Towards Modelling

Web Search Behaviour:

Integrating Users’ Cognitive Styles

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Keywords

Statement of Original Authorship

The work contained in this thesis has not been previously submitted to meet requirements for an award at this or any other higher education institution. To the best of my knowledge and belief, the thesis contains no material previously published or written by another person except where due reference is made.

Signature: __________________________

Date: 21/02/2013
Abstract

With the rapid growth of information on the Web, the study of information searching has led to an increased interest. Information behaviour (IB) researchers and information systems (IS) developers are continuously exploring user - Web search interactions to understand and to help users to provide assistance with their information searching. In attempting to develop models of IB, several studies have identified various factors that govern user’s information searching and information retrieval (IR), such as age, gender, prior knowledge and task complexity. However, how users’ contextual factors, such as cognitive styles, affect Web search interactions has not been clearly explained by the current models of Web Searching and IR.

This study explores the influence of users’ cognitive styles on their Web search behaviour. The main goal of the study is to enhance Web search models with a better understanding of how these cognitive styles affect Web searching. Modelling Web search behaviour with a greater understanding of user’s cognitive styles can help information science researchers and IS designers to bridge the semantic gap between the user and the IS. To achieve the aims of the study, a user study with 50 participants was conducted. The study adopted a mixed method approach incorporating several data collection strategies to gather a range of qualitative and quantitative data. The study utilised pre-search and post-search questionnaires to collect the participants’ demographic information and their level of satisfaction about the search interactions. Riding’s (1991) Cognitive Style Analysis (CSA) test was used to assess the participants’ cognitive styles. Participants completed three pre-designed search tasks and the whole user-web search interactions, including think-aloud, were captured using a monitoring program. Data analysis involved several qualitative and quantitative techniques: the quantitative data gave raise to detailed findings about users’ Web searching and cognitive styles, the qualitative data enriched the findings with illustrative examples.

The study results provide valuable insights into Web searching behaviour among different cognitive style users. The findings of the study extend our understanding of
Web search behaviour and how users search information on the Web. Three key study findings emerged:

- Users’ Web search behaviour was demonstrated through information searching strategies, Web navigation styles, query reformulation behaviour and information processing approaches while performing Web searches. The manner in which these Web search patterns were demonstrated varied among the users with different cognitive style groups.
- Users’ cognitive styles influenced their information searching strategies, query reformulation behaviour, Web navigational styles and information processing approaches. Users with particular cognitive styles followed certain Web search patterns.
- Fundamental relationships were evident between users’ cognitive styles and their Web search behaviours; and these relationships can be illustrated through modelling Web search behaviour. Two models that depict the associations between Web search interactions, user characteristics and users’ cognitive styles were developed. These models provide a greater understanding of Web search behaviour from the user perspective, particularly how users’ cognitive styles influence their Web search behaviour.

The significance of this research is twofold: it will provide insights for information science researchers, information system designers, academics, educators, trainers and librarians who want to better understand how users with different cognitive styles perform information searching on the Web; at the same time, it will provide assistance and support to the users. The major outcomes of this study are 1) a comprehensive analysis of how users search the Web; 2) extensive discussion on the implications of the models developed in this study for future work; and 3) a theoretical framework to bridge high-level search models and cognitive models.
Dedication

This dissertation is dedicated to my family: my wife, Lhamo, my son, Tenzi Jurmin Lhendup, and my daughter, Kinley Om, for their love and support.
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## Abbreviations

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<th>Full Form</th>
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<tbody>
<tr>
<td>ANOVA</td>
<td>Analysis of Variance</td>
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<td>CFA</td>
<td>Confirmatory Factor Analysis</td>
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<tr>
<td>CSA</td>
<td>Cognitive Styles Analysis</td>
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<td>CSI</td>
<td>Cognitive Style Index</td>
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<td>EFA</td>
<td>Exploratory Factor Analysis</td>
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<td>EFT</td>
<td>Embedded Figure Test</td>
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<td>GEFT</td>
<td>Group Embedded Figures Test</td>
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<tr>
<td>HCI</td>
<td>Human Computer Interaction</td>
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<td>IB</td>
<td>Information Behaviour</td>
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<td>IP</td>
<td>Internet Protocol</td>
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<td>IPA</td>
<td>Information Processing Approach</td>
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<td>IR</td>
<td>Information Retrieval</td>
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<td>IS</td>
<td>Information System</td>
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<td>IS&amp;R</td>
<td>Information System and Retrieval</td>
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<td>ISS</td>
<td>Information Searching Strategies</td>
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<td>MANOVA</td>
<td>Multivariate analysis of variance</td>
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<td>NF</td>
<td>Normalizing Factor</td>
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<td>PA</td>
<td>Path Analysis</td>
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<td>RASI</td>
<td>Revised Approaches to Studying Inventory</td>
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<td>SD</td>
<td>Standard Deviations</td>
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<td>Structural equation Modelling</td>
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<td>Structured Query Language</td>
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<td>VI</td>
<td>Verbal-Imagery</td>
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<td>W3C</td>
<td>World Wide Web Consortium</td>
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<td>WA</td>
<td>Wholist-Analytic</td>
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Chapter 1: Introduction

Research is to see what everybody else has seen, and to think what nobody else has thought.

A. Szent-Gyorgyi

1.1 Overview

This chapter provides an overview of the study background, aims and significance, and research questions addressed in this study. This chapter also outlines the structure of the remaining chapters of the thesis.

1.2. Research Background

The Web has become an important integral part of people’s life as a main source of information for all types of users. Students, professionals, academics and researchers search the Web daily to perform information retrieval tasks in order to satisfy their information needs. As a result, Web search behaviour has emerged as a topic for both information science researchers and information systems developers.

Several researchers have shown a keen interest in Web search and interaction behaviour studies (examples: Belkin, 1996; Du & Spink, 2011; Ellis, 1989; Ellis, 1993; Ingwersen, 1996; Jansen, Booth, & Spink, 2009a; Kuhlthau, 1991; Saracevic, 1997; Spink, 1997; Weber & Jaimes, 2011; Wilson, 1997); they were concerned with how users search information on the Web. Studies continue to explore factors that influence users’ Web searching experience, such as demographics, information needs, perceptions, prior Web search experience, and individual differences. One important factor is that of users’ cognitive style, which is under-researched in information science.

