.

4. The psychologists also had a higher number of web search sessions compared to accountants ($U=12.5, Z= -2.854, p <.05$) (see Table 28).

Ranks				
	Disciplines	N	Mean Rank	Sum of Ranks
Number of web search sessions	Psychologists	10	14.25	142.5
	Accountants	10	6.75	67.5
	Total	20		

Table 28. Mann-Whitney results for number of web search sessions for psychologists and accountants.

4.6.5.3. Flow Groups

Table 29 shows the mean number of queries, the mean number of opened windows/tabs, and the number of web search sessions for each flow group.

Flow groups	Mean number of queries	Mean number of opened windows/tabs	Number of web search sessions
	Mean	Mean	Sum
Low flow	7.3	3.3	185
High flow	6.8	2.2	221

Table 29. Mean number of queries, mean number of opened windows/tabs and number of web search sessions for each flow group.

The Mann-Whitney U test was performed to identify statistically possible differences between the two groups. Regarding the mean number of queries, no significant differences were found between the two flow groups ($U=101$, $Z= -.481$, $p >.05$). No significant differences were also found between the two flow groups regarding the opened tabs ($U=85.5$, $Z=-.1.163$, $p >.05$) or regarding the web search sessions ($U=111$, $Z=-.063$, $p >.05$).

4.7. Feelings

Participants answered in the pre and post questionnaires how they felt before and after the information seeking procedure. Participants' explanations for these feelings were identified from the pre and post questionnaires, think aloud data as well as from the interviews.

If the feelings could be put into two categories, these would be: 1) *Before the seeking process*: negative feelings (information overloading, tiredness, frustration, boredom) and positive feelings (desire, happiness, curiosity), and 2) *After the seeking process*: negative feelings (frustration, tiredness, confusion, disappointment for not having knowledge) and positive feelings (people were informed, desire for more research, happiness, self-confidence curiosity, calmness). There were no significant differences between the working memory groups, the disciplines and the flow groups regarding the types of feelings.

4.8. Cognitive Holistic Shifts

Holistic shifts are the changes of users' perception about the information topics. In this study, the cognitive holistic shifts identified with the pre and post questionnaires regarding the degree of change of knowledge, the degree of becoming informed about the topics and the change of depth of peoples' knowledge before and after the information seeking process.

4.8.1. Degree of Change of Knowledge

4.8.1.1. Working Memory Groups

The degree of change of knowledge was identified in the post-questionnaires for all the types of information topics. Table 30 shows the overall Likert scores of the degree of change of knowledge for each working memory group for information topics with and without prior knowledge as they measured on the 7-item Likert scale. Although both working memory groups gained knowledge for both types of information topics the degree of change was not found to be significant (topics with prior knowledge, $U=98$, $Z= -.618$, $p >.05$ and topics without prior knowledge, $U=95.5$, $Z= -.722$, $p >.05$). Similarly, the two working memory groups had higher levels of change of knowledge for information topics without prior knowledge than for information topics with prior knowledge, but again the differences were not significant ($Z=-1.673$, $p>0.5$ and $Z=-1.704$, $p>0.5$).

Working memory groups	Overall Likert scores of degree of change of knowledge for topics with prior knowledge	Overall Likert scores of degree of change of knowledge for topics without prior knowledge
Low working memory	4	4.3
High working memory	3.2	3.8

Table 30. Likert scores of degree of change of knowledge for each working memory group for information topics with and without prior knowledge.

4.8.1.2. Disciplines

Table 31 below shows the overall Likert scores of degree of change of knowledge for each discipline group for information topics with and without prior knowledge as they

measured on the 7-item Likert scale. It seemed that all disciplines gained knowledge for all the types of information topics, with higher degrees of change of knowledge for the information topics without prior knowledge. However, when investigated further, the degrees of change were not found to be significant.

Disciplines	Overall Likert scores of degree of change of knowledge for topics with prior knowledge	Overall Likert scores of degree of change of knowledge for topics without prior knowledge
Psychologists	3.3	5.6
Mechanical engineers	3	4
Accountants	3.5	4

Table 31. Likert scores of degree of change of knowledge for each discipline group for information topics with and without prior knowledge.

4.8.1.3. Flow Groups

Table 32 shows the overall Likert scores of the degree of change of knowledge for each flow group for information topics with and without prior knowledge as they measured on the 7-item Likert scale. It would appear that both flow groups experienced a positive change in their level of knowledge through the information seeking process. This was evident from their Likert scores and from data from the post-questionnaires and interviews. Unlike the Mann-Whitney U test did not show any significant differences between the two groups regarding the information topics with prior knowledge ($U=111$, $Z=-.064$, $p>.05$). People with high flow had a significantly higher degree of change of knowledge for information topics without prior knowledge ($U=60$, $Z= -2.229$, $p <.05$).

Flow groups	Overall Likert scores of degree of change of knowledge for topics with prior knowledge	Overall Likert scores of degree of change of knowledge for topics without prior knowledge
Low flow	3	3.3
High flow	3.3	4.6

Table 32. Likert scores of degree of change of knowledge for each flow group for information topics with and without prior knowledge.

Ranks				
	Flow groups	N	Mean Rank	Sum of Ranks
Degree of change of knowledge for information topics without knowledge	High	15	19	285
	Low	15	12	180
	Total	30		

Table 33. Mann-Whitney results for degree of change of knowledge for flow groups for information topics without prior knowledge.

A Wilcoxon signed rank sum test also found that the degree of change of knowledge for high flow participants was higher for topics without prior knowledge than for topics with prior knowledge ($Z=-2.848$, $p=.004$). People with high flow probably had the desire to search more for topics without prior knowledge, an information seeking procedure, which required more attention, interest, concentration and engagement.

4.8.2. Becoming informed

In the pre and post questionnaires, participants rated their degree of becoming informed before and after the information seeking process for the four topics on a 7-item Likert scale. The question was: “*Where are you in the process of becoming informed on the topic?*”. Then, the differences of pre and post ratings were calculated. Table 34 provides details of the number of participants who became more informed by searching for the topics with and without prior knowledge.

Groups	Topics	
	Topics with prior knowledge	Topics without prior knowledge
Working memory groups		
Low working memory	11	13
High working memory	8	11
Disciplines		
Psychologists	8	9
Mechanical engineers	4	6
Accountants	7	7
Flow groups		
Low flow	9	11
High flow	10	12

Table 34. Number of participants from each group who became informed for both types of information topics.

It can be seen that both working memory groups gained knowledge during the information seeking process. However, the degree of knowledge obtained appeared greater when participants searched for information about topics without prior knowledge.

It also seemed that psychologists and accountants became more informed than the mechanical engineers for both types of information topics. From the post-questionnaires and interviews, the mechanical engineers replied that, because their topics were more practical and because there is always something new to learn, they discovered many new things while they searched on the web. They realised many times during the information seeking process that they do not know a lot even for topics with prior knowledge. This is also the reason of why they generated more evolving information topics, more queries, opened more tabs and practised more web search sessions. Finally, most participants from flow groups became more informed about both types of topics from the searching process. Neither the Wilcoxon signed rank sum test nor the Mann-Whitney U test showed any statistical difference regarding the degree of becoming informed between the groups for either of the information topics.

4.8.3. Depth of Knowledge

In the pre and post questionnaires, participants rated their degree of the depth of their knowledge before and after the seeking process for the four topics on a 7-item Likert

scale. The question was: “*How certain are you about the depth of knowledge you have for each information topic?*”. Then, the differences of their ratings for each topic were calculated. Table 35 provides details of the number of participants who gained more depth of knowledge by searching for the topics with and without prior knowledge.

Groups	Topics	
	Topics with prior knowledge	Topics without prior knowledge
Working memory groups		
Low working memory	15	11
High working memory	9	8
Disciplines		
Psychologists	8	7
Mechanical engineers	4	7
Accountants	7	8
Flow groups		
Low flow	6	5
High flow	11	12

Table 35. Number of participants from each group who had more depth of knowledge for both types of information topics

Neither the Wilcoxon signed rank sum test nor the Mann-Whitney U test showed any statistical difference regarding the depth of knowledge between the groups for either of the information topics. As it can be seen from the results most participants gained depth of knowledge during the searching process, although interestingly most mechanical engineers had more depth of knowledge for information topics without prior knowledge. The researcher also found backward and no holistic shifts but the number of participants who experienced these was small. These results confirm previous researchers (Spink, 2002; Spink and Dee, 2007; Du, 2011), who suggested that participants reported three types of holistic shifts: forward, backward and no holistic shift.

4.9. Cognitive State Shifts

Cognitive state shifts were the cognitive state changes between the interaction of the user and the web. The five types of cognitive states from Du’s (2011) model have been identified: topic (TOP), strategy (STR), evaluation (EVA), view (VIE), and overview (OVE). In this study, the first cognitive state, topic has also been named as current

search goal (CSG). Xie (2000) and Daniels (1986) also used this term in order to describe the information problems that are determined by each task. The cognitive state of strategy includes strategies as: terms selection, query (re)formulation, results saving, web search systems selection and browsing more results and web pages. Thus, in this study the general cognitive state of strategy distinguished as the following multiple sub strategies: term selection (TERM), query reformulation (QUERY), web search system selection (WSS), results saving (RS), and browsing more results (BR). Cognitive state shifts were explored through the thematic analysis of the web search logs.

4.9.1. Working Memory Groups

The thematic analysis showed that for both working memory groups (see Table 37):

- The most frequent cognitive state shift was from STR (WSS) to CSG. Most participants chose their preferred web search engine first and then examined the topic.
- The second most frequent cognitive state shift was the other way around from CSG to STR (WSS). Many participants also looked at the topics first before choosing a search engine.
- The third most frequent cognitive state shift was from VIE to STR, WSS was the most frequent sub strategy for the high working memory group and BS was the most frequent sub strategy for the low working memory group. Most participants, after they made judgements about the context of each web page, preferred either to change their web search system to improve their information seeking or they browsed more results e.g. hyperlinks into the particular web page in order to find the desired information.

Table 36 shows numbers of the most frequent cognitive state shifts for each working memory group. Cognitive state shifts were regarded as any activity associated with a shift in cognition on the part of the user, such as shift between the topics, selection of the search engine, entering a search query, reformulating the queries, saving the results, browsing more results, looking and evaluating at the retrieved results,

evaluating the content of the web pages and judging the overall information seeking process.

Most frequent cognitive state shifts	Numbers of the most frequent cognitive state shifts for each working memory group	
	Low working memory group	High working memory group
1 st frequent: STR to CSG	144	205
most frequent sub strategy: WSS	65	92
2 nd frequent: CSG to STR	102	151
most frequent sub strategy: WSS	44	73
3 rd frequent: VIE to STR	71	103
most frequent sub strategy: WSS	36	44
most frequent sub strategy: BS	20	22
Total number of cognitive state shifts	1002	1401

Table 36. Numbers of the most frequent cognitive state shifts for each working memory group.

Mann-Whitney U tests was performed to identify any significant differences between the two working memory groups. The results suggest that the participants in the high working memory group had a significantly higher number of cognitive state shifts than the participants in the low working memory group ($U=13$, $p=.004$). The high number of cognitive state shifts from the high working memory group means that they tended to switch between their information topics, search queries, results and evaluation many times in order to test and retest different strategies when trying to achieve the best outcome and find the desired information. Regarding the sub strategies for high and low working memory groups, the results showed that the most experienced was WSS, followed by BR, TERM, QUERY and RS.

The statistical difference of task complexity that has been found earlier for the low working memory showed that people with low working memory felt that topics without prior knowledge were more complex at the end of the information seeking process. From the thematic analysis of the web logs, it has also been found that 13 from the total 15 participants of the low flow group generated less cognitive state and coordination shifts for topics without prior knowledge than for topics with prior knowledge. On the other hand, seven people from the total 15 from the high working

memory group generated less cognitive state and coordination shifts for topics without prior knowledge than for the topics with prior knowledge.

This means that people with a low working memory felt that topics without prior knowledge were complex enough and they did not, or could not, generate many cognitive state and coordination shifts. For example, they could not generate more strategies or evaluate and judge the content of the webpages in the same way as they did for the topics with prior knowledge. It is possible that people with low working memories have limitations with regard to their attention to relevant information in contrast to people with high working memory, who tend to allocate their attention to task-relevant information and coordinate information successfully (Engle et al., 1999). In this experiment, it seemed that, people with low working memory could not allocate their attention to relevant information especially for topics without any prior knowledge and therefore accepted a lower level of cognitive state occurrence (less cognitive state and coordination shifts).

4.9.2. Disciplines

From the thematic analysis, it was found that:

- The most frequent cognitive state shift for all disciplines was from STR (WSS) to CSG. Most participants chose their preferred web search engine first and then examined the topic.
- The second most frequent cognitive state shift for all disciplines was the other way around from CSG to STR (WSS). Many participants also looked at the topics first before choosing a search engine.
- However, the third most frequent cognitive state shift varied between disciplines: for psychologists was from CSG to VIE whereas for mechanicals and accountants the shift was from STR to STR. BS was the most frequent sub strategy for both mechanical engineers and accountants whereas it was WSS for psychologists. Many mechanical engineers and accountants browsed more results to find the desired information in contrast to psychologists who chose their preferred web search engine.

Table 37 shows numbers of the most frequent cognitive state shifts for each discipline. Where a “-“ is used in the tables instead of a numeric value it means that the value in each case is not applied to the certain group of participants e.g. in the table below the third most frequent cognitive state shift for psychologists was from CSG to VIE but not for mechanical engineers for whom the third most frequent cognitive state shift was from STR to STR. The numbers indicate the number of times that cognitive state shift occurred in the different disciplines. A cognitive state shift was regarded as any activity on the part of the user, such as selection of a search engine, entering a search query or looking at a retrieved result.