1 Albert Szent-Gyorgyi (1893 – 1986), Hungarian Biochemist; 1937 Nobel Prize for medicine
Cognitive style can be defined as an individual’s preferred and habitual approach to organising and representing information (Riding & Rayner, 1998, p. 8). Each individual has a unique cognitive style (Felder & Spurlin, 2005). Cognitive style affects the ways in which events and ideas are viewed; the ways how an individual may think, react to, represent situations, and make decisions (Riding & Rayner, 1998, p. 118); and the ways the users’ perform tasks and retrieve information (Chen & Liu, 2009). The different ways of accessing information affect the quality of the information retrieved.

While several studies have explored Web searching and developed models of information behaviour (IB), few studies have developed Web search models that explore users’ cognitive styles and Web searching process. There is a need to model the inter-relationships between users’ Web search behaviour and their contextual factors, particularly their cognitive styles. It is important not only to investigate how users search, process, navigate and query the Web in order to retrieve relevant information to satisfy their information needs, but also to examine the impact of contextual factors such as users’ cognitive styles on their Web search behaviour. Modelling Web search behaviour with a greater understanding of users’ cognitive styles will help to bridge the gap between information users and information systems.

Given the importance of the roles played by user characteristics in Web searching, this study explores three aspects: how users search information on the Web; various aspects of users’ Web search behaviour; and how users’ cognitive styles influence their Web searching. The main goal of the study is to enhance Web search models with a better understanding of how cognitive styles affect Web searching.

The significance of this research is twofold: it will provide insights for information science researchers, information system designers, academics, educators, trainers and librarians who want to better understand how users with different cognitive styles perform information searching on the Web; at the same time, it will provide assistance and support to the users.

In this study, Web searching is defined as user activities involving Web search engines, such as information searching and retrieval; and cognitive style is
understood to be and is defined as a Web user’s thinking approach to information processing, organising and retrieval (Riding & Rayner, 1998).

1.3. Research Problem

IB researchers and IS developers are continuously exploring user - Web search interactions to understand and to help users to provide assistance with their information searching. However, few studies have explored the relationships between users’ Web searching behaviour and their cognitive styles. Several studies that have attempted to develop models of IB have identified various factors that govern users’ information searching and information retrieval (IR), such as age, gender, prior knowledge, and cognitive style. However, there exist few studies and models that incorporate cognitive styles to provide user-oriented support for information search and retrieval. How users’ contextual factors, such as cognitive styles, affect Web search interactions has not been clearly explained by the current models of Web Searching and IR.

This research addresses two issues with regard to Web searching and modelling. Firstly, with the rapid growth of information on the Web, users often find it difficult to search relevant information. Secondly, of the many factors that influences user-Web search interactions, user’s cognitive style is potentially one of the most important. Figure 1-1 illustrates some examples of factors that influence user–Web search interactions. How users’ cognitive styles affect Web search interactions is not clearly explained by the current models of IR. In particular, only limited number of studies has explored the relationships between users’ Web searching behaviour and their cognitive styles. This is significant because these relationships help better understanding of how users with different cognitive styles perform their information searching.

Investigating the effects of cognitive styles on Web search behaviour will help IS designers and developers design a user-personalised interface and model that will enhance Web search interactions. This research addresses these research gaps and extending our limited understanding of the inter-relationships between users’ Web search behaviour and their cognitive styles. Since the time of the reviewed studies, search engines have advanced in search features. For example, the auto-fill feature of
Google search engines assists users in recognizing search terms to be included in a search query. Consequently, user search strategies may have also changed. Thus, examining contextual factors such as cognitive styles and their influence on user search behaviour is an important research area.

Figure 1-1: Some examples of the factors, such as user cognitive style, that influence user-Web search interactions.

1.4. Research Aims and Objectives

While the overall goal of the study was to develop an enhanced Web search model that integrates a greater understanding of how cognitive styles affect Web searching, this study intended to serve three main purposes. The first purpose was to investigate how users perform their Web searches. The literature review (in Chapter 2) indicated that users show different Web search patterns. This study aimed to further investigate types of search strategies, query reformulations, navigational styles and information processing approaches that users adopt in order to search information on the Web in order to achieve their information needs.

The second purpose of the study was to investigate the impact of users’ cognitive styles on their Web search behaviour by investigating the relationships between users’ cognitive styles and their Web search behaviour.
The third purpose of the study was to develop a model of Web search behaviour that recognises and integrates users’ cognitive styles. Two models that depict the inter-relationships between users’ Web search behaviour and their cognitive styles were developed. These models provide insights on Web search behaviour that will help researchers and information systems developers provide adaptive support to users.

1.5. Research Questions

The main goal of the study was to develop a Web search model that integrates a greater understanding of users’ cognitive styles. Hence, the fundamental research question underpinning the study was:

*What are the relationships between users’ cognitive styles and their Web search behaviour?*

While this research question remains the main focus, the following three sub research questions corresponding to the three purposes of the study were framed and addressed in this study:

i. How do users perform Web searching to achieve their information needs?

ii. What are the effects of users’ cognitive styles on their Web search behaviour?

iii. How can the interrelationships between users’ cognitive styles and their Web search behaviour be effectively modelled?

1.6. Significance and Contributions

This study is based on the rationale that users and their characteristics, specifically their cognitive styles, play an important role in their Web search interactions. The major anticipated outcomes of this study are (1) a comprehensive analysis of how users search the Web, (2) an extensive discussion on the implications of the models developed in this study, and (3) a theoretical framework to bridge high-level search models and cognitive models for future researchers, IS designers, academics and librarians.

1. This research provides comprehensive analyses of how users, with different cognitive styles, search the Web: this will contribute to a better understanding of
Chapter 1: Introduction

the Web search characteristics and cognitive factors that influence Web searching processes and results. Such an understanding is vital to user studies that are driven towards improving user–Web interactions because it can help to develop a personalised Web-search interface.

2. This study provides an extensive discussion of the implications of the models developed in this study for future researchers and information systems developers. The models, which depict the relationships between users’ cognitive styles and their Web search behaviour, provide valuable insights into the development of effective IR systems and Web search interfaces that both offer adaptive personalised support to individual users.

3. This study provides a theoretical framework that bridges high–level search models and cognitive models. The outcome of this study benefits website and search engine designers in the development of user-oriented search engines to provide support and assistance to the users. Future researchers, academics and librarians can also utilise the findings from this study to provide support and assistance to users.

To achieve the aims of the study, a user study with 50 participants was conducted. The study adopted a mixed method approach that used several data collection strategies to gather a range of qualitative and quantitative data. The study results provide valuable insights into Web searching behaviour among different cognitive style groups. The findings of the study extend our understanding of Web search behaviour and how users search information on the Web.

1.7. Overview of the Thesis Structure

This thesis consists of six chapters. Chapter 1 provides background information to the study, including aims and objectives, and research questions. The chapter also outlines expected research outcomes and contributions of the study.

Chapter 2 presents the review of the related literature, outlining what has been done to date in related areas of study. This chapter also includes key theoretical models underpinning the study, situating it within IB, Web search and cognitive style domain research. This chapter establishes the research gap covered by the study.
The research design, including concepts and theories, and the research approaches to the data collection and data analysis, are described in Chapter 3. This chapter is very important because it guides the whole study process. Other studies should be able to use the research design to replicate similar results in the research area.

The results of the research are reported in Chapter 4. The chapter includes two main result sections, one on user characteristics and demographic information, and another on Web search behaviour and cognitive styles.

The key findings and research implications discussed in Chapter 5 address the research questions framed for the study. Two models, based on the results of the study, are developed and presented in this chapter.

Chapter 6 presents a summary of the study findings and research contributions. This chapter also outlines the limitations of the study, the challenges faced and the recommended future work.
Chapter 2: Literature Review: Information Searching Behaviour

*Literature adds to reality; it does not simply describe it. It enriches the necessary competencies that daily life requires and provides; and in this respect, it irrigates the deserts that our lives have already become.*

C. S. Lewis

2.1. Introduction

The study of users’ information behaviours and how users interact with Web search is a significant contemporary topic. Many studies have modelled aspects of Web searching tools (e.g., Drigas & Vrettaros, 2006), Web searching behaviour (e.g., Jansen, Spink, & Taksa, 2008; Spink & Zimmer, 2008), and information retrieval interaction (e.g., Ingwersen, 1996; Saracevic, 1997), as well as cognitive style theories in general (Pask, 1976; Riding & Cheema, 1991; Witkin et al., 1977a).

Figure 2-1 represents connections between different components of the selected and related literature. The study of information behaviour provides a background and better understanding of interactive information retrieval (IR), which in turn acts as a driving force for user–Web search interactions. Web searching and user modelling should support and consider Web users’ cognitive styles in order to provide a personalised user interface.

The main aim of this study was to establish the relationships between users’ cognitive styles and their Web search behaviour. Understanding the existing literature around the subject provides not only what has been done to date but also reveals the gap in current research findings.

2 Clive Staples Lewis (1898–1963), British scholar and novelist
Chapter 2: Literature Review

This chapter reviews the previous studies, theories and models on information behaviour, Web search behaviour, user modelling, and the contextual factors and users’ cognitive styles. While the first three sections (sections 2.2-2.4) and the following section (section 2.5) provide background information on Web searching and users’ cognitive styles respectively, the last section (section 2.6) reviews the literature that has attempted or has examined to establish the relationship between Web search behaviour and users’ cognitive styles.

Figure 2-1 Literature review process and connections between different components

2.2. Information Behaviour

With the rapid growth of information on the Web, the study of information behaviour (IB) within the field of library and information science has led to an increased interest. As illustrated in Figure 2-1, the study of IB provides background information on user–Web interactions. Information behaviour refers to how people seek, manage and use information, and includes “activities concerned with information use, such as information seeking behaviour and interactive IR” (Ingwersen & Järvelin, 2005, p. 21).

Wilson (2000) defined information behaviour as “the totality of human behaviour in relation to sources and channels of information, including both active and passive
information seeking and information use” (2000, p. 1). Active information seeking refers to face-to-face communication and active online information seeking. Passive information reception includes information received through informal channels, such as watching television, without any intention to act on the information received. IB can be broadly categorised into three groups: information seeking, information searching, and interactive information retrieval. These are defined below.

2.2.1. Information Seeking Behaviour

Information seeking is defined as “purposive seeking for information” in which an individual interacts with “manual information system” (such as newspaper or library) or with a “computer-based systems” (such as the Internet) in order to achieve a goal (Wilson, 2000, p. 1).

The traditional practice of information seeking was associated with libraries. However, in modern times informal channels such as face-to-face chatting with people, and watching TV are preferred by the users (Spink & Cole, 2006). Many researchers use the term ‘information seeking’ interchangeably with ‘information searching’ or ‘information retrieval’.

2.2.2. Information Searching Behaviour

Information searching behaviour is the action engaged by information users in interacting with IR systems (Wilson, 2000). These interactions with the systems could be either at the human–computer interaction level, such as typing, or at the cognitive intellectual level, which may involve mental acts such as using a Boolean search strategy or judging the relevance of the information.

Wilson (1999) proposed a nested model of information behaviour, illustrated in Figure 2-2. He reported that various models within the area of information behaviour may be seen as a series of nested fields with a variety of methods that people employ in order to access information resources. He described information searching behaviour as a subset of information seeking behaviour and information seeking behaviour as a subset of information behaviour (see Figure 2-2).
2.2.3. Interactive Information Retrieval

Information retrieval (IR) is a process of finding and obtaining material that satisfies information needs. It is usually initiated by presenting a series of queries to the information processing system. IR systems started as processing systems in the 1950s and 1960s (Saracevic, 1997). With the emergence of information technology, IR systems became interactive in the 1970s. Interactive IR is viewed as “interactive communication processes” that occur between an end user and an IR system during information retrieval in organised knowledge sources, such as the Internet (Ingwersen, 1992, p. 228).

The way a user retrieves and uses information is linked with cognition and situational application (Saracevic, 1996) and with meta-cognition (Gorrell et al., 2009). Interactive IR involves many human cognitive shifts at different information behaviour levels. In a study to evaluate user interaction with Web search engines, Spink (2002) found that all users experienced some level of shift/change in their information seeking and their personal knowledge due to their interactions with the Web search engines.
2.3. Web Search Behaviour

Web search behaviour refers to information seeking and information searching on the Web that requires users to interact with Web search engines to retrieve the required information. Many studies have modelled aspects of Web searching and more researchers are exploring it.

User-Web search behaviour depends on information searching strategies, Web navigations and query reformulations. In other words, Web search behaviour can be expressed in terms of the information searching strategies, Web navigational styles, and query reformulations of a user. The following sections describe studies that have focused on these major components of Web search behaviour.

2.3.1. Search Strategies

A user’s Web search strategy refers to how he or she approaches his or her information searching. Different authors and researchers look at search strategies in different way and classify them into different types.