Most frequent cognitive state shifts	Numbers of the most frequent cognitive state shifts for each discipline		
	Psychologists	Mechanical engineers	Accountants
1 st frequent: STR to CSG	123	152	74
most frequent sub strategy: WSS	49	63	45
2 nd frequent: CSG to STR	91	110	52
most frequent sub strategy: WSS	38	55	24
3 rd frequent: CSG to VIE	35	-	-
3rd frequent: STR to STR	-	47	20
most frequent sub strategy: WSS	24	-	-
most frequent sub strategy: BS	-	45	11
Total number of cognitive state shifts	785	992	626

Table 37. Numbers of the most frequent cognitive state shifts for each discipline.

These results confirm and support the results of queries, opened tabs, web search session as well as the number of the evolving information topics. Accountants had significantly lower number of cognitive state shifts because of the nature of the topics, which were regarded as being more straightforward. Thus, they did not have to change between many cognitive states.

Mann-Whitney U tests was performed to identify any significant differences between the three disciplines. The results suggest that the mechanical engineers had a significantly higher number of cognitive state shifts than the accountants (U=58, p=.023).

Moreover, the statistical difference of task complexity that was found earlier showed that accountants felt that topics without prior knowledge were less complex at the end of the information seeking process. From the thematic analysis of the web logs, it has also been found that seven from the total 10 accountants generated less cognitive state and coordination shifts for topics without prior knowledge than for topics with prior knowledge. Accountants generated less cognitive state and coordination shifts for topics without prior knowledge as they could easily find the information they wanted.

On the other hand, psychologists generated more cognitive states shifts to find the information they wanted. This can either mean difficulty from the participants to use the right terms and strategies or the psychological information topics were more complex.

Mechanical engineers, however, generated the highest number of evolving information topics, more queries, opened more tabs and practised more web search sessions. This is the reason of why they also had the highest number of cognitive states shifts. Regarding the sub strategies for the three disciplines, the results showed that the most experienced was WSS, followed by BR, TERM, QUERY and RS.

4.9.3. Flow Groups

The results from the thematic analysis showed that:

- People with high flow were more engaged, so they experienced more cognitive state shifts (n=1374) in contrast to the low flow group (n=1029).
- The most frequent cognitive state shift for both flow groups was from STR (WSS) to CSG. Most participants chose their preferred web search engine first and then examined the topic.
- The second most frequent cognitive state shift for the high flow group was from CSG to STR (WSS) and for the low flow group from CSG to EVA. This means that people with high flow chose the topics first and then chose their preferred web search engine whereas people with low flow evaluated the results of the web pages regarding the information topics they searched for.

- The third most frequent cognitive state shift for the high flow group was from CSG to EVA and for the low flow group from CSG to VIE. People with high flow chose the topics and then evaluated the results whereas people with low flow chose the topics and then viewed the content of the webpages.

Table 38 shows numbers of the most frequent cognitive state shifts for each flow group.

Most frequent cognitive state shifts	Numbers of the most frequent cognitive state shifts for each flow group	
	Low flow group	High flow group
1 st frequent: STR to CSG	132	217
1 st frequent sub strategy: WSS	62	95
2 nd frequent: CSG to STR	-	169
2 nd frequent: CSG to EVA	112	-
3 rd frequent: : CSG to EVA	-	143
3 rd frequent: CSG to VIE	89	-
Total number of cognitive state shifts	1029	1374

Table 38. Numbers of the most frequent cognitive state shifts for each flow group.

Mann-Whitney U tests was performed to identify any significant differences between the two flow groups. The results suggest that the high flow group had a significantly higher number of cognitive state shifts than the low flow group ($U=52$, $p=.013$). Regarding the sub strategies for both flow groups, the results showed that the most experienced was WSS, followed by BR, TERM, QUERY and RS.

It seems that, all participants, regardless of their working memory and flow levels as well as their disciplines, had the same the first two frequent cognitive state shifts. These results differ from those of Du (2011), who suggested that people divert their attention more between their strategies and their evaluation of the results. From the results of this study, it is obvious that people switched more between their preferred strategies and then continued with the topics.

The most experienced cognitive state for all groups was strategy (31%) followed by the current search goal (29%), view (23%), evaluation (14%) and finally overview (3%).

These results differ from those of Du (2010) except for the most experienced cognitive state. She found that the most experienced cognitive state was strategy followed by view and evaluation with the same percentages. This study showed that people paid more attention to strategies, then to information topics, then they judged and evaluated the content of the webpages, and finally they evaluated the system search results and the overall search outcome and time allocation.

4.10. Cognitive Coordination Shifts

Du (2011) found three levels of coordination:

1. the Information Task Coordination(IT), which is the coordination of all topics;
2. the Cognitive Coordination Mechanism, which includes all the mechanisms that help the information task coordination, and they are:
 - a. content relevance feedback(CRF) (judgments about the context of each item),
 - b. magnitude feedback(MF) (judgments in terms of the size of each item),
 - c. self-learning and regulating(SRL) (examination of the gathered data),
 - d. tactical review feedback(TCF) (judgments about changing the strategy based on the retrieved results), and
 - e. term relevance feedback(TRF) (identifying a term in the retrieved data and reformulate the queries); and
3. the Cognitive Strategy Coordination, which is the strategic plan for the whole seeking process. This level involves the specific strategy (PSS) (queries, terms, web search systems) and the global strategy (GS) (time allocation and overall plan). In this study, the PSS has also involved sub strategies, the same which have been identified for the cognitive state shifts: term selection (TERM), query reformulation (QUERY), web search system selection (WSS), results saving (RS), and browsing more results (BR).

Regarding the results of this study, the coordination levels were defined as coordination types as it has been found that there were no levels. Coordination types and shifts identified through the thematic analysis of web search logs, think aloud data and observations. However, in this study the coordination type of mechanism was named as evaluating results and coordinating search techniques type. Furthermore,

two more coordination types identified: 4. the Personal knowledge coordination type and 5. The Interruptions (internal and external) and management coordination type.

4. The Personal Knowledge Coordination Type

Participants before, after or during the information seeking process examined and evaluated their level of personal knowledge or the possible gaps they might have. For example,

Participant 1: First examined the four topics and then he/she said: “ok, I will start with this first, which I know better”. He/she started with the first information task.

Participant 8: He/she saw all the information topics and decided also to start the seeking process with the first information task: “I think I will start with this first, which I know”.

Participant 30. He/she examined the four information topics and said: “I think I will do these in order”.

The coordination type of personal knowledge happened also many times when the participants were thinking with which information topics to continue their search and how to coordinate the topics. For example:

Participant 1.: “Let’s move to a familiar topic”, “I know a bit about this”.

Participant 10. “What is this exactly?” (while moving to a topic with no or little prior knowledge), “This area is a little bit funny and tricky.”

Participant 4. “It is an area that I don’t have much knowledge of”, “ I move to my next topic”.

Participant 22. “I’d like to focus on stuff that I do not have knowledge about .(while start to seek for an unfamiliar task), “I will go probably to something I know more about in terms of knowledge and influence”, “ and because I have in-depth knowledge I intend to look more”.

5. The Interruptions (internal and external) and Management Coordination type.

Participants experienced and managed different kind of interruptions. Interruptions can be both: internal and external. External interruptions result from events in the

environment. Internal interruptions come from our own thought processes - new ideas that draw attention from the current activity” (Miyata and Norman, 1986, p. 268).

In this study, internal interruptions captured from the think aloud data and the Camtasia software and external from the think aloud data as well as from the observation.

a) Internal Interruptions

Some examples are:

Participant 3: “I am so distractive. I am looking always for something else”.

Participant 25: “Oh! There is something else...” (and changed the query), “One think I forgot” (and from the information topics 4 went to the second information topics).

Participant 22: “I want to go to Facebook to relax for a while”.

Some of the participants gave reasons for this behaviour.

- “To get a break from intensive searching, which required more thought” (Participant 29).
- “I wanted to relax for a while” (Participant 13).
- “I went on Facebook to see if I had any notifications” (Participant 14).
- “I went on YouTube to listen music while I was searching. Music relaxes me. I also went on Facebook in order to find and save there any articles” (Participant 27).

b) External Interruptions

Some examples are:

Participant 11: She ate a snack while seeking on web. She answered on the pre-questionnaire that she felt tired before the information seeking process due to the hot weather.

Participant 8: He starred many times the windows and the outside environment and then focused again on the experiment. He checked his mobile phone multiple times during the experiment for some seconds.

4.10.1. Working Memory Groups

- The most frequent cognitive coordination sequence for both working memory groups was from STR (WSS) to IT. Most participants chose their preferred web search engine first and then examined the topic.
- The second most frequent cognitive coordination sequence was the other way around from IT to STR (WSS).

Table 39 shows numbers of the most frequent cognitive coordination sequences for each working memory group.

Most frequent cognitive coordination sequences	Numbers of the most frequent cognitive coordination sequences for each working memory group	
	Low working memory group	High working memory group
1 st frequent: STR to IT	156	226
most frequent sub strategy: WSS	76	99
2 nd frequent: IT to STR	135	202
most frequent sub strategy: WSS	65	78
Total number of cognitive coordination shifts	1090	1415

Table 39. Numbers of the most frequent cognitive coordination sequences for each working memory group.

Mann-Whitney U tests was performed to identify any significant differences between the two working memory groups. The results suggest that the high working memory group had a significantly higher number of cognitive coordination shifts than the low working memory group ($U=14$, $p=.005$).

Regarding the evaluating results and coordinating search techniques type for both working memory groups, the results showed that the most experienced mechanism was CRF, followed by SLR, TCF, TRF and MF. Regarding the sub strategies for both working memory groups, the results showed that the most experienced was WSS, followed by BR, TERM, QUERY and RS.

4.10.2. Disciplines

During the analysis regarding the three disciplines, it was found that:

- Mechanical engineers experienced more cognitive coordination sequences (n=1025) followed by psychologists (n=770) and accountants (n=710). The reasons are the same, which were provided for the cognitive state shifts.
- The most frequent cognitive coordination sequence for all disciplines was from STR (WSS) to IT. For one more time, most participants chose their preferred web search engine first and then examined the topic.
- The second most frequent cognitive coordination sequence for all disciplines was the other way around from IT to STR. WSS was the most frequent sub strategy for the mechanical engineers, whereas BS was for the psychologists and accountants.

Table 40 shows numbers of the most frequent cognitive coordination sequences for each discipline.

Most frequent cognitive coordination sequences	Numbers of the most frequent cognitive coordination sequence for each discipline		
	Psychologists	Mechanical engineers	Accountants
1 st frequent: STR to IT	132	165	82
most frequent sub strategy: WSS	56	69	54
2 nd frequent: IT to STR	115	135	67
most frequent sub strategy: WSS	-	52	-
most frequent sub strategy: BS	43	-	33
Total number of cognitive state shifts	770	1025	710

Table 40. Numbers of the most frequent cognitive coordination sequences for each discipline.

Mann-Whitney U tests was performed to identify any significant differences between the three disciplines. These results suggest that the mechanical engineers had a significantly higher number of cognitive coordination shifts than the accountants (U=57, p=.026). Regarding the evaluating results and coordinating search techniques type for the three disciplines, the results showed that the most experienced mechanism was CRF, followed by SLR, TCF, TRF and MF. Regarding the sub strategies for the three disciplines, the results showed that the most experienced was WSS, followed by BR, TERM, QUERY and RS.

4.10.3. Flow Groups

During the same analysis regarding the two flow groups, it was found that:

- The high flow group had more cognitive coordination sequences (n=1412) than the low flow group (n=1093). People with high flow were more engaged, so they precede to more cognitive coordination sequences in contrast to the low flow group.
- The most frequent cognitive coordination sequence for both flow groups was from STR (WSS) to IT.
- The second most frequent cognitive coordination sequence for both flow groups was the other way around from IT to STR (WSS).

Table 41 shows numbers of the most frequent cognitive coordination sequences for each flow group.

Most frequent cognitive coordination sequences	Numbers of the most frequent cognitive coordination sequences for each flow group	
	Low flow group	High flow group
1 st frequent: STR to IT	145	224
most frequent sub strategy: WSS	68	101
2 nd frequent: IT to STR	132	167
most frequent sub strategy: BS	53	78
Total number of cognitive state shifts	1093	1412

Table 41. Numbers of the most frequent cognitive coordination sequences for each flow group.

Mann-Whitney U tests was performed to identify any significant differences between the two flow groups. The results suggest that the high flow group had a significantly higher number of cognitive coordination shifts than the low flow group (U=58, p=.025). Regarding the evaluating results and coordinating search techniques type for both flow groups, the results showed that the most experienced mechanism was CRF, followed by SLR, TCF, TRF and MF. Regarding the sub strategies for both flow groups, the results showed that the most experienced was WSS, followed by BR, TERM, QUERY and RS.

All participants regardless of their working memory and flow levels as well as their disciplines, had the same the first two cognitive coordination sequences. These results differ from those of Du (2010), who suggested that the most frequent coordination sequence was that from one type of mechanism to another. From the results of this study, it is obvious that people switched more between the coordination of their preferred strategies and the topics.

The most frequent cognitive mechanisms exhibited by participants were the content relevance feedback followed by the self-learning and regulating process. The magnitude feedback mechanism seldom occurred. Table 42 shows the number of the cognitive mechanisms of this study.

Cognitive Mechanisms	Number
Content Relevance Feedback	349
Self-learning and Regulating	151
Tactical Review Feedback	98
Term Relevance Feedback	77
Magnitude Feedback	19
Total	694

Table 42. Number of cognitive mechanisms.