Navarro-Prieto, Scaife and Roger (1999) broadly classified users’ search strategies into three types: top-down, bottom-up and mixed. A top-down strategy is when users search on a general area and then narrow down their search from the links provided until they find the information they are looking for. In contrast, in a bottom-up strategy users look for specific keywords using the search engine and then scroll down the results until they find the required information. In a mixed search strategy, users use both the top-down and bottom-up search strategies.

Navarro-Prieto, et al. (1999) examined the search strategies employed while users performed Web searching. Four types of search tasks were assigned to students with different levels of search experience, namely: dispersed structure specific fact-findings (e.g., look for criteria for the diagnosis of diseases); dispersed structure exploratory (e.g., find all the available jobs for profession); category structure specific fact-finding (e.g., look for word definition); and category structure exploratory (e.g., find all information about 1997 Nobel Prize for Literature). The study found that for the dispersed structure specific fact-finding task, the experienced
Web users followed a mixed strategy at the beginning of the experiment and then gradually adopted a bottom-up approach. For the dispersed structure exploratory task, experienced users followed a top-down strategy. On the other hand, novice users employed a top-down search strategy in the beginning and a bottom-up strategy towards the end of the dispersed structure task completion, while for the category structure task, they started searching with bottom-up and then changed to top-down.

Wile investigating Web searching performed by 80 participants to complete two researcher-defined tasks and two participant-defined information-seeking tasks, Thatcher (2006) identified twelve different cognitive search strategies that reflected both retrospective verbal protocol data and groups of search behaviour patterns. Thatcher reported that participants with higher levels of Web experience, measured by a questionnaire adapted from Thatcher and Greyling (1998), were more likely to use parallel player, parallel hub-and-spoke, known address search domain, and known address strategies, whereas participants with lower levels of Web experience were more likely to use virtual tourist, link-dependent, to-the-point, sequential player, search engine narrowing, and broad first strategies.

The above studies indicated that Web users adopt different patterns of Web search strategies and approaches to information searching. Theses studies provided valuable insights on the types of search strategies searchers use. However, there is still a need to examine extensively how users employ different search strategies, and how their contextual factors, such as cognitive style, influence their Web search strategies.

### 2.3.2. User Navigational Styles

Web navigational styles refer to browsing behaviour in which the users access the content of the Web by following a series of links or pages. The study of how users navigate the Web is a significant contemporary topic. Most search engines today provide multiple navigation tools that allow users to structure their navigation strategies with multiple approaches. For example, Google provides different search features and tools, such as maps, image and video, and users can use these tools to search information. Other studies have reported users getting lost or disoriented while navigating on the Web. Chen and Macredie (2002) reported user comments such as “disorientation problem”, “lost in hyperspace”, and “mismatching” while
navigating on the Web. They also reported a user’s preference having significant effects on his or her navigation. (This provides motivation to investigate how users’ cognitive styles influence their navigational styles.)

A number of studies have modelled users’ navigation behaviour in order to provide adaptive navigation support in Web applications (Herder & Van Dijk, 2004; Leung et al., 2000). According to Herder and Juvina (2004), a dynamic user navigation model could include:

- **Syntactic information** (e.g. which links are followed? What does the navigation graph look like? What is the time that users spent on each page?);
- **Semantic information** (i.e. what is the meaning of the information that the user encountered during navigation?); and
- **Pragmatic information** (i.e. what is the user using the information for? What are the user’s goals and tasks?) (2004, pp. 3-4).

Kim (2008b) investigated how users’ emotional and affective responses, and search tasks interact and influence Web search navigations. Kim’s study findings indicated that users tended to use more navigation tools in a general search task that required them to find a few pieces of information on a broad topic than they were in a specific task that required locating one specific piece of information that was known to exist on the Web.

**Types of Navigational Styles**

Several researchers while investigating users’ navigational styles have used a number of factors/characteristics to measure user navigation. Page visits and link clicks are the most common form of measurement in Web navigation. Herder and Juvina (2004) investigated the Web navigation patterns by capturing various aspects of page revisits. They proposed two types of navigational styles: flimsy and laborious. *Flimsy navigation styles* were associated with a small number of pages visited, a high number of returns to the pages previously visited, a low number of cycles (difference between the number of links followed and the number of pages visited), a high rate of home page visit and a high frequency of back button use. The *laborious navigation style* was associated with a high number of links followed per page, high
Chapter 2: Literature Review

Page revisitation rate, high number of cycles, high return rate (average number times a page was revisited), high frequency of back button use and high number of pages visited. Users who navigated in a flimsy style were not able to reconstruct their navigation paths and thus were prone to get stuck. On the contrary, users in a laborious navigation seemed to employ a trial and error strategy. They followed links just to test usefulness.

Aforementioned studies provided motivations for this study. However, there seem to be a lack of explicit mention of cognitive styles and their roles during Web navigations. This study investigates the impact of users’ cognitive styles on their Web search behaviour in which Web navigational style is one of the major components of Web search behaviour.

2.3.3. Query Reformulations

Query reformulation, considered as one of the components of Web search behaviour, can be defined as a process of altering a given query in order to improve search or retrieval performance (Jansen, Booth, & Spink, 2009b). Users constantly reformulate their queries while searching information on the Web (Jansen, et al., 2009a; Tjondronegoro, Spink, & Jansen, 2009). Users also issue more query reformulations in a more complex search task (Li, 2009). A user’s query reformulation pattern forms a major component of the Web search behaviour on the basis that it reveals the user’s searching activities and skills.

Investigating users’ query reformulation behaviour can provide valuable information about the interactions between a user and the Web search engine. Users submit queries to search engines to conduct their first search, frequently making changes to their queries in order to improve the results of the search. Depending on the system feedback and searching results displayed, users employ their prior knowledge and experience to reformulate their queries until the required information is retrieved.

Sutcliffe and Ennis (1998) proposed a process model of information searching activities and knowledge sources in which query formulations and reformulations were identified as part of the core component of the model. They argue that query formulation/reformulation is one of the main activities performed in a retrieval
process. They found that the complexity of query formulation depends on the complexity of the IR system and the user’s skill in generating queries. Complex queries can be formed if the user is skilled in query languages, such as Boolean and structured query language (SQL), where the information need is transformed into keywords and query syntax, which are employed by IR systems.

Huang and Efthimiadis (2009) analysed query reformulations in the America Online (AOL) query logs. They reported that different query reformulation strategies had distinct characteristics and found certain query modifications, such as add/remove words, word substitution and spelling correction most effective. They reported that users performed a query reformulation because of dissatisfaction with the previous results.

In a study of Dogpile.com log analysis of 4,056,374 records, Jansen, et al. (2009a, 2009b) reported that 22.73% of the search queries were query reformulations in which searchers modified their previous queries. They also reported that Web searchers moved to narrow their query at the start of a session and then moved to reformulation in the midth and later portions of the session.

It is important to understand query reformulation classification for the present study because users’ Web search behaviours are examined through their query reformulation, along with other components. Several researchers classified query reformulations using a different approach. The following sections present query reformulations classifications adopted by past researchers.

### 2.3.3.1 Query Reformulation Classifications

Different researchers tend to classify query reformulations differently. Table 2-1 illustrates and summarises the query reformulations classification taxonomy adopted by various authors, of which some examples are briefly reported here. Rieh and Xie (2006) characterised Web query reformulation as having three facets: content, format and resource.

*Content* modifications refer to those instances in which users made changes to the meaning of a query. *Format* modifications include the cases in which users made changes without altering the meaning of the query, by means of using operators.
Resource modifications refer to those instances in which users intended to make changes in types of information resources (e.g., news, images, and music files). In the analysis of 313 search sessions, content modifications account for 80.3% of the query reformulations, while 14.4% of the query reformulations are format modifications and 2.8% of the modifications are related to resource modifications.

Recent researchers have used automatic detection methods to classify queries into several taxonomies of query reformulation classes. Jansen, et al. (2009a, 2009b) classified query formulations into six groups while investigating Dogpile.com search logs:

- **New**: The query is the first query from a unique User Identification–Cookie, or the query is on a new topic from this searcher
- **Assistance**: This query is generated by the searcher’s selection of an ‘Are You Looking For?’ feature.
- **Content Change**: The user executed a query on another content collection. The available content collections were Web, Images, Audio, News, and Video.
- **Generalization**: The current query is on the same topic as the searcher’s previous query, but the searcher is now seeking more general information.
- **Reformulation**: The current query is on the same topic as the searcher’s previous query, and both queries contain common terms.
- **Specialization**: The current query is on the same topic as the searcher’s previous query, but the searcher is now seeking more specific information. Jansen, et al. determined a query reformulation to be specialization if the query contained more terms than the previous query by a particular user (2009b, p. 1362).

They reported that 63% of the total queries submitted correspond to users initiating a new search. Thus, **New** reformulation dominated among the different types of query modifications.
<table>
<thead>
<tr>
<th>Source</th>
<th>Query Reformulation Categories</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fidel (1991)</td>
<td>Operational: a user does not change the meaning of a request.</td>
</tr>
<tr>
<td></td>
<td>Conceptual: the user changes the meaning of a request.</td>
</tr>
<tr>
<td>Lau and Horvitz (1999)</td>
<td>New: A query for a topic not previously searched for by this user within the scope of the dataset (twenty-four hours).</td>
</tr>
<tr>
<td></td>
<td>Generalization: A query on the same topic as the previous query, but seeking more general information than the previous query.</td>
</tr>
<tr>
<td></td>
<td>Specialization: A query on the same topic as the previous query, but seeking more specific information than the previous query.</td>
</tr>
<tr>
<td></td>
<td>Reformulation: A query on the same topic that can be viewed as neither a generalization nor a specialization, but a reformulation of the prior query.</td>
</tr>
<tr>
<td></td>
<td>Interruption: A query on a topic searched on earlier by a user that has been interrupted by a search on another topic.</td>
</tr>
<tr>
<td></td>
<td>Request for additional results: A request for another set of results on the same query from the search service.</td>
</tr>
<tr>
<td></td>
<td>Blank queries: Log entries containing no query. These entries arise when a user clicks on the search button with no query specified or when a query by example is performed.</td>
</tr>
<tr>
<td>Jörgensen &amp; Jörgensen (2005)</td>
<td>Add, Eliminate, Change</td>
</tr>
<tr>
<td>Kowalczyk, et al., (2005)</td>
<td>Location (where), Number (how much), Person (who, whom, whose), and Time (when?).</td>
</tr>
<tr>
<td>Rieh and Xie (2006)</td>
<td>Specified reformulation refers to those sessions in which a user persists in specifying previous queries. Adding more terms and combining concepts are the most frequently used specified reformulations. Generalized reformulation refers to those sessions in which a user begins with a narrow concept and continues on to generalize through successive trials. Deleting terms is the most popular move for generalized reformulation. Parallel reformulation refers to those sessions in which a user modifies the queries from one aspect of an entity to another or from one thing to another, both of which share common characteristics. Building-block reformulation refers to sessions in which a user identifies and combines the concepts from the previous queries and uses them in subsequent queries. Dynamic reformulation refers to those sessions in which a user employs inconsistent patterns to increase specificity or generality, moving around from one type of query reformulation to another. Multi-tasking reformulation refers to those sessions in which a user looks for two or more topics simultaneously in the same search session. Recurrent reformulation represents cases in which a user enters exactly the same query that has been already used two or more steps previously. Format reformulation refers to those sessions in which a user attempts to figure out how to formulate his/her queries correctly in terms of format. Format reformulation might include term variation, operator usage, operator change, and error correction.</td>
</tr>
<tr>
<td>Tseng, Tjondronegoro and Spink (2009)</td>
<td>Generalized: A user may begin with several search terms and subsequently drop some of the terms to include more results. Specified: A user persistently specifies a query by adding more terms or changing to more specific phrases. Dynamic: A user inconsistently switches between generalized and specified reformulation. Such modification pattern manifests the unplanned nature of user’s search process. Constant: Constant search occurs when a user modifies terms of the same concept level which shares some common characteristics, for example when substituting with related objects (e.g. from PC to Mac) or synonyms.</td>
</tr>
<tr>
<td>Jansen et al. (2009a, 2009b)</td>
<td>New: The query is the first query from a unique User Identification–Cookie, or the query is on a new topic from this searcher. Assistance: This query is generated by the searcher’s selection of an ‘Are You Looking For?’ feature. Content Change: The user executed a query on another content collection. The available content collections were Web, Images, Audio, News, and Video. Generalization: The current query is on the same topic as the searcher’s previous query, but the searcher is now seeking more general information. Reformulation: The current query is on the same topic as the searcher’s previous query, and both queries contain common terms. Specialization: The current query is on the same topic as the searcher’s previous query, but the searcher is now seeking more specific information.</td>
</tr>
<tr>
<td>Huang and Efthimiadis (2009)</td>
<td>Spelling correction, Word substitution, Add word, Substring, Remove word, Word reorder, Expand acronym, Stemming, New, Abbreviation, Superstring, Form acronym, URL stripping</td>
</tr>
<tr>
<td>Liu and Gwizdka (2010)</td>
<td>Generalization: Qi and Qi+1 contain at least one term in common; Qi+1 contains fewer terms than Qi. Specialization: Qi and Qi+1 contain at least one term in common; Qi+1 contains more terms than Qi. Word Substitution: Qi and Qi+1 contain at least one term in common; Qi+1 has the same length as Qi, but contains some terms that are not in Qi. Repeat: Qi and Qi+1 contain exactly the same terms, but the format of these terms may be different New: Qi and Qi+1 do not contain any common terms. Note: Qi+1 is the query immediately following the query Qi in the same session.</td>
</tr>
</tbody>
</table>