Table 43 shows the total number of coordination occurrences for each coordination type for each group

		Groups of participants						
		High WM group	Low WM group	Psychologists	Mechanical Engineers	Accountants	High flow group	Low flow group
Coordination types	Evaluating results and coordinating search techniques	347	347	195	230	269	340	354
	Strategy	569	384	260	406	275	555	397
	Information task	355	283	219	280	127	361	266
	Knowledge	91	52	62	63	26	91	55
	Interruptions	53	24	34	46	13	65	21

Table 43. Number of coordination occurrences for each coordination type for each group.

4.11. Cognitive Load

As mentioned in the literature review, the high cognitive load may affect the information seeking performance as well as the cognitive shifts and coordination sequences. Cognitive load was measured with the Short Subjective Instrument (SSI) in the post-questionnaire (Paas et al., 1994; Gimino, 2002). People are able to provide reliable answers about their levels of cognitive load (Gopher and Braune, 1984). 21 participants felt significant cognitive load from 4 and above on the 7-item Likert scale. The results showed that:

- Six were psychologists, seven were accountants and eight were mechanical engineers.
- Nine had high working memory and 12 had low working memory.
- Ten had high flow, and 11 had low flow.

The Mann-Whitney U test was also performed in order to evaluate possible differences between the two working memory groups, the three disciplines and the two flow groups. No significant differences were found regarding the cognitive load of information topics with prior and without prior knowledge.

4.12. Time Pressure

Only six participants from the total 30 felt significant time pressure from 4 and above on the 7-item Likert scale:

- Two were psychologists, three mechanical engineers and one accountant.
- Two had high working memory and four had low working memory capacity.
- Two had high flow, and four had low flow.

From these results, it seems that time pressure did not affect the majority of the participants. The Mann-Whitney U test did not find any significant difference between the two working memory groups, the three disciplines and the two flow groups.

Chapter 5 DISCUSSION

This chapter discusses the findings from the Results chapter relating them to the issues and hypotheses of this research and previous research. Based on the results a new more integrated model for multitasking information behavior is presented showing the relationships between multitasking information behavior, cognitive state shifts, cognitive coordination shifts, working memory and flow as described in the PAT model. Then the implications and significance of the study are discussed.

5.1. Key Findings of this Study

This section discusses the most important findings of this study. It highlights the new findings and differences between these and previous related studies.

5.1.1. Working Memory and Flow

The results have provided statistical evidence that there is no relation between working memory and flow. This means that having different working memory levels did not affect people's flow levels. Thus, the first hypothesis of flow is rejected. The first hypothesis of flow of this research mentioned that people's different working memory levels would affect their levels of engagement to multitasking information behavior. However, this assumption has not been proved.

5.1.2. Multitasking Information Behavior

Multitasking was found to be the major element of this study. All participants when trying to solve a set information task used multiple web search engines, various reformulated queries and opened multiple windows/tabs. This was characterised as a web search session. All participants were seen to have multiple search tabs open using multiple web search engines and entering different queries, meaning that they conducted multiple web search sessions at the same time or simultaneously. Spink (1996) found that 56.5% of the users in her experiment conducted multiple web search sessions. She investigated users' web search sessions while using online catalogs and CD-ROM public access databases. Du (2011) found that 42 participants conducted 315 web search sessions when they searched information on the web for three unrelated topics in one hour. In this study, similar data was gathered; participants conducted 406 web search sessions for four information topics in one hour.

It confirms that multitasking is common practice noticeable behaviour when using the web (Ozmutlu et al., 2003a, 2003b; Benbunan-Fich and Truman, 2009; MacKay and Watters, 2012).

5.1.2.1. Information Topics

Most of the participants switched the order of the information topics and only a few followed the order that was given to them. Working memory and flow levels as well as disciplines did not affect this behaviour. The factors that influenced the chosen order of the information topics were mostly the degree of interest in the topic and level of knowledge. However, the degree of boredom and tiredness experienced by the participants also affected the order in which they searched. People preferred to start seeking topics where they had prior knowledge and changed their order when they felt bored. These results confirm Spink et al. (2006) as well as Du's (2011) findings, who suggested that people's familiarity with the topic as well as personal interest were two major factors that influenced task ordering. Additionally, personal factors like boredom and tiredness, found in this study were also found to have an impact in the two studies above.

From the web search analysis it seemed that there were three types of information searching undertaken: the original information topics, the evolving information topics and serendipity browsing. These results confirm the findings of Du (2011), who also found similar results.

Regarding the second type of information, Spink (1996, 2004) found that evolving information topics were a crucial component of the information seeking procedure when using the web. Du (2010) found that over 70% of her study participants generated evolving information topics. In this experiment, 28 participants, generated evolving information topics. Where this didn't happen, the participants were both accountants, a discipline that had the lowest number of evolving information topics. On further examination of the web logs and questionnaires, it seemed that one of them was tired and wasn't very motivated before the start of the information seeking process whereas the other one, while motivated, knew exactly what she wanted to search, reducing the need to generate further information topics.

Spink (2004) found that serendipity browsing formed an important part of the information seeking process. One participant, for example, in her experiment while searching the library shelves, saw, by chance, some political books unrelated to the information task, read one and finally borrowed one book. Many other researchers also support the importance of serendipity browsing in the information seeking process (Van Andel, 1994; Foster and Ford, 2003; Erdelez, 2005; Palsdottir, 2011; Dantonio et al., 2012). Conversely, however, Du (2011), did not find serendipity browsing to be an important phenomena; participants preferred searching either for the original or the evolving information topics. The results of this study confirmed Du's findings. In this study, the majority of participants primarily restricted their search to the original and evolving information topics, only a small number of participants deviated from their information topics to explore new topics. This confirms previous studies, which stated that some participants might experience serendipity more frequently than other participants (Erdelez, 1999; McBirnie, 2008; Sun et al., 2011).

People with high and low working memory generated almost the same number of evolving information topics. Regarding flow, the low flow group had a lower number of evolving information topics than the high flow group. This implies that people with high flow were more actively engaged with the information seeking process and generated more information topics.

There were a number of interesting findings regarding the disciplines and the number of their evolving information topics. Accountants had the lowest number of evolving information topics whereas mechanical engineers had the highest. Accountants also had a significantly lower number of cognitive state and coordination shifts, compared to other disciplines, and mechanical engineers had the highest. These findings are analysed in detail in the following sections. From the analysis of web logs and the interviews, it was indicated that the nature of information topics for both disciplines was the reason for these behaviours. The accounting information topics were regarded as being more straightforward and more specific and so accountants were more focused whereas engineering topics were often evolving and less structured, resulting in the need to be more flexible in the way they searched for information.

On the other hand, psychologists generated fewer numbers of evolving information topics than mechanical engineers but more than accountants. They mostly changed keywords rather than altering the main context. This was either because participants' did not possess the information seeking capabilities to use the right keywords or this was due to the complex nature of the psychological information topics or both.

5.1.2.2. Multiple Web Search Sessions

There were no statistical differences regarding the mean number of queries, the number of opened tabs or the number of web search sessions generated between the two working memory groups. There were some significant differences concerning the three disciplines, however. Compared to the other two disciplines accountants made significantly less queries, opened fewer windows and made less web search sessions. The results for the mechanical engineers were the opposite. Mechanical engineers also generated more cognitive state and coordination shifts, which are explained in detail in the following sections.

The analysis of the think aloud data, the post questionnaires as well as the interviews revealed that, the nature of the topics were catalysts for this behaviour. These results can also be linked to the number of evolving information topics for each discipline. Mechanical engineers generated more queries because they also generated more evolving information topics when trying to find up-to-date information for a range of topics. On the other hand, accountants and psychologists generated fewer queries and web search sessions and produced fewer evolving information topics.

5.1.3. PAT Model

5.1.3.1. Artefact Characteristics

The PAT (person, artefact, and task) model by Finneran and Zhang (2003) suggests that these variables are flow's antecedents in human-computer environments. They investigated how these propositions influence people's flow experience.

An artefact must have telepresence, which involves vividness and responsiveness (Finneran and Zhang, 2003). In the study reported here, participants rated on a 7-point Likert scale, in the post-questionnaires, the degree of vividness for each web search system they used during the information seeking process and the degree of the

network speed during the experiment. The two working memory groups felt that the levels of vividness and network speed were high. However, there were no statistical differences between the groups.

There were also no differences between the two flow groups. However, regarding the PAT model of Finneran and Zhang (2003) the flow group would have been expected to have high scores of vividness and responsiveness explaining their high flow levels whereas people with low flow should have experienced low levels of telepresence in order to explain their low flow levels. This did not happen in this study. Both groups had high levels of vividness and responsiveness supporting the PAT model only for the high flow group. This means that people with low flow felt that the web characteristics were vivid, the network speed was quick enough, and yet they had low flow levels. The artefact characteristics were, therefore, not responsible for their flow levels.

However, there was a significant difference between the three disciplines. Accountants experienced a highest mean of vividness compared to psychologists and mechanical engineers. From the interviews and the think aloud data, accountants claimed that the web sites, which they visited and which had information that was relevant to their topics, were vivid and explanatory. They could easily understand the information they read without any frustration or difficulty in conjunction with the simple nature of the topics. Accounting information topics were regarded to be more straightforward, which means that most web sites were also regarded to be more vivid than other web sites providing information related to the other two disciplines.

Regarding vividness and how people perceive it, Finneran and Zhang (2003, p. 481) explained, "the interaction between the person and the artefact also involves clear artefact goals, which indicate that the person knows how to perform a specific action using the artefact. The sense of control indicates that the person feels that he/she is in control of the particular artefact". In this experiment, accountants were regarded to have clearer goals regarding the topics and the artefacts than the other two disciplines and the nature of the topics was the key for this behaviour.

Vividness was high for accountants and that is connected with the less web search sessions and fewer number of evolving topics due to their specific goals. Thus, it can be argued that vividness maybe connected not only with the type of artefacts but also with the nature of each topic. Finneran and Zhang (2003) have provided an assumption connecting the artefact and the task that states: “a person is more likely to experience flow if there is a clear fit between task and the artefact” (Finneran and Zhnag, 2003, p. 487). However, they do not explain in detail what “a clear fit” means. It seemed that the definition of Finneran and Zhang (2003) regarding vividness could be more specific. Therefore, a new definition of vividness is proposed:

Vividness is the interaction between the artefact and the person which is associated with clear artefact goals. The type of artefact, which in their turn may be influenced by the academic nature of the information topic, affects the clarity of their goals. Together these may lead to a greater sense of control by the person.

5.1.3.2. Task Complexity

Finneran and Zhang (2003) proposed that the complexity of information tasks might have a positive or negative influence on flow. They stated that “a person is more likely to experience flow if the task is more goal-oriented, autonomous, enables more variety, and at the appropriate level of complexity” (Finneran and Zhang, 2003, p. 487). A complex task could lead either to high levels of flow because it may be considered as a challenge or to low flow levels as it would also be considered as being daunting. However, they did not explain what a complex task means, what it involves or by what factors may be affected.

In this study, each participant rated the level of complexity of each information task in the pre and post questionnaires on a 7-point Likert scale. Both flow groups felt that the topics were at the right level of complexity. People with high flow felt that when topics were complex and challenging, this led them to experience high flow, whereas people with low flow felt that high task complexity was challenging causing them to feel anxious. A similar result was found by Finneran and Zhang (2003).

Regarding the three disciplines, the most significant difference between the groups was that accountants felt that task complexity at the end of the information seeking

procedure was significantly less for topics without prior knowledge. This result can be connected with the number of cognitive state and coordination shifts. Seven out of 10 accountants generated less cognitive states and coordination shifts for topics without prior knowledge compared to the topics for which they had prior knowledge. The same explanation, which was given for the number of the evolving information topics as well as for the number of queries, opened windows and web search sessions, can be used. The straightforward nature of the accounting topics made the information topics without prior knowledge easier.

Finally, regarding working memory and task complexity, the results are interesting. Participants with low working memory capacity felt that task complexity, at the end of the seeking procedure, was higher for topics without prior knowledge than for topics with prior knowledge. As working memory and flow are not related to each other, these results indicate something different as shown below.

The thematic analysis of the web logs, found that 13 of the total 15 participants in the low working memory group generated less cognitive state and coordination shifts for topics without prior knowledge than for topics with prior knowledge. On the other hand, seven people from the total 15 from the high working memory group generated less cognitive state and coordination shifts for topics without prior knowledge than for the topics with prior knowledge. This indicates that people with low working memory felt that the complexity of the topics without prior knowledge meant that they did not or could not generate many cognitive state and coordination shifts. For example, they could not generate more strategies or evaluate and judge the content of the webpages in the same way as they did for the topics with prior knowledge. People with low working memory are less able to allocate their attention to relevant information in contrast to people with high working memory, who tend to allocate their attention to task-relevant information and coordinate information more successfully (Engle et al., 1999). In this experiment, it seemed that, people with low working memory found it more difficult to focus their attention on relevant information especially for topics without any prior knowledge and therefore experienced a lower level of cognitive state occurrence (less cognitive state and coordination shifts).

The above findings show that task complexity is related to the nature of the topics as well as to the levels of working memory and the prior knowledge of the topic. Bearing this in mind, a new proposition for task complexity would be more suitable involving the above findings. Thus, the proposition of task complexity stemming from the PAT model of Finneran and Zhang (2003) could be as follows:

A person is more likely to experience flow if the task is varied, at the right level of complexity, is goal-orientated and autonomous. Furthermore, people with low working memory when working on information topics with which they have no or little prior knowledge may experience higher task complexity than people with high working memory.

5.1.4. Cognitive Shifts

This section presents the key findings regarding the cognitive shifts during the web search. These findings are related and compared to the findings from previous studies. Cognitive shifting was found to be an important aspect of web interaction and information seeking behaviour. Two cognitive shifts types were identified: the holistic and the state shifts. Holistic shifts were the holistic change in people's knowledge regarding one information topic whereas cognitive state shifts were participants' cognitive changes between the topic, strategy, evaluation, view and overview as discussed below.

5.1.4.1. Cognitive Holistic Shifts

In this study, the cognitive holistic shifts were identified with the pre and post questionnaires with respect to the degree of change of knowledge, the degree of becoming informed about the topics and the change of depth of peoples' knowledge before and after the information seeking process.

The study results confirm Spink's (2002), Spink and Dee's (2007) as well as Du's (2011) findings, which suggested that participants reported three types of holistic shifts: forward, backward and no holistic shift. The results confirmed Du's (2011) findings, which stated that most people experienced forward holistic shifts. In this study the degree of change of knowledge for all participants regardless group was 3 and

above on a 7-point Likert scale. Furthermore, most participants became more informed about the topics and gained more depth of knowledge.

The most important finding was that the high flow group had significantly higher degree of change in knowledge for information topics without prior knowledge compared to the low flow group. The degree of change of knowledge for the high flow group was higher for topics without prior knowledge than for topics with prior knowledge. These results indicate two things. First, people with high flow were more inclined to search and learn something new rather than find information for familiar topics. Their high levels of attention, interest, concentration and engagement were a significant influence. These results confer with Finneran and Zhang's (2003) research which stated that high levels of flow lead to better performance (Massimini and Carli, 1988; Csikszentmihalyi, 1997; Chen et al., 2000; Finneran and Zhang, 2003; Shin, 2006). Thus, people with high flow gained more knowledge than people with low flow.

5.1.4.2. Cognitive State Shifts

Cognitive state shifts were the cognitive state changes, which are synonymous with the mental activities and the associated behaviour and the interaction between the user and the web. Spink (2002) and Spink and Dee (2007) found that people only experienced cognitive holistic shifts. In this study, like Du (2011), five types of cognitive states were identified through the thematic analysis of the web search logs: topic (TOP), strategy (STR), evaluation (EVA), view (VIE), and overview (OVE). In this study, the first cognitive state, topic was renamed as current search goal (CSG) and follows Xie (2000) and Daniels (1986) who also used this term in order to describe the information problems that are determined by each task. Unlike Du (2011), the cognitive state strategy, in this study, was divided into five sub strategies to provide a clearer idea of which strategy each group of participants used most: term selection (TERM), query reformulation (QUERY), web search system selection (WSS), results saving (RS), and browsing more results (BR). Table 44 shows the differences of the identified types of cognitive state between this study and Du's (2011) study.

Cognitive State Types	Cognitive State of Du's study (2011)
<ul style="list-style-type: none"> • Current search goal • Strategy Sub strategies: <ol style="list-style-type: none"> i. term selection ii. query reformulation iii. web search system selection iv. results saving v. browsing more results <ul style="list-style-type: none"> • Evaluation • View • Overview 	<ul style="list-style-type: none"> • Topic • Strategy • Evaluation • View • Overview

Table 44. Comparison between this study and Du's study (2011) regarding the cognitive state types.

The results differed from those of Du (2011) who found that the most experienced cognitive state was strategy followed by view whereas in this study strategy was followed by the current search goal. This study showed that people paid more attention to strategies, then they chose one information topic and evaluated the content of the webpages. For example, participant 29 first chose his preferred web search engine, which was the Google Scholar and then he decided to start with the second information topic. Then, he evaluated the content of a specific webpage (e.g. if the information was relevant or not, if there were images or not etc.).

The results showed that all participants regardless of their working memory and flow levels as well as their disciplines had the same frequency of cognitive state shifts: from strategy to current search goal, and from current search goal to strategy. These results differ from those of Du (2011), who suggested that people shift their attention more between their strategies and their evaluation of the results. From the results of this study, it was evident that people moved between their preferred strategies for information seeking and their decisions about whether to start a new information topic or to continue their search.

The most common activities involving cognitive state shifts were the web search system selection, the strategy of browsing more results, term selection, query reformulation and finally saving the results. This means that people chose their

preferred web search engine in order to start seeking information irrespective of the topic.

The high working memory group had a higher number of cognitive state shifts than the low working memory group meaning that they switched between their information topics, search queries, results and evaluation more times in order to find the information they wanted. This result supports the previous literature that working memory is a predictor and mediator for multitasking (König et al., 2005; Bühner et al., 2006; Juvina and Oostendorp, 2006; Hambrick et al., 2010; Colom et al., 2010) and confirms the first hypothesis of this study regarding working memory. It also confirms the findings of Butler et al. (2011), who suggested that people with low working memory can also multitask, but their performance is lower than participants' performance with high working memory. As mentioned earlier, performance in this study is considered to be related to the number of the cognitive state and coordination shifts as well as to the degree of change in knowledge. People with high flow therefore had better performance than people with low flow producing more cognitive state shifts.

It was also mentioned earlier that task complexity for the low working memory regarding the topics without prior knowledge was connected with fewer cognitive states shifts for these topics. These findings support the suggestion of Engle et al. (1999) that people with low working memory cannot easily allocate their attention to finding relevant information in contrast to people with high working memory, who can allocate their attention to task-relevant information and coordinate information more successfully.

Regarding flow, people with high flow generated more cognitive state shifts than the low flow group. They were more engaged and so they experienced more cognitive state shifts compared to the low flow group. These results confirm previous studies which stated that flow enhances information behaviour and performance as well as provokes positive outcomes (Massimini and Carli, 1988; Chen et al., 2004). This study supported Hoffman and Novak's (1996) suggestion that web consumers had more positive behaviours and learning outcomes when they experienced flow.

As far as disciplines are concerned, accountants had significantly lower number of cognitive state shifts and mechanical engineers had the highest. These results confirm and support the results from the queries, opened tabs, web search session as well as the number of the evolving information topics. The nature of the accounting information topics, which were regarded as being more straightforward, did not lead them to change between many cognitive states whereas the psychological and mostly the engineering information topics were regarded as more complicated and were associated with more cognitive state shifts.

5.1.5. Cognitive Coordination Types

Cognitive coordination was found to be another important factor affecting multitasking information behaviour while using the web. Cognitive coordination describes the mechanisms which combines all the cognitive state shifts and cognitive processes (Crowston, 1994) as described below.

Unlike Du (2011), who found three coordination levels (Information Task, Mechanism and Strategy coordination levels), this study identified five coordination types adding two types:

- The Information Task coordination type (the coordination of all topics),
- The Evaluating results and coordinating search techniques type (this includes all the mechanisms that help the information task coordination),
- The Strategy coordination type (the strategic plan for the whole seeking process),
- The Personal Knowledge coordination type,
- The Interruptions (external and internal) and Management coordination type.

The strategy coordination type in Du (2011) involved the specific strategy, which includes the formulation of queries and terms, the choice of web search engines, and the global strategy like time allocation. In this study, the specific strategy was explored in detail and it involved sub strategies, the same that have been identified for the cognitive state shifts: term selection (TERM), query reformulation (QUERY), web search system selection (WSS), results saving (RS), and browsing more results (BR).

Table 45 shows the differences of the identified cognitive coordination types between this study and Du's (2011) study.

Cognitive Coordination Types	Cognitive Coordination Levels of Du's study (2011)
<ul style="list-style-type: none"> • Information Task type • Evaluating results and coordinating search techniques type • Strategy type: <ol style="list-style-type: none"> 1. Specific Strategy Sub strategies: <ol style="list-style-type: none"> 1.1. term selection 1.2. query reformulation 1.3. web search system selection 1.4. results saving 1.5. browsing more results 2. Global Strategy <ul style="list-style-type: none"> • Personal Knowledge type • Interruptions and Management type: <ol style="list-style-type: none"> 1. internal 2. external 	<ul style="list-style-type: none"> • Information Task level • Mechanism level • Strategy level: <ol style="list-style-type: none"> 1. Specific Strategy 2. Global Strategy

Table 45. Comparison between this study and Du's study (2011) regarding the cognitive coordination types.

1. Information Task type

The information task type involved the coordination between the original information topics, the evolving information topics and the serendipity browsing. Serendipity browsing seldom occurred during the information seeking sessions in this study.

2. Evaluating results and coordinating search techniques type

The evaluating results and coordinating search techniques type involved all the mechanisms such as content relevance, magnitude feedback, self-learning and regulating, tactical review feedback and term relevance feedback.

The results showed that the ranked order of the frequency of cognitive mechanisms exhibited by participants were the content relevance feedback followed by the self-learning and regulating process. The magnitude feedback mechanism seldom occurred. Table 46 compares the ranked order of the frequency of the different types of mechanism of this study between Du's (2011) and Spink's (1997) study.

This study	Du's study (2011)	Spink's study (2011)
<ol style="list-style-type: none"> 1. Content Relevance Feedback 2. Self-learning and Regulating 3. Tactical Review Feedback 4. Term Relevance Feedback 5. Magnitude Feedback 	<ol style="list-style-type: none"> 1. Self-learning and Regulating 2. Content Relevance Feedback 3. Tactical Review Feedback 4. Magnitude Feedback 5. Term Relevance Feedback 	<ol style="list-style-type: none"> 1. Magnitude Feedback 2. Content Relevance Feedback 3. Term Relevance Feedback 4. Tactical Review Feedback 5. Term Review Feedback

Table 46. Ranked order of the frequency of the different types of mechanism of this study between Du's (2011) and Spink's (1997) study.

Below the differences between these three models are explained.

- The frequencies of cognitive coordination mechanisms between this study and Du's (2011) study are not the same. Only the tactical review feedback remained in the same ranked order in both studies.
- Feedback mechanisms in this study as well as in Du's (2011) study were examined under different contexts than Spink's (1997) study. In Du's and this study feedback resulted solely from an action by the user. In Spink's (1997) study, feedback mechanisms could be generated either by a user or by a search intermediary.
- The tactical review feedback in Spink's (1997) study described as participants' judgements followed by a strategy judgement which led to query reformulation. However, in this study as well as in Du's (2011) study, the tactical review feedback led to both query reformulation as well as web search engine changes.
- Self-learning and regulating feedback was explored and occurred frequently in this study and in Du's (2011), which was about people's judgements and sense-making process regarding the information on the opened webpages.
- The term review feedback which in Spink's (1997) study was concerned with users' strategy-related judgements based on requested display terms from search intermediaries was not included in this study because intermediaries were not involved.

- Magnitude feedback in this study and in Du's (2011) study seldom occurred whereas in Spink's (1997) study it was found to be a major feedback mechanism.

3. Strategy type

The strategy coordination type involved the plans that participants used to seek and find the information they wanted. The specific strategy and the global strategy identified in this study confirmed the results of Du (2011) and Park (2008). In this study, however, the researcher identified five sub-strategies and explored in-depth each strategy. Web search system selection was found to be the most frequent sub strategy followed by browsing the results, term selection, query reformulation and finally the saving of the results.

Global strategy guided the information seeking procedure. It was about users' decisions about how to allocate the one hour seeking time to the four information topics.

4. Personal Knowledge type

Unlike Du (2011), in this study two more types were identified. The type of personal knowledge involved participants' subjective judgements and evaluations regarding their level of knowledge for each information topic during the information seeking process. Participants evaluated their level of personal knowledge or the possible gaps they might have while they searched information on the web.

5. Interruptions (internal and external) and Management type

The new type that has been identified during the information seeking process and explored was the type of interruptions. Two kinds of interruptions have been identified supporting the suggestions of Miyata and Norman's (1986): external and internal interruptions.

Internal interruptions were participants' irrelevant thoughts which drew their attention away from topics during the information seeking process. External interruptions were interruptions from the environment, which cause participants' diversion of their attention for some seconds or minutes. Even though the research was conducted in a

controlled quiet environment, even small environmental factors could possibly distract participants from their information seeking process. This meant the study was to some extent more realistic and that it was not a completely controlled environment.

The results showed that all participants regardless of their working memory and flow levels as well as their disciplines had same the first two frequent cognitive coordination sequences: from strategy to topic, and from topic to strategy. In contrast Du (2011), suggested that the most frequent coordination sequence was that from one type of mechanism to another. The results of this study showed that coordination was mostly between the participant's preferred strategies in order to choose the most appropriate and then to proceed to the decision of their topics. These results also reject the second hypothesis of working memory and the second of flow, which supported that different working memory and flow levels might influence the coordination shifts.

Moreover, the most frequent sub-strategy for the two first cognitive coordination shifts was the web search system selection (with some exceptions) followed by the strategy of browsing more results. This means that people chose first their preferred web search engine in order to start seeking information.

The number of cognitive coordination shifts regarding the groups were similar to the number of the cognitive state shifts. Participants in the high working memory group had a higher number of cognitive coordination shifts compared to those in the low working memory group. These findings again support previous research with regard to working memory and its effect on multitasking behaviour (König et al., 2005; Bühner et al., 2006; Juvina and Oostendorp, 2006; Hambrick et al., 2010; Colom et al., 2010). The findings also supports the first hypothesis of working memory which states that working memory affects multitasking information behaviour while searching on the web. Task complexity for the low working memory group regarding the topics without prior knowledge was connected one more time with the fewer cognitive coordination shifts for these topics. These findings support again the suggestion of Engle et al. (1999).

People with high flow generated more cognitive coordination shifts than the low flow group confirming again the previous studies about flow's positive role in performance and information (Massimini and Carli, 1988; Chen et al., 2004).

Regarding the three disciplines, accountants had significant lower number of cognitive coordination shifts and mechanical engineers had the highest. These results support the results from the cognitive state shifts, queries, opened tabs, web search session as well as the number of the evolving information topics.