Table 2-1: Query Classifications
2.3.4. Web Logs Analysis

A search log, also referred to as a transaction log, is a record of interactions between a system, such as a search engine, and the users of the search system. The process of analysing this data is referred to as search log analysis. Search log analysis provides rich data for the investigation of information behaviour (Jansen, 2006; Jansen, 2008; Jansen, et al., 2008). Data gathered by search logs has significant advantages over the data collected by other instruments, such as questionnaires.

Although the World Wide Web Consortium (W3C) sets log file format, researchers use different fields depending on the goal of the study. The W3C is an international community that develops Web standards including Web log formats (Hallam-Baker & Behlendorf, 2009). Search logs can be recorded either on a client machine or on a Web server by running application software.

Jansen (2006) proposed the following fields to record each searching interaction.

- **User identification**: The Internet Protocol (IP) address of the client’s computer. This is sometimes also an anonymous user code address assigned by the search engine server.
- **Date**: The date of the interaction as recorded by the search engine server.
- **Time**: the time of the interaction as recorded by the search engine server.
- **Search Uniform Resource Locator (URL)**: the query terms as entered by the user.

Many researchers have used search logs to investigate interactions between users and Web search engines. Ellis et al. (2002) used Web search log analysis to examine the information-searching behaviour of academic researchers during a mediated interaction with an IR system. Spink, Park and Koshman (2006a) investigated assigned information problem ordering using search log analysis as one of their data analysis methods. Spink, et al. (2006b) employed search logs analysis to investigate the characteristics of user task switching and multitasking information behaviour during Web searching sessions. Jansen, Zhang & Spink (2007; 2006, 2009a, 2009b) also used a Web search engine transaction log to investigate users’ actions and to predict relationships between searcher actions.
This study used Web search session logs, similar to Web search logs, to investigate each participant’s interactions with search engines. The study used a monitoring program to capture user–Web search interactions from which Web search session logs were created manually.

Several studies indicated users’ contextual factors influencing their Web search behaviour. The following section presents some of the current studies that explored contextual factors influencing Web search behaviour.

2.3.5. Factors Affecting Web search behaviour

The previous sections reported studies on Web search behaviour. Users employ different search strategies to locate information on the Web, and their interactions with the search engines are influenced by various factors. Previous studies identified various attributes that govern user information searching and retrieval, such as task types (Gwizdka & Spence, 2006; Kim, 2008a).

The following sections review related studies that have explored the influence of search task types on Web search behaviour.

2.3.5.1. Search Task Complexity

Many studies have investigated the relationship between search task types and information seeking and retrieval behaviour (e.g. include: Byström & Järvelin, 1995; Gwizdka & Spence, 2006; Kim, 2006a, 2006b; Kim, 2008a; Vakkari, 1999). Some of these are briefly reviewed below.

Gwizdka and Spence (2006), in a study of Web navigation, reported that the more times a searcher spent on a search task and the more Web pages they visited, the more difficult they assessed the information seeking task. They found that low complexity tasks were characterised by shorter optimal paths (2 to 3 ‘clicks’) and high complexity tasks by longer optimal paths (5 to 6 ‘clicks’). They also reported that individual differences among Web users affected the relationships between objective task complexity and subjective task difficulty. They highlighted that a searcher’s perception of task difficulty depends on individual characteristics such as
search experience, domain knowledge, verbal ability, motivation, and notably, cognitive ability.

Bilal (2001) reported that children’s cognitive, physical and affective behaviours are affected by different types of search tasks while searching information on Yahooligans, a Web search engine for children. The search tasks were categorised as fact-based and research. A fact-based task is one that required a single, and straightforward answer. A research task is one that required the use of critical thinking skills to construct meaning from the relevant information found, and that had multiple facets.

Bilal (2001) found that children experienced more difficulty with the research task than with the fact-based task. The study also reported that the types of search task influenced children’s levels of success. Children who partially succeeded on the research task and fully succeeded on the fact-based one backtracked (i.e., use of Netscape Back command) slightly less on the research task than they did on the fact-based one. Unsuccessful children backtracked more often on the research task than they did on the fact-based task. Partially successful children looped searches and hyperlinks less frequently than done by unsuccessful ones.

Choi (2010) investigated the effects of search task goals, Web search experience, work task stage and topic familiarity on the image searching process. The task goal is defined as the reason or activity that prompts the need to search. The work task stage is a user’s assessment of their progress in completing a task. The study reported that most of the search interactions, such as search duration, querying, and navigating, were influenced by contextual factors. Among the contextual factors, task goals, work task stages and searching experience were found to be the most influential. Users who performed a search for an academic task goal tended to have a longer search session and they also modified their queries frequently. Users with a lower level of search experience were found to spend more time performing searches to employ more querying and navigating tactics and to rate ‘usefulness’ and ‘satisfaction’ with search results at a lower rating than those who had a higher level of search experience.
Kim (2006a) argued that task difficulty depends on an individual searcher’s perception, interpretation and judgment of the objective task complexity. She reported that a searcher’s background, such as search experience and domain knowledge, specificity and source of information, and search process characteristics, influences the searcher’s perception of task difficulty.

Information researchers tend to categorise information search task attributes from a theoretical prospective, such as “information need” (Wilson, 1997, p. 552), “well-defined/ill-defined” (Ingwersen, 1996), and “task- and fact-oriented” (Kelly et al., 2002). Borlund and Ingwersen (1997) introduced the concept of “simulated work task situation”, which discuss the source of information need, the environment of the situation and the problem which has to be solved; and which serves to make the test person understand the objective of the search. They reported that simulated work task situation provides with the context, which ensures “a degree of freedom” to react in relation to individual interpretation of the given situation (Borlund & Ingwersen, 1997, p. 232).