5.1.5.1. The Relationship between the Five Types of Cognitive Coordination

The findings of this study showed that people experienced coordination in sequences and that all groups experienced the most coordination sequences first at the strategy type, then at the evaluating results and coordinating search techniques type, followed by information task, knowledge and finally interruption (internal and external) and management type.

Regarding the relations and interplay between the coordination types, Du (2011) claimed that the information task level was the first level and initiated the information seeking process followed by the strategies and pushed by the mechanisms. For example, Du (2011) suggested that participants seek for information for one topic (information tasks type), then they select one strategy (strategy type) and then they follow using some mechanisms (evaluating results and coordinating search techniques type). The findings of this study, however, showed that there were no specific patterns or sequences of activities; and in fact participants seemed to be moving from one activity to another in any direction apart from the fact that evaluating results and coordinating search techniques type, could never have initiated the information seeking process (Figure 14).

Figure 14 below demonstrates the relationship between the five types of cognitive coordination.

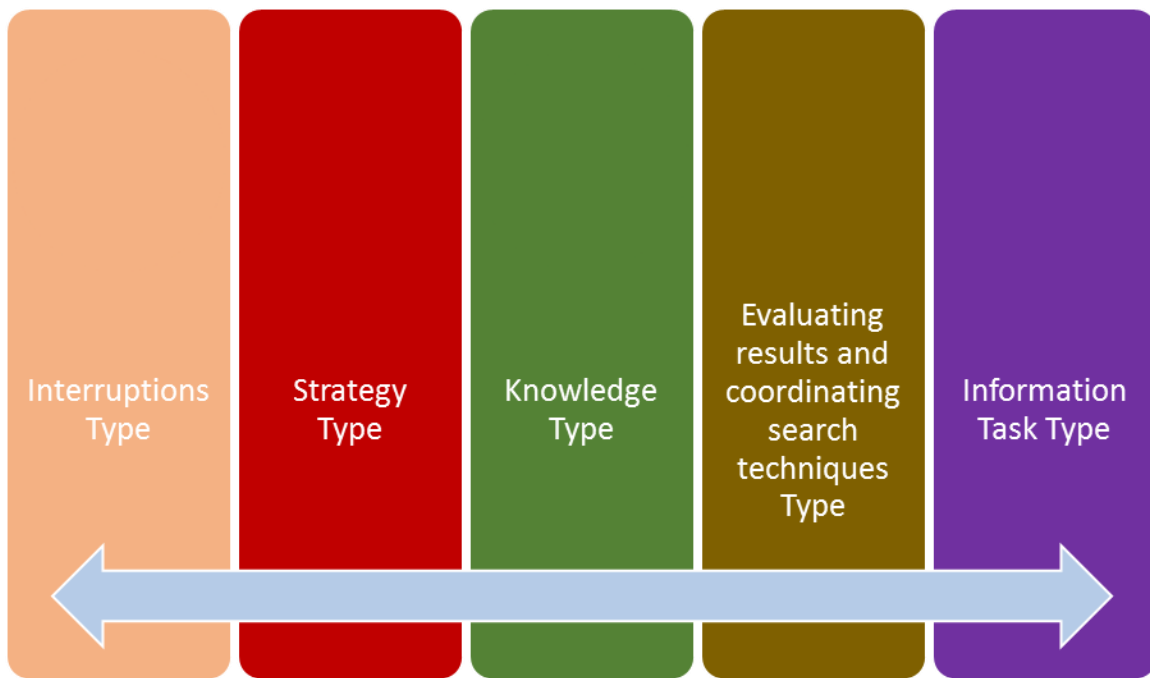


Figure 14. Relationships between the five types of cognitive coordination.

There were sequence transitions between the coordination types. For example, a person started by choosing a web search engine and then continued searching on their information topic, then they might think about something not directly connected with the topic, then returned to the same and continued with one mechanism, followed by acknowledgement of the gap in their knowledge.

For example, participant 15 started his information seeking process choosing the “Google” web search engine, then he chose the information topics he wanted to search. This was interrupted by an internal thought about another irrelevant topic. He started searching for that irrelevant topic and then he searched for the first original chosen information topic/task. In this example, the strategy coordination type was adhered to and this was followed by the interruption type. In another example, Participant 23 said, during the think aloud aspect of the experiment that, she had knowledge on the original topic before she started seeking for information on the web (she explained what and how she knew). She then decided to start with that information topic and selected the web search engine she wanted to use.

At a higher level, this diagram indicates that information seeking is therefore not a linear and simple process. It is more a complex process whereby people choose different routes.

5.2. A new more Integrated Model

The aim of this research was to enhance knowledge about multitasking while using the web and provide a new, integrated, and a more comprehensive framework to help describe multitasking. The major research question was:

To examine the effects of working memory, flow as defined by the PAT model, cognitive coordination and cognitive shifts on multitasking information behaviour while using the web.

This study investigated possible relationships between these variables. The lower part of preliminary theoretical model on page 89 proposed a relationship between multitasking while using the web, working memory and flow as influenced by the PAT model. The results of the study shows that working memory capacity does not relate to flow. Based on the findings of this research, therefore, Figure 15 presents the new revised model illustrating the relationships between multitasking information behaviour, working memory, cognitive coordination, cognitive shifts, disciplines, and flow influenced by the PAT model.

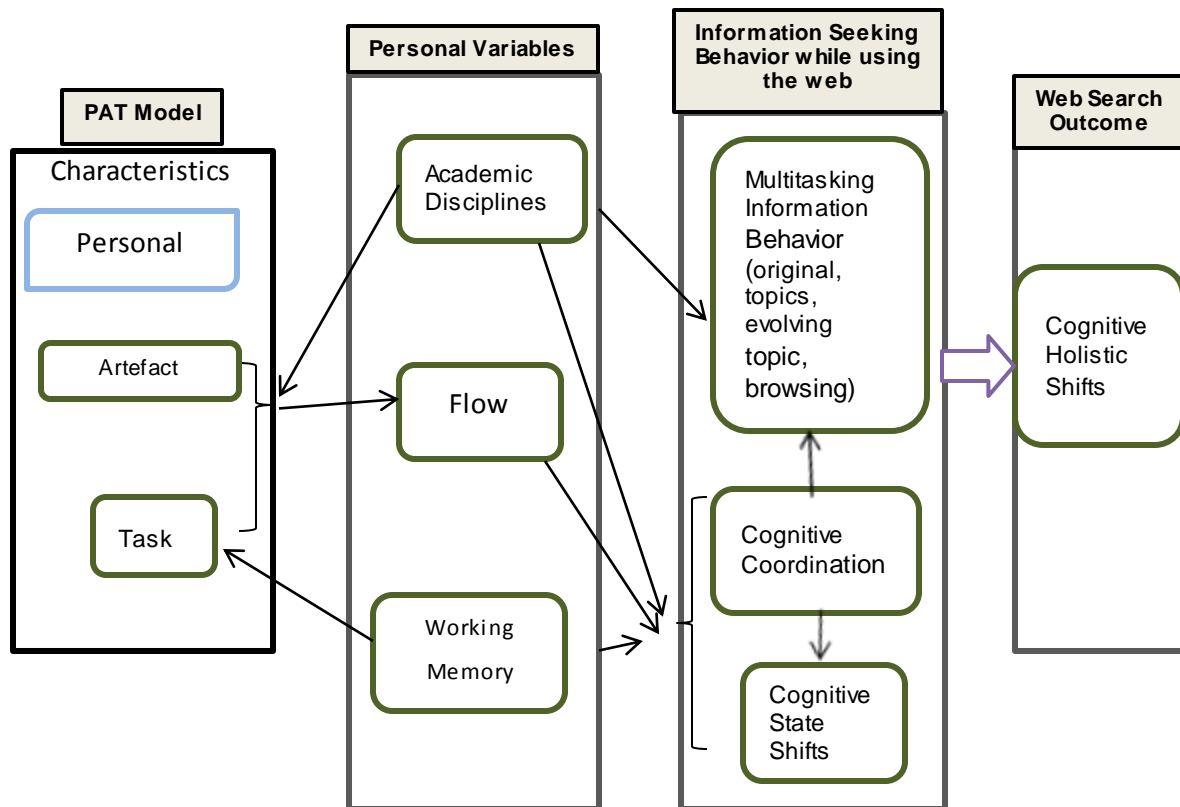


Figure 15. The new model

* = variables that have been investigated

= characteristics that have not been investigated

- The above model illustrates how the personal variables, which have been explored in this study, interact and influence multitasking information behaviour while using the web as well as the cognitive state and coordination shifts. Different disciplines, flow and working memory levels generated a different number of cognitive coordination and state shifts for different reasons. For example, people with high flow and working memory capacity had more cognitive coordination and state shifts.
- The model indicates the dynamic interaction between the personal variables and the information seeking behaviour while using the web. The identification of the impact of those personal variables on the multitasking information behaviour, cognitive coordination and cognitive state shifts provide a better understanding of the underlying cognitive mechanisms of the information

seeking process. The role of working memory as well as flow have been explored.

- This research showed that the web search outcome, which is the cognitive holistic shifts, is multidimensional and depends on people's personal variables. It also reveals that there is an interaction between people's variables and cognitive procedures during the information seeking process.
- In this study, the first two factors of the PAT model have been explored except the personal characteristics as they were described by Finneran and Zhang (2003) (exploratory behaviour, playfulness, absorption, his current state is conducive to time distortion and loss of self-consciousness). Tasks, artefacts and personal characteristics are the major components of the PAT model. As it was mentioned in the Literature review chapter, the further exploration of the personal characteristics of the PAT model was not the purpose of this study. The purpose was the exploration of the task and artefact characteristics on the web and their relationships with the other variables. Task and artefact characteristics are influenced by the different nature of disciplines. People's different working memory levels, as it has been found, also influence task complexity.
- The research supported that disciplines was the only variable which strongly provided sufficient evidence for different multitasking information behaviour meaning number of original and evolving information topics as well as web search sessions, queries and opened windows/tabs.
- The above model illustrates that cognitive coordination, which involved the five coordination types was responsible for the coordination of the information topics (multitasking information behaviour) as well as for the cognitive state shifts. It is the human ability to coordinate the web searches and to provoke the complicated cognitive state shifts.
- People's information seeking behaviour was also affected by various other personal factors, which have not been explored in this study. They have been identified, however, through the detailed literature review combining both fields of Psychology and Information Science.
- Unlike Du's (2011) model, the cognitive holistic shifts that have been characterised in this model as the web search outcome and not as part of the

cognitive shifts. Cognitive holistic shifts are people's general change of knowledge regarding the information topics after the information seeking procedure. The aim of each web seeking behaviour is for people to gain knowledge, learn something new or even identify their possible knowledge gaps. People mentioned at the end of the experiment how much their knowledge and its depth has changed for each information topic as well as whether they had become informed.

- Another difference between this model and Du's (2011) is that the relationships between the cognitive coordination types have been further changed. In this model, all coordination types interact and affect each other as shown in Figure 13. Therefore, there are no levels of cognitive coordination rather than types of cognitive coordination.

5.3. Theoretical Implications

This section discusses the theoretical implications of this study and the possible contributions to user-web search model, human-computer interaction, and interactive information retrieval research.

5.3.1. Multiple Web Search Sessions

This study, exploring multitasking information behaviour, found that people conducted multiple web search sessions when seeking information for different topics. A web search session was defined as people's submission of an entire sequence of queries, tabs and web search systems for one information topic. All participants performed multiple web search sessions using multiple queries, web search systems and windows/tabs.

These findings confirm those of Spink (1996) who suggested that people conducted multiple web search sessions driven by evolving and original information topics. It confirms previous researchers that multitasking information behaviour while using the web exists (Ozmutlu et al., 2003a, 2003b; Benbunan-Fich and Truman, 2009; MacKay and Watters, 2012). It also confirms Du's (2011) findings, who found that 42 participants in her experiment conducted 315 web search sessions when they searched information on the Web for three unrelated topics in one hour. In this study, participants conducted 406 web search sessions for four information topics in one

hour. Some previous studies have focused on users' searches using single information topics and single information retrieval systems (Saracevic et al., 1990; Huang, 1992). Multitasking information behaviour is a more complicated behaviour in which multiple web sessions are important factors.

5.3.2. Task Switching and Cognitive Coordination

As discussed in the Results chapter most participants switched the order of the information topics. There were six reasons for that information behaviour: degree of interest, level of knowledge, boredom, tiredness, random switch of order and reasons related to artefact characteristics, for example the network speed, which was low sometimes and could not load the web pages, leading some participants to switch into another information topic.

Most reasons have also been identified in the studies of Spink (2004) and Du (2011). The last factor, however, relating to artefact characteristics, such as the network speed, was highlighted in this study.

The cognitive coordination types were also responsible for task switching. Cognitive mechanisms such as content relevance feedback, tactical review feedback or self-learning and regulating process led people to switch the order of the information topics and seek information for other topics. The global strategy was also a factor but not an important one. Unlike Du and Spink (2011), more coordination types were identified as having major importance for switching the order of the information topics. The coordination type of personal knowledge mainly affected the information behaviour of task switching. When participants felt that they knew enough or they could not find enough information for one information topic, they tended to switch into another topic. For example:

- *Participant 4*: "It is an area that I don't have much knowledge of..I cannot find a lot of information here so I move to my next topic".
- *Participant 22*: "I will go probably to something I know more".

Information topics were also switched due to interruptions. When participants thought something other than the topic or an environmental factor disturbed them, they tended to switch information topic. For example:

- *Participant 25*: “Oh! One thing I forgot” (and from the information topic 4 went to the second information topic) [Internal interruption].
- *Participant 8*: He was seeking information for the second topic. He stared out the windows many times and then focused again on the experiment. He checked his mobile phone and then he switched to the fourth information topic [External interruption].

As it seems, task switching does not only occur due to physical or emotional factors, but it is related closely to people’s cognitive procedures and coordination mechanisms. The investigation of these cognitive factors of task switching provides a better understanding of the cognitive information behaviour model.

5.3.3. Comparing the Personal Factors in Information Behaviour Models

In the Literature review chapter, several models of information behaviour have been mentioned. Wilson’s first model (1981) of information seeking behaviour is a more general model using words such as “systems” and “sources”. It explores the “*broad scope of information behaviour and thus is more useful as a heuristic diagram for designing empirical studies of information seeking*” (Case, 2007, p. 138). It emphasizes the results of information seeking behaviour (failure, success) and the satisfaction of a need but it does not explore the source characteristics (Case, 2007).

Wilson’s second model (1996) was more complex identifying personal variables such as psychological, demographic, environmental, social roles etc. Niedwiedzka (2003), however, identifies the major problem in that model of separating the “context” from the intervening variables and that the activating mechanisms are apparent through the whole information seeking process and not only during the decision to seek information. Wilson depicted these factors but he did not explore them in detail as this study did. This study explored cognitive and psychological state factors and their effect on information seeking behaviour.

Dervin (1983) mentioned the role of attention and cognitive discomfort as elements of her sense making theory but she did not explore in-depth these factors and their effects. Ellis (1989), Ellis et al. (1993), and Ellis and Haugan (1997) mentioned the stages of the information seeking process such as starting, chaining, browsing etc. but they did not explore in-depth these processes in conjunction with personal factors as this study did. Kuhlthau's model (1991) mentioned factors such as feelings, thoughts, emotions and the cognitive state of uncertainty, which may lead to doubt and anxiety, but they were not clear in each task stage. Vakkari's model (2001) also stated terms such as task knowledge, seeking strategies and cognitive structure but as an "*auxiliary concept*" (Vakkari, 2001, p. 57). Sutcliffe and Ennis's cognitive model (1998) mentioned the process of information with query reformulation, results evaluation etc. as well as the general knowledge of people and representations but it did not explore in-depth this procedure. This study identified different sub types of strategies such as query reformulation, saving results, browsing etc., in conjunction with cognitive and psychological state factors. Hepworth's model (2004) was more integrated identifying many factors in the information seeking process such as the sociological data (roles, norms, tasks), the psychological data (knowledge, cognitive, affective, and style states), the behavioural data (behaviour), the source data (source character and behaviour) and the relationships between them but as he stated its needs further exploration. Foster (2004, 2012) explored the intrinsic and extrinsic context during the information seeking behaviour and the factors that are involved in each one. He did not, however explore in-depth how these factor influence the information seeking behaviour. The present study explored how cognitive and psychological state factors influenced the information seeking process as well as how time and other navigation issues such as telepresence and vividness influenced in their turn this behaviour.

Krikelas model (1983) mentioned uncertainty as a motivating factor for information seeking. He talked about information gathering and information giving. Information gathering may lead to memory storage of information. However, he did not explore in detail memory or how memory storage may affect searching. This study, however, investigated working memory and how it affects task complexity, cognitive states and cognitive coordination.

Byström and Järvelin's model (1995) mentioned the term task complexity. Task complexity is when people do not have a mental model "*that would enable them to judge exactly what need to be done*" (Case, 2007, p. 129). Perceived task complexity as well as personal and situational factors can affect user's actions and decisions. This study went a step further and provided a new more integrated definition about task complexity including new factors that affect it.

Finally, the Savolainen's ELIS model (1995) involved social, cultural, cognitive and economic factors that affect "*how people use the information sources*" (Savolainen, 2005, p. 143). This model depicts some factors but it did not explore the casual relationships between them (Case, 2007).

This study explored working memory and flow in-depth during multitasking information seeking behaviour in conjunction with people's cognitive states and coordination shifts. It revealed various important relationships between these factors as well as between task complexity and artefact characteristics. It also provided new definitions about task complexity and vividness.

5.3.4. Comparing the Personal Factors in Interactive Information Behaviour Models

As it has been mentioned in the Literature review chapter, the previous interactive information behaviour models tried to explore and identify the cognitive procedures of this behaviour. Ingwersen (1992, 1996), for example, mentioned that people may change the information they have during the information seeking process and, in the end, they may alter them or seek new ones. The five interactive IR multidimensional models (Bates, 1989; Ingwersen, 1992, 1996; Saracevic, 1996; Belkin, 1996; Spink, 1997) investigated interactive information behaviour and provided details about the cognitive factors and procedures, which may be involved in this behaviour. For example, Belkin (1996) stated that cognitive uncertainty refers to a user's problem. Saracevic (1997) mentioned that the cognitive level is about information, which is presented as texts or other forms. Ingwersen (1996) also referred to cognitive procedures and elements. There were four cognitive factors, which influence users' information needs: a work task/interest; a current cognitive state; a problem space,

including a state of uncertainty; and an information need. Bates (1989) believed that people could experience cognitive changes during the information seeking behaviour.

All these models investigated interactive information behaviour providing general characteristics about the cognitive information procedure without exploring in detail the underlying cognitive mechanisms as well as the effect of some cognitive factors. There is a need of a model, which could highlight and identify particular variables and their effects on the interactive information behaviour providing a more detailed view of this complex and multidimensional information behaviour.

This study investigated in-depth the interactive information behaviour in relation to two personal variables: working memory and flow relating them to web and task characteristics from the PAT model. It explored the underlying cognitive procedures, which are obvious during the information seeking process such as cognitive state and cognitive coordination shifts.

5.3.5. Comparing the Personal Factors in Multitasking Information Behaviour Models while using the Web

Although there have been previous web search models (Wang et al., 2000; Choo et al., 2000; Ford et al., 2001, 2005; Knight and Spink, 2008; Du and Spink, 2011), this study provided a more detailed picture of the multitasking information behaviour while using the web. For example, Wang et al. (2000) suggested that there were cognitive, affective, and physical factors during the information web-seeking process. Choo et al. (2000) explored only the information seeking strategies. Ford et al. (2001, 2005) identified that self-efficacy, gender and cognitive styles influence people's seeking ability but the limitation in their study was that participants used only one web search engine. Knight and Spink (2008) provided a macro-model of this behavior. People's self-perceptions as well as perceptions about the system, and expected interactions between them influence their seeking strategies. Du and Spink (2011) also provided a microanalysis of this behavior but they did not explore in particular any personal variable in relation to the cognitive procedures.

This study provided insights about how people search for multiple information topics while using the web at a practical level as well as at a higher level highlighting the

cognitive procedures regarding two personal variables, working memory and flow. This study enhanced our understanding about multitasking information behaviour in a web context.

5.3.6. A new integrated PAT Model

From the findings it seemed that the definitions and the assumptions about the relationship between artefact and task complexity from the PAT model of Finneran and Zhang (2003) need redefining.

Finneran and Zhang (2003) mention that vividness involves clear artefact goals. They did not, however, explain in detail this relationship or provide any more factors to describe it and support this assumption. From the current research it is obvious that the nature of each information topic affect the type of artefact people choose, a relationship which led people to have clearer goals and a greater sense of control.

Task complexity has also redefined. Finneran and Zhang (2003) mentioned that people could feel flow if the task is at the right level without explaining in detail which level this is or by what it may be affected. This research investigated task complexity and found that it can be affected by the nature of the topic. Although there was also a relationship between low working memory and no or little prior knowledge which was found to increase task complexity. These new elements provide a new more integrated version of the PAT model of Finneran and Zhang (2003) regarding task complexity and artefact.

Chapter 6 CONCLUSION AND FURTHER RESEARCH

6.1. Introduction

In this chapter, the main findings with regard to the research hypotheses presented at the outset of this thesis are described. Furthermore, the contribution and overall implications as well as the limitations of this thesis are considered and suggestions for further research are provided.

6.2. Findings with regard to the Research Hypotheses

The objectives of the research were to investigate working memory in relation to cognitive coordination and cognitive shifts; to explore the impact of flow, as specified in the PAT model, with respect to cognitive coordination and cognitive shifts; to determine whether flow is influenced by working memory; to explore the relationships between task characteristics, artefact characteristics, working memory, disciplines and flow; and to provide an integrated framework based on the results of the study. The literature on this subject, specifically in the context of multitasking information behaviour while using the web, is inconclusive. The research sought to answer the hypotheses as described below.

6.2.1. Hypothesis 1a

Working memory affects multitasking information behavior during web searching.

The research confirmed previous findings (König et al., 2005; Bühner et al., 2006; Juvina and Oostendorp, 2006; Hambrick et al., 2010; Colom et al., 2010) about the role of working memory on multitasking behaviour. For example, the high working memory group had a statistically significantly higher number of cognitive coordination and cognitive state shifts than the low working memory group. This evidence supports the above hypothesis (see pages 156, 148).

6.2.2. Hypothesis 1b

Participants with high working memory capacity have different cognitive coordination shifts from participants with low working memory capacity.

The results partially confirm the above hypothesis. As stated in the previous hypothesis, the high working memory group had a significantly greater number of cognitive coordination shifts than the low working memory group. The results also showed that all participants, regardless of their working memory capacity, had the same first two frequent cognitive coordination sequences: from strategy to topic, and from topic to strategy. Moreover, the most frequent sub-strategy for the two first cognitive coordination shifts was the web search system selection (with some exceptions) followed by the strategy of browsing more results. These results therefore partially reject the above hypothesis. The two working memory groups showed no difference in their coordination shifts (regarding the two most frequent coordination shifts) but overall there was a significant difference in the number of cognitive coordination shifts made by the two groups (so expand the hypothesis 1a).

6.2.3. Hypothesis 1c

Participants with high working memory capacity have different cognitive state shifts from participants with low working memory capacity.

The results partially reject this hypothesis. People with high working memory capacity had a significantly higher number of cognitive state shifts than people with low working memory capacity. However it was found that participants regardless of their working memory had the same first two frequent cognitive state shifts: from strategy to current search goal, and from current search goal to strategy. These results differ from Du (2011), who found that the most frequent cognitive state shifts were between strategies and evaluation of the results. The two working memory groups had the same cognitive state shifts (regarding the two most frequent not all the cognitive state shifts) but they had different number of cognitive state shifts.

6.2.4. Hypothesis 2a

Flow is related to working memory

The results rejected the above hypothesis. This hypothesis stated that people's different working memory levels would affect their levels of engagement when multitasking using the web. However, this assumption was not proved.

6.2.5. Hypothesis 2b

Flow affects cognitive state and cognitive coordination shifts of participants.

The results confirm the above hypothesis relating to flow. The current research confirmed previous findings (Massimini and Carli, 1988; Chen et al., 2004) about flow's positive role in performance. People with high flow experienced more cognitive coordination and state shifts than the low flow group. Additionally, the high flow group had a higher degree of change of knowledge for information topics without prior knowledge compared to the low flow group and the degree of change of knowledge for the high flow group was higher for topics without prior knowledge than for topics with prior knowledge. These results also confirm previous findings (Massimini and Carli, 1988; Csikszentmihalyi, 1997; Chen et al., 2000; Finneran and Zhang, 2003; Shin, 2006) which suggested that high levels of flow lead to better performance.

6.3. Contributions of the Study

The findings of the research enabled an exploratory integrated model to be created, which illustrates the nature of multitasking information behaviour when using the web. This incorporated the coordination mechanisms as well as the state and holistic shifts that are involved in this behaviour.

This study explored multitasking information behaviour, cognitive coordination, cognitive state and holistic shifts in conjunction with personal characteristics, such as working memory and flow, and identified the type of relationships between them. Further, the current research also incorporated and explored task and artefact characteristics identifying possible relationships between all these factors.

In contrast to previous interactive information behaviour models (Bates, 1989; Ingwersen, 1992, 1996; Saracevic, 1996; Belkin, 1996; Spink, 1997) as well as web search models (Wang et al., 2000; Choo et al., 2000; Ford et al., 2001, 2005; Knight and Spink, 2008; Du and Spink, 2011), the current research explored information behaviour at a more granular level of analysis and how specific personal characteristics, as well as task and artefact factors, affect multitasking information behaviour and, in particular, its underlying mechanisms, including cognitive state, cognitive coordination and holistic shifts.

One other contribution of this research was to develop new more specific definitions of task complexity and artefact characteristics from the PAT model of Finneran and Zhang (2003). The new definitions are closely grounded in the empirical data generated from the respondents' experience and indicate more explicitly the role and the factors which affect these two elements.

From a pragmatic perspective this new research influence the creation of more effective web search systems by placing more emphasis on our understanding of the complex cognitive mechanisms of multitasking information behaviour when using the web. The key element of an interactive system is based on the theoretical model, which describes it. The model of this study provides evidence about the effect of two specific people's variables in relation to web and task characteristics in a multitasking context. For example, in this research it was shown that participants with low working memory capacity felt that task complexity at the end of the procedure was higher for topics without prior knowledge than for topics with prior knowledge. Moreover, the literature review indicates that people with low working memory have difficulties allocating their attention to relevant information in contrast to people with high working memory, who allocate their attention to task-relevant information and coordinate information more successfully (Engle et al., 1999). In this experiment, it was also been found that, people with low working memory found it more difficult to focus their attention on relevant information especially for topics without any prior knowledge and therefore experienced a lower level of cognitive state occurrence (less cognitive state and coordination shifts). Bearing these results in mind, a web company could create a new web search engine, which would be more helpful to people with low working memory capacity. For example, the web search engine could categorise all the

information about one topic according to the level of difficulty or complexity. For example, there could be three or more categories of information for each topic and therefore, all people and especially people with low working memory capacity would be more able to allocate their attention to one category of information at a time according to their level of knowledge. For example, if the level of their knowledge for one topic is very low, then they could choose the first category or results which would include basic information about the topic. This new web search engine would not only help people with low working memory capacity to allocate their attention more effectively to relevant information but also help them experience more cognitive state occurrences (more cognitive state and coordination shifts), which in turn would help them find the desired information and gain knowledge. As a consequence if web companies had a better understanding of how their products influence people's performance and engagement in web searching or how task characteristics influence people's web seeking behaviour or how people's variables affect their web seeking behaviour, then ideally they would be able to create more productive web systems.