Based on the degree of a priori determinability (or structuredness) of a task, that the more familiar a task performer is with the task requirement, the less complex the task is perceived, Byström and Järvelin (1995) classified task complexity into five categories ranging from an automatic information processing task to a genuine decision task, as illustrated in Figure 2-3. In automatic information processing tasks, the process, result and types of information used can be described in advance, whereas in genuine decision tasks, none of them can be determined a priori.

In this study, based on Borlund and Ingwersen’s (1997) concept of a “simulated work task situation”, three search tasks were designed to ensure that these tasks are as close as possible to real world situations.
### 2.4. User Modelling

The previous sections highlighted the existing studies on information behaviour and Web search behaviour. Through the review of these studies it is seen that researchers and search engine designers have built several user models. This section presents some of the important user models, which are closely related to the Web search behaviour component of this study.

There has been considerable recent interest in producing conceptual models for IR research. Several researchers have shown a keen interest in Web search and interaction behaviour studies (examples: Belkin, 1996; Ellis, 1989; Ellis, 1993; Ford, 2004; Ingwersen, 1996; Knight & Spink, 2008; Kuhlthau, 1991; Saracevic, 1997; Spink, 1997; Wilson, 1997). Early research studies were more focused on IR system needs rather than on human interaction behaviour and information needs. The research into the human or cognitive aspects of IR is in its infancy.

Researchers are exploring, investigating, and developing conceptual models that depict the process of retrieving information from IR systems or the Web. Ingwersen

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#### Figure 2-3: Task complexity categories (Byström and Järvelin, 1995)

<table>
<thead>
<tr>
<th>Task Category</th>
<th>Apriori Determinability of:</th>
</tr>
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<tr>
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<td>Information Needed Process Result</td>
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<tr>
<td>Genuine Decision Task</td>
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<tr>
<td>Known, Genuine Decision Task</td>
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<td>Normal Decision Task</td>
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<tr>
<td>Normal Information Processing Task</td>
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<td>Automatic Information Processing Task</td>
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<th>Determinable parts</th>
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and Jarvelin (2005) categorised interactive IR models into four different kinds, depending on the needs of the applications and the kind of task the model is designed for.

- **Process Models – Static Models:** Some models are explicitly process models or functional models in that they model the stages of some information system and retrieval (IS&R) process. Other models are static as a sequence of stages.

- **Abstract Model – Concrete Models:** Concrete models focus on actual concrete stakeholders in an IS&R process and their relationships. On the contrary, theoretical or abstract models focus on abstract phenomena, interpretations or structures related to the stakeholders, and the relationships of the former.

- **Summary Models – Analytical Models:** Summary models seek to summarise the central objects in an IS&R process and their gross relationships without classifying and analysing either. Analytics models, often narrower in scope, seek to classify the objects and relationships, and to generate testable hypotheses.

- **General models – Specific Models.** General models claim applicability and validity over a range of empirical domains. The early information seeking models were specific models for science and technology whereas some more recent models claim greater generality, i.e., applicability in more general work and leisure contexts (Ingwersen & Järvelin, 2005, p. 15).

It is acknowledged that there are many models being developed and used by researchers to study the process of retrieving information from the Web. Some of the major developments of models closely related to Web search behaviour are outlined below.

### 2.4.1. Wilson’s (1981) Model of Information Behaviour

In 1981, Wilson presented a model for examining information seeking behaviour. The model, illustrated in Figure 2-4, suggested that information seeking behaviour
arises as a result of the information need of an information user, and that this relationship between the user and the information need is affected by the so-called information environment. Wilson’s model included three main components: information user, information need, and information environment.

Figure 2-4: Wilson’s (1981) Model of Information Behaviour

The information user remains the centre of attraction, for all other information seeking behaviour takes place around the user – it is the user who engages in information behaviour. The user may demand information from information systems, which may perform ‘information functions’ to obtain the information. Users may alternatively seek information from ‘other people’ (‘information exchange’).

Wilson’s (1981) model is not a specifically Web-focused model. However, it includes various aspects of general information searching that are also relevant to Web searching, such as information need and information user. The model provides a foundation for model building in this study.

While the model presented relationships between different components, such as information needs, person-in-context, and information processing, it did not consider an individual’s cognitive styles and their relationship with information searching. The continuous looping nature of the model also indicates that there is no stopping in the feedback cycle, which implies that information needs are never satisfied.
Information seeking takes place in order to satisfy the *information need* of the user, which can be further grouped into three sub-categories: physiological needs, such as the need for food, water, shelter; affective needs (sometimes called psychological or emotional needs) such as the need for attainment, domination; and cognitive needs, such as the need to plan, to learn a skill. It is these information needs that lead to information searching. These three categories are interrelated in the sense that physiological needs may trigger affective and/or cognitive needs; affective needs may give rise to cognitive needs; and problems relating to the satisfaction of cognitive needs, such as failure to satisfy needs, may result in affective needs. Affective needs are prominent in health-related information seeking, where an individual may be looking for information about prevention, detection and treatment, or any information that may help ease the problem emotionally.

Many other factors besides information need, such as personal, interpersonal and environmental barriers, affect a user’s information seeking behaviour. The model had two limitations. Firstly, although the model sheds some insights into information seeking behaviour, all the hypotheses were only implicit, not made explicit. For example, it was assumed that the ‘information environment’ barrier would have similar effects on the information need and therefore would have similar effects on the information seeking behaviour. However, there were no explicit measures assessed to show the impact of the information environment on the information seeking behaviour.

Secondly, the model identified several factors that influence information seeking behaviour, such as information needs and personal, interpersonal and environmental barriers. However, important contextual factors, such as the users’ cognitive styles that influence their information seeking behaviour, were excluded from the study and the model.

This thesis explores some of Wilson’s (1981) model by including users’ cognitive styles as an important component of a model of information behaviour. However, A model of associations between users’ cognitive styles and their Web search behaviour was developed and presented. Wilson’s (1981) model is theoretical in nature, whereas the model presented in this thesis is empirical. Therefore, the model
will provide concrete meaning to understanding of how users’ cognitive styles affect their Web search behaviours.