6.4. Limitations

The study has offered an evaluative perspective on multitasking information behaviour while using the web, however, the study encountered a number of challenges.

First of all, this study used a small numbers of Greek participants, some of them were located in UK and some of them in Greece. The length of time required to conduct the experiment had impact on the number of the volunteers. This may decrease the generalisability of the results. Ideally, a larger number of participants would have been included. Nevertheless, the statistical tests did indicate the reliability of the relationships between the key variables.

Secondly, participants had to think aloud during the information seeking process. Most of the participants with guidance were able to externalize their thoughts, feelings, and emotions and describe the information seeking process. Some of them, however, found this difficult and felt discomfort or they did not know what to say. Six participants from the total 30 responded in this fashion. They did not voluntarily speak out loud and the researcher had to remind them to do it. This meant that the information seeking process was interrupted, even if only for a few seconds, which may have decreased

people's concentration. However, this method has been approved as a valid method for identifying mental and cognitive procedures in real time while people perform a complicate task (Eriksson and Simon, 1993; Fonteyn et al., 1993; Branch, 2000). Many researchers have also used this method in their experiments (Yang, 1997; Spink et al., 2006) nevertheless this limitation should be recognised.

Finally, some participants said they felt tired prior to the start of the experiment. This might have affected the way they searched information while using the web and the results. In the Discussion chapter the feelings before the seeking process were categorized into two categories: negative feelings (information overloading, tiredness, frustration, boredom) and positive feelings (desire, happiness, curiosity). The negative feelings could have led people to alter their information seeking process in order to make it simpler and easier. However it could be argued that, the study reflected a real life experiment based on people's everyday life information seeking processes, which would involve all the type of feelings. Nevertheless it would be possible to exclude or divide respondents into sub categories according to their feelings but a larger sample of respondents would be necessary to make this possible.

6.5. Further Research

This study investigated people's characteristics such as working memory and flow in relation to multitasking information behaviour when using the web. From the literature review many personal factors, which influence multitasking information behaviour, have been identified. In the current study, however, it was impossible to explore all these factors as well as the diversity of the results of the research did not indicate the existence of intervening variables. Future studies could examine in detail these factors such as cognitive styles, personality dimensions, attention and self-efficacy.

Further research is also needed to examine possible patterns of more than two transition steps of cognitive state and cognitive coordination shifts. This study revealed patterns of the three most frequent transition steps, for example from strategy to current search goal and from current search goal to view. Further research could explore if there are possible larger patterns and combine them with people's personal characteristics as well as identify how they might affect these patterns.

Further research could also investigate the personal characteristics of the PAT model by Finneran and Zhang (2003) (exploratory behaviour, playfulness, absorption, his current state is conducive to time distortion and loss of self-consciousness) in relation to multitasking information behaviour while using the web. The purpose of this study was the exploration of the task and artefact characteristics on the web and their relationships with the other variables. The exploration of the personal variables of the PAT model indicates a whole new experiment aiming to identify only the relationship of these particular factors.

Finally, further research could be done with a larger sample of participants with different ages, different academic disciplines or different cultures. This could increase the generalizability of the results and apply the study to different contexts.

Appendix A. Research Tools

A.1. Request for Participation in the Study

Hello all,

I am looking for people to take part in a my Ph.D. research and I would be very grateful if any of you can spend approximately 2.15 hours of your time to take part.

The aim of the study is to investigate multitasking information behaviour during web searching.

The session can take place wherever there is a quiet environment without any external distraction. The experiment has two phases. In the first phase you will be asked to complete a working memory test and a short pre interview will follow. Please follow the link <http://palexopoulou.youcanbook.me/> to book date and time. This phase will last about 30 minutes.

During the second phase you will complete a short questionnaire. After that, you will search on web for four topics for one hour. Finally, you will complete another questionnaire, a short flow questionnaire and a small interview will follow. Please follow the link <http://palexopoulou1.youcanbook.me/> to book date and time. The total time is about 1.45 minutes. In order to proceed to this phase, you have to pass the working memory test (first phase). If you do not, I will inform you immediately after the working memory test about the cancellation of your appointment for the second phase of the experiment.

Please book your appointment for the both phases of the experiment.

There will be a small lunch as a reward for those who will complete the two faces of the experiment.

If you have any question, please email me.

Thank you in advance.

A.2. Participant Information Sheet



A new integrated model for Multitasking during Web searching

Participant Information Sheet for Pilot Study

Alexopoulou Peggy, Loughborough University, Leicestershire, UK, LE11 3TU,
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Dr Mark Hepworth, Loughborough University, Leicestershire, UK, LE11 3TU,
M.Hepworth@lboro.ac.uk, 0)1509 223039

What is the purpose of the study?

This research will try to investigate how some personal variables may be related to how people search on web for multiple information problems simultaneously. This research will explore some particular variables enhancing our understanding for the multitasking information behaviour on web and providing a new model. This research will explore working memory and other personal variables in order to investigate multitasking information behaviour. The aim is to enhance our knowledge about multitasking on web, providing an integrated and more comprehensive framework.

Who is doing this research and why?

This study is conducted by Alexopoulou Peggy, a PhD student in the department of Information Science, at Loughborough University. The supervisors of this study are: Professor Anne Morris and Dr Mark Hepworth. This is a pilot study, which is conducted before the pilot study and the main experiment. The purpose of this pilot study is to test the material, its results, reliability and if it is the appropriate material (this or any other similar material) for this research study. This study is part of a Student research project supported by Loughborough University.

Are there any exclusion criteria?

No

Once I take part, can I change my mind?

Yes! After you have read this information and asked any questions you may have we will ask you to complete an Informed Consent Form, however if at any time, before, during or after the sessions you wish to withdraw from the study please just contact the main investigator. You can withdraw at any time, for any reason and you will not be asked to explain your reasons for withdrawing.

Will I be required to attend any sessions and where will these be?

You are going to seek information for two topics for which you have prior knowledge and for two more for which you have little or no knowledge. The session will take place in the usability lab of the Information Science Department at Loughborough University, which can offer a quite environment without any external distraction.

How long will it take?

The total time, which is required, is 90-120 minutes.

Is there anything I need to do before the session?

You should complete a pre questionnaire.

Is there anything I need to bring with me?

No.

What type of clothing should I wear?

Anything.

Who should I send the questionnaire back to?

You should give the questionnaire back to investigator.

What will I be asked to do?

The researcher will provide you with 4 topics. You will be asked to seek information for two topics for which you have knowledge and for other two for which you have little or no knowledge. You will be able to seek on web using any web engine you like. You will also be asked to multitask as much as possible. The total seeking time is 1 hour.

What personal information will be required from me?

It will be required from you to answer a post questionnaire, a flow state scale and a small interview will follow.

Are there any risks in participating?

There is no risk in participating.

Will my taking part in this study be kept confidential?

Any information you provide will be kept strictly confidential. Alexopoulou Peggy will be the only individual to view and maintain your personal information. When pre pilot study is completed, any identifying information will be destroyed immediately. The investigator will not use your information for any purposes outside of this research project and she is not going to save any identifying information for any individual or organization.

What will happen to the results of the study?

Your results will be analysed in order for the investigator to be able to test her materials, such as questionnaires and tests, and decide if she is going to use them or if she has to make any essential corrections. The results from the pilot study will also help the investigator to test if these materials show what she wants to explore.

What do I get for participating?

Your participation in this pilot study is voluntary. Everyone will respect your decision of whether or not you want to participate in the pre pilot study. If you decide to join the study now, you can still change your mind during the study. You may stop at any time if you feel stressed.

I have some more questions who should I contact?

If you have more questions you should contact the supervisors of the investigator, Professor Anne Morris and Dr Mark Hepworth, whose contact numbers are above.

What if I am not happy with how the research was conducted?

If you are not happy with how the research was conducted, please contact the Mrs Zoe Stockdale, the Secretary for the University's Ethics Approvals (Human Participants) Sub-Committee:

Mrs Z Stockdale, Research Office, Rutland Building, Loughborough University, Epinal Way, Loughborough, LE11 3TU. Tel: 01509 222423. Email: Z.C.Stockdale@lboro.ac.uk

The University also has a policy relating to Research Misconduct and Whistle Blowing which is available online at [http://www.lboro.ac.uk/admin/committees/ethical/Whistleblowing\(2\).htm](http://www.lboro.ac.uk/admin/committees/ethical/Whistleblowing(2).htm).

A.3. Informed Consent Form



A new integrated model for Multitasking during Web searching

INFORMED CONSENT FORM FOR STUDY

The purpose and details of this study have been explained to me. I understand that this study is designed to further scientific knowledge and that all procedures have been approved by the Loughborough University Ethical Approvals (Human Participants) Sub-Committee.

I have read and understood the information sheet and this consent form.

I have had an opportunity to ask questions about my participation.

I understand that I am under no obligation to take part in the study.

I understand that I have the right to withdraw from this study at any stage for any reason, and that I will not be required to explain my reasons for withdrawing.

I understand that all the information I provide will be treated in strict confidence and will be kept anonymous and confidential to the researchers unless (under the statutory obligations of the agencies which the researchers are working with), it is judged that confidentiality will have to be breached for the safety of the participant or others.

I agree to participate in this study.

Your name

Your signature

Signature of investigator

Date

A.4. Pre Questionnaire of Working Memory

Date.../.../...

User Number _____

Demographic Variables:

Name:	Age:
Please indicate your Gender: Female <input type="checkbox"/> Male <input type="checkbox"/>	
Your Faculty/Institution:	
Student Status: Full time <input type="checkbox"/> Part time <input type="checkbox"/>	
Degree sought:	

A.5. Pre Interview Questions of Pilot Study

Date.../.../....

User Number:

- 1. Identify from your educational field and background the information topics for which you have prior knowledge and you would like to seek information on the Web.**

- 2. Please rate the degree of your personal knowledge about the information problems on the following 7- point Likert scale.**

Information topic 1	Very little knowledge	1—2—3—4—5—6—7	Great knowledge
Information topic 2	Very little knowledge	1—2—3—4—5—6—7	Great knowledge
Information topic 3	Very little knowledge	1—2—3—4—5—6—7	Great knowledge
Information topic 4	Very little knowledge	1—2—3—4—5—6—7	Great knowledge
Information topic 5	Very little knowledge	1—2—3—4—5—6—7	Great knowledge

Information topic 6	Very little knowledge	1—2—3—4—5—6—7	Great knowledge
Information topic 7	Very little knowledge	1—2—3—4—5—6—7	Great knowledge

3. Identify from your educational field and background the information topics for which you have little or no knowledge and you would like to seek information on the Web.

4. Please rate the degree of your personal knowledge about the information topics on the following 7- point Likert scale.

Information topic 1	Very little knowledge	1—2—3—4—5—6—7	Great knowledge
Information topic 2	Very little knowledge	1—2—3—4—5—6—7	Great knowledge
Information topic 3	Very little knowledge	1—2—3—4—5—6—7	Great knowledge
Information topic 4	Very little knowledge	1—2—3—4—5—6—7	Great knowledge
Information topic 5	Very little knowledge	1—2—3—4—5—6—7	Great knowledge

Information topic 6	Very little knowledge	1—2—3—4—5—6—7	Great knowledge
Information topic 7	Very little knowledge	1—2—3—4—5—6—7	Great knowledge

A.6. Pre Interview Questions of Study (e.g. for Psychologists)

Date

User Number

1. Identify from your education field and background 4 to 7 information topics for which you have prior knowledge and you would like to seek information on the web.

- cognitive (memory, attention, perception etc.)
- Neuropsychology
- Developmental Psychology
- research / Statistics
- occupational psychology
- social representations
- social identity
- psychotherapy
- psychological assessment
- psychological tests
- loss mourner
- addictions

2. Please rate the degree of your personal knowledge about the information topics on the following 7-point Likert scale.

Information topic 1	Very little knowledge	1—2—3—4—5—6—7	Great knowledge
Information topic 2	Very little knowledge	1—2—3—4—5—6—7	Great knowledge
Information topic 3	Very little knowledge	1—2—3—4—5—6—7	Great knowledge

Information topic 4	Very little knowledge	1—2—3—4—5—6—7	Great knowledge
Information topic 5	Very little knowledge	1—2—3—4—5—6—7	Great knowledge
Information topic 6	Very little knowledge	1—2—3—4—5—6—7	Great knowledge
Information topic 7	Very little knowledge	1—2—3—4—5—6—7	Great knowledge

3. Identify from your education field and background 4 to 7 information topics for which you have little or no prior knowledge and you would like to seek information on the web.

cognitive (memory, attention, perception etc.)

-Neuropsychology

-Developmental Psychology

-research / Statistics

-occupational psychology

-social representations

-social identity

-psychotherapy

-psychological assessment

-psychological tests

-loss mourner

-addictions

4. Please rate the degree of your personal knowledge about the information topics on the following 7-point Likert scale.

Information topic 1	Very little knowledge	1—2—3—4—5—6—7	Great knowledge
Information topic 2	Very little knowledge	1—2—3—4—5—6—7	Great knowledge
Information topic 3	Very little knowledge	1—2—3—4—5—6—7	Great knowledge
Information topic 4	Very little knowledge	1—2—3—4—5—6—7	Great knowledge
Information topic 5	Very little knowledge	1—2—3—4—5—6—7	Great knowledge
Information topic 6	Very little knowledge	1—2—3—4—5—6—7	Great knowledge
Information topic 7	Very little knowledge	1—2—3—4—5—6—7	Great knowledge

A.7. Pre Questionnaire

Date.../.../....

User Number: _____

1. Demographic characteristics:

1.1 What is your age? _____

1.2 What is your gender? Female Male

1.3 Your institution/ faculty/department:

1.4 Student status: Full time Part time

1.5 Degree sought:

2. Web variables:

2.1 How many years have you been using the Web in order to seek for information?

a) one year –five years _____ b) six years- ten years _____

c) 11 years and over _____

3. Please rate the complexity of each information topic on the following 7-point Likert scale.

Information topic 1	No complexity	1—2—3—4—5—6—7	Very complex
Information topic 2	No complexity	1—2—3—4—5—6—7	Very complex
Information topic 3	No complexity	1—2—3—4—5—6—7	Very complex
Information topic 4	No complexity	1—2—3—4—5—6—7	Very complex

4. Please describe your feelings before starting to look for information (e.g. frustration, desire to find information etc.)

**5. Where are you in the process of becoming informed on the topic?
Please rate the degree of your current information stage for each topic on the following 7- point Likert scale.**

Information topic 1	Not informed	1—2—3—4—5—6—7	Well informed
Information topic 2	Not informed	1—2—3—4—5—6—7	Well informed
Information topic 3	Not informed	1—2—3—4—5—6—7	Well informed
Information topic 4	Not informed	1—2—3—4—5—6—7	Well informed

6. How certain are you about the depth of knowledge you already have for each information topic?

Information topic 1	Very uncertain 1—2—3—4—5—6—7 Very certain
Information topic 2	Very uncertain 1—2—3—4—5—6—7 Very certain
Information topic 3	Very uncertain 1—2—3—4—5—6—7 Very certain
Information topic 4	Very uncertain 1—2—3—4—5—6—7 Very certain

A.8. Post Questionnaire

Date.../.../....

User Number: _____

1. Which Web search engines did you use in your searches?

2. Was the way the information was presented on the screen vivid, i.e. exciting, stimulating, interesting, and engaging?

Web search engines	No vivid	1—2—3—4—5—6—7	Very vivid
	No vivid	1—2—3—4—5—6—7	Very vivid
	No vivid	1—2—3—4—5—6—7	Very vivid
	No vivid	1—2—3—4—5—6—7	Very vivid
	No vivid	1—2—3—4—5—6—7	Very vivid
	No vivid	1—2—3—4—5—6—7	Very vivid
	No vivid	1—2—3—4—5—6—7	Very vivid
	No vivid	1—2—3—4—5—6—7	Very vivid

	No vivid	1—2—3—4—5—6—7	Very vivid
	No vivid	1—2—3—4—5—6—7	Very vivid
	No vivid	1—2—3—4—5—6—7	Very vivid
	No vivid	1—2—3—4—5—6—7	Very vivid
	No vivid	1—2—3—4—5—6—7	Very vivid
	No vivid	1—2—3—4—5—6—7	Very vivid

	No vivid	1—2—3—4—5—6—7	Very vivid
	No vivid	1—2—3—4—5—6—7	Very vivid

3. Please rate the level of network speed during your searches:

Very slow 1—2—3—4—5—6—7 Very quick

4. Did you switch the order of the information problems during your search? If yes, why?

5. Please rate the complexity of each information topic on the following 7-point Likert scale.

Information topic 1	No complexity	1—2—3—4—5—6—7	Very complex
Information topic 2	No complexity	1—2—3—4—5—6—7	Very complex
Information topic 3	No complexity	1—2—3—4—5—6—7	Very complex
Information topic 4	No complexity	1—2—3—4—5—6—7	Very complex

6. Please describe your feelings after your searches.

7. Are you satisfied with what you have found or will you need to do more searching?

Information Topic 1:

Information Topic 2:

Information Topic 3:

Information Topic 4:

- 8. To what extent did your knowledge on the topic change? Did you feel that you made a great deal of mental effort for each information topic? Please rate the degree of change and of mental effort on the following 7-point Likert scale.**

Information topic 1	No change In my knowledge	1—2—3—4—5—6—7	Great change in my knowledge
	No mental effort	1—2—3—4—5—6—7	Great mental effort
Information topic 2	No change In my knowledge	1—2—3—4—5—6—7	Great change in my knowledge
	No mental effort	1—2—3—4—5—6—7	Great mental effort
Information topic 3	No change In my knowledge	1—2—3—4—5—6—7	Great change in my knowledge
	No mental effort	1—2—3—4—5—6—7	Great mental effort
Information topic 4	No change In my knowledge	1—2—3—4—5—6—7	Great change in my knowledge
	No mental effort	1—2—3—4—5—6—7	Great mental effort

- 9. Where are you in the process of becoming informed on the topic? Please rate the degree of your current information stage for each topic on the following 7-point Likert scale.**

Information topic 1	Not informed	1—2—3—4—5—6—7	Well informed
Information topic 2	Not informed	1—2—3—4—5—6—7	Well informed
Information topic 3	Not informed	1—2—3—4—5—6—7	Well informed
Information topic 4	Not informed	1—2—3—4—5—6—7	Well informed

10. How certain are you about the depth of knowledge you have for each information topic?

Information topic 1	Very uncertain	1—2—3—4—5—6—7	Very certain
Information topic 2	Very uncertain	1—2—3—4—5—6—7	Very certain
Information topic 3	Very uncertain	1—2—3—4—5—6—7	Very certain
Information topic 4	Very uncertain	1—2—3—4—5—6—7	Very certain

11. Did you search for other information problems? If yes, what were they?

12. For what reasons did you search for other information problems?

13. Please rate the degree of time pressure that you felt during the experiment.

Low time pressure 1—2—3—4—5—6—7 High time pressure

14. Do you have any more comments about the search process?

A.9. Flow State Scale

Date:.../.../...

User Number:

Flow State Scale (Jackson and Marsh, 1996)

Please answer the following questions in relation to your experience in the event you have just completed. These questions relate to the thoughts and feelings you may have experienced during the event. There are no right or wrong answers. Think about how you felt during the event and answer the questions using the rating scale below. Circle the number that best matches your experience from the options to the right of each question.

Rating Scale:

Strongly disagree 1	Disagree 2	Neither agree nor disagree 3	Agree 4	Strongly agree 5	
			Strongly disagree	Strongly agree	
1. I was challenged, but I believed my skills would allow me to meet the challenge.	1	2	3	4	5
2. I made the correct movements without thinking about trying to do so.	1	2	3	4	5
3. I knew clearly what I wanted to do.	1	2	3	4	5
4. It was really clear to me that I was doing well.	1	2	3	4	5
5. My attention was focused entirely on what I was doing.	1	2	3	4	5
6. I felt in total control of what I was doing.	1	2	3	4	5
7. I was not concerned with what others may have been thinking of me.	1	2	3	4	5
8. Time seemed to alter (either slowed down or speeded up).	1	2	3	4	5
9. I really enjoyed the experience.	1	2	3	4	5
10. My abilities matched the high challenge of the situation.	1	2	3	4	5
11. Things just seemed to be happening automatically.	1	2	3	4	5
12. I had a strong sense of what I wanted to do.	1	2	3	4	5
13. I was aware of how well I was performing.	1	2	3	4	5
14. It was no effort to keep my mind on what was happening.	1	2	3	4	5
15. I felt like I could control what I was doing.	1	2	3	4	5
16. I was not worried about my performance during the event.	1	2	3	4	5

17. The way time passed seemed to be different from normal.	1	2	3	4	5
18. I loved the feeling of that performance and want to capture it again.	1	2	3	4	5
19. I felt I was competent enough to meet the high demands of the situation.	1	2	3	4	5
20. I performed automatically.	1	2	3	4	5
21. I knew what I wanted to achieve.	1	2	3	4	5
22. I had a good idea while I was performing about how well I was doing.	1	2	3	4	5
23. I had total concentration.	1	2	3	4	5
24. I had a feeling of total control.	1	2	3	4	5
25. I was not concerned with how I was presenting myself.	1	2	3	4	5
26. It felt like time stopped while I was performing.	1	2	3	4	5
27. The experience left me feeling great.	1	2	3	4	5
28. The challenge and my skills were at an equally high level.	1	2	3	4	5
29. I did things spontaneously and automatically without having to think.	1	2	3	4	5
30. My goals were clearly defined.	1	2	3	4	5
31. I could tell by the way I was performing how well I was doing.	1	2	3	4	5
32. I was completely focused on the task at hand.	1	2	3	4	5
33. I felt in total control of my body.	1	2	3	4	5
34. I was not worried about what others may have been thinking of me.	1	2	3	4	5
35. At times, it almost seemed like things were happening in slow motion.	1	2	3	4	5
36. I found the experience extremely rewarding.	1	2	3	4	5

4. Probe questions

Information

1. Where there any difficulties in getting the information you needed from that source?
2. What did you learn that was new?

Analogs

1. Have you done this kind of search before?

Aiding

1. If you are not satisfied from the results of your search process, what knowledge or information could have helped?

Errors

1. Do you think you made any errors while searching?

Hypotheticals

1. If was one thing that you could have changed with the systems to have made your search easier, what would it have been?

Appendix B. Results of the Study

B.1. Demographic Characteristics of the Participants

Participants	Gender	Age	Department	Academic Status	Student status	Years of web experience
1	F	29	Psychology	Doctoral	Full time	11 and over
2	F	20	Psychology	Bachelor	Full time	1-5
3	F	26	Psychology	Bachelor	Full time	1-5
4	F	24	Psychology	Bachelor	Full time	1-5
5	M	25	Psychology	Doctoral	Full time	11 and over
6	M	28	Psychology	Doctoral	Full time	11 and over
7	F	26	Psychology	Doctoral	Full time	11 and over
8	F	29	Psychology	Bachelor	Full time	6-10
9	M	29	Psychology	Bachelor	Full time	11 and over
10	M	30	Psychology	Bachelor	Full time	11 and over
11	M	28	Mechanical Engineering	Master	Full time	6-10
12	M	25	Mechanical Engineering	Master	Full time	6-10
13	M	27	Mechanical Engineering	Master	Full time	11 and over
14	M	31	Mechanical Engineering	Master	Full time	11 and over
15	M	27	Mechanical Engineering	Bachelor	Full time	6-10
16	M	23	Mechanical Engineering	Bachelor	Full time	6-10
17	F	23	Mechanical Engineering	Bachelor	Full time	11 and over
18	M	26	Mechanical Engineering	Master	Full time	11 and over
19	M	28	Mechanical Engineering	Master	Full time	11 and over
20	F	25	Mechanical Engineering	Doctoral	Full time	11 and over
21	F	30	Accounting	Master	Full time	11 and over
22	M	25	Accounting	Doctoral	Full time	11 and over
23	M	23	Accounting	Bachelor	Full time	1-5
24	M	29	Accounting	Bachelor	Full time	11 and over
25	F	25	Accounting	Bachelor	Full time	6-10
26	M	27	Accounting	Bachelor	Full time	6-10
27	M	22	Accounting	Bachelor	Full time	6-10
28	M	28	Accounting	Bachelor	Full time	6-10
29	F	29	Accounting	Bachelor	Full time	6-10
30	M	30	Accounting	Master	Full time	11 and over

Appendix C. Publications and Conference Presentations

PUBLICATIONS

- Alexopoulou, P., Morris, A., and Hepworth, M., 2013. A new integrated model for multitasking during Web searching. *Procedia - Social and Behavioral Sciences*, 16-25.
- Alexopoulou, P., Hepworth, M., and Morris, A., 2014. An Investigation of Multitasking Information Behaviour and the Influence of Working Memory and Flow. *AIP Conference Proceedings AIP Conference Proceedings*, 1644, 37-43.
- Alexopoulou, P., Kotsopoulou A., 2014. Multitasking Information Behaviour, Information Task Switching and Anxiety: An Exploratory Study. *AIP Conference Proceedings*, 1644, 44-50.

CONFERENCES PRESENTATIONS

- Alexopoulou, P., Hepworth, M., Morris, A., 2015. *An Investigation of Multitasking on the Web: Key findings*. Poster Presentation, SBE Conference, Loughborough University.
- Alexopoulou P., Hepworth, M., and Morris, A., 2014. *A new integrated model for Multitasking during Web searching*. Poster Presentation, Centre for Information Management Launch, Loughborough University.
- Alexopoulou P., Hepworth, M., and Morris, A., 2014. *A preliminary theoretical model of Multitasking during Web searching*. Poster Presentation. The Web: Wisdom of Crowds and a Long Tail, Loughborough University.
- Alexopoulou, P., Hepworth, M., and Morris, A., 2014. *An Investigation of Multitasking Information Behaviour and the Influence of Working Memory and Flow*. 4th International Conference on Integrated Information, Spain.
- Alexopoulou, P. (2012). *Multitasking Information Behaviour, Information Task Switching and Anxiety: An Exploratory Study*. 4th International Conference on Integrated Information, Spain.
- Alexopoulou, P., Morris, A., and Hepworth, M., 2013. *An Integrated Cognitive-Experiential Approach to Multitasking during Web Searching*. PhD Symposium, Loughborough University.
- Alexopoulou, P., Morris, A., and Hepworth, M., 2013. A new integrated model for multitasking during Web searching. *3rd International Conference on Integrated Information*, Prague.
- Alexopoulou, P., Morris, A., and Hepworth, M., 2013. *Personal dimensions in information seeking and retrieving behavior*. Poster Presentation, Science Matters conference, Loughborough University.
- Alexopoulou, P. (2012). *Multitasking Information Behaviour, Information Task Switching and Anxiety: An Exploratory Study*. Poster Presentation, 1st City Unity College students Psychology Conference.

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