2.4.2. Ingwersen’s (1996) Cognitive IR Interaction Model

Ingwersen (1996) proposed a global cognitive model of IR interaction from a cognitive point of view based on the concept of *polyrepresentation*. The concept of polyrepresentation refers to user’s cognitive space, and methods of representation of the information objects in the information space. The model, as illustrated in Figure 2-5, has three main components: information objects, the intermediary and the information space of the IR system (IR system setting). *Information objects* are text, pictures and models that represent the user’s information. Ingwersen (1996) argued that the information seeking process is also dependent on the *IR system* and its associated techniques.

![Figure 2-5: Ingwersen’s (1996) cognitive model of IR interaction](image-url)
The intermediary component has two elements: the user’s cognitive space and the social environment. User’s cognitive space relates to his or her information need, problem, goal, knowledge states, and work task and interest, determined by the experiences gained through time in a social and historical context. Different cognitive structures of the individual users, which may end up in a problem or uncertainty state, influence not only the authors of texts and systems design attitudes but also the current searcher in a ‘historical social-semantic sense’. Ingwersen believes that the functions of each of these components are the results of cognitive models of the domain of interest.

The cognitive transformations take place while moving from an information seeking state to an information acquisition state; the result of the transformation affects the generator’s knowledge structures and the recipient’s state of knowledge. In IR the cognitive structures are represented in the form of transformations generated by a variety of human actors, such as system designers and producers, IR techniques developers, authors of texts and image, intermediary mechanism designers, and users in a domain-related societal or organisational context. In the IR system setting, an IR system designer’s cognitive structures are represented by specific database architectures and one or several algorithms and models.

Ingwersen’s (1996) model is of particular interest because it focuses on users’ cognitive involvement. Users’ cognitive space influences their information seeking; therefore, it also has some implications for Web searching. Ingwersen’s (1996) cognitive IR interaction model depicted not only the interactive interaction process between the cognitive space of a user and the information space of the IR system, but also between a user and the social environment.

2.4.3. Saracevic’s (1997) Stratified Interactive IR Model

Saracevic’s (1997) stratified interactive IR model has three components: acquisition, cognition and application, as illustrated in Figure 2-6. Saracevic defined IR as a process occurring in three connected levels or strata: surface, cognitive, and situational. Each strata/level involves different specific processes, such as physiological, psychological, and cognitive on the human side, and physical and symbolic on the computer side.
During surface level interaction, users interact with a system (computer) through an interface; such interaction may repeat again and again with a change in the user’s interaction process. During the cognitive level, users interact cognitively with text such as images and data in order to change the state of knowledge. On the situational level, users interact with the given situation to solve a problem through investigation.

Saracevic’s (1997) model recognises the importance of user contexts, such as situational and cognitive, during information retrieval; however, it is not specifically developed for Web-based information searching. As with Wilson’s (1997), Saracevic’s model provides background information on a particular Web-based information searching model because users’ contexts, such as cognitive, play a vital role when performing information searches on the Web.

Saracevic’s (1997) model acknowledged that each component within the three levels of interaction changes during the IR process. However, how these changes occur was neither discussed nor indicated in the model. There may be other factors, such as a user’s cognitive style, which affects the level of change and degree of interaction. Further, the model does not take into consideration the user’s information process.

Figure 2-6: Saracevic’s (1997) stratified model of Interactive IR
approaches and interaction preferences. Further study and data are required to establish relationship between significant factors, such as user’s cognitive style, and query reformulation strategies, that influence the interaction process.

2.4.4. Edwards’ (2006) Net Lenses Model

Edwards (2006) proposed a theoretical model that describes students’ information searching experiences and Web search strategies (Figure 2-7). The Web-based information searching experiences are categorised into four using the words used by the information searchers:

- *Information searching seen is as looking for a needle in a haystack.* Searchers focus on the topic of their search. There is often confusion between different tools and search options. Searchers are comfortable with searching but lack confidence to push further into the environment.

- *Information searching is seen as finding a way through a maze.* Searchers perceive information searching as the process or planning of a search. They emphasise terms and synonyms, database selection, and retrieved search
results. If they persist further, they will find the way out of the maze and achieve the required information.

- *Information searching is seen as using the tools as a filter.* Searchers use search tools to help them understand the topic, and to find the required information. They tend to be successful in information searching.

- *Information searching is seen as panning for gold.* Searchers use appropriate tools to locate information and personal reflections to filter the retrieved search results and find the required information of high quality.

Edwards’s (2006) ‘Net Lenses’ model differs from the previous ones (Ingwersen, 1996; Saracevic, 1997; Wilson, 1997) in that it refers specifically to Web searching and emphasises the cognitive process as an important aspect of the users’ information searching experience. Edwards’ model reveals that students’ information searching experiences can be classified into four categories. In most cases students select the appropriate search strategy depending on their current information need. However, due to individual differences – the fact that individuals differ in the manner they search the Web – there may be factors that might have influenced the students’ preference for a particular category. It is believed that factors such as searchers’ information experience, prior knowledge of the topic, cognitive style, and information needs might have influenced their Web search experiences.

This study aims to explore the impact of users’ cognitive styles on their Web search behaviour.

### 2.4.5. Wang, Hawk and Tenopir’s (2000) multidimensional model of user–Web interaction

Wang, Hawk and Tenopir’s (2000) multidimensional model of user–Web interaction, illustrated in Figure 2-8, consists of three components: the user, the interface, and the Web space. User–Web interaction is viewed as a communication process through an interface involving a series of transactions between the user and the Web.

The *user* dimension is influenced by situational factors, such as the type of the task, information need, user domain knowledge, individual cognitive style, and psychomotor skills. An *interface* is the communication channel that facilitates user–
Web interactions through the use of several elements such as access method, navigation tool, and input/output devices. The Web is what the user interacts with to obtain needed information. It contains several elements, such as information objects that include information content, structure, and links available to the user; Web spaces (search engines); and metadata that identify document structure.

The important part of the model for the proposed study is the inclusion of individual cognitive styles as one of the factors that affect user-Web interactions. Wang, Hawk and Tenopir (2000) reported that, as Web users search in a different way, individual differences may cause difficulties during information processing from the Web.

Built on previous studies, such as that of Wang, et al. (2000), this study takes one step forward, exploring the influence of users’ cognitive styles on their Web search behaviour.

Figure 2-8: Wang et al. (2000) multidimensional model of user-Web interaction


Ford (2004) proposed a model of information behaviour, illustrated in Figure 2-9, that is specifically on learning associated with information needs, information processing types, information processing approaches, and information searching. The model, drawn from the prevailing studies and theories, includes both information behavioural processes and the factors affecting these processes such as mental
process and mental states that act as learning objectives. Learning objectives are what the learner will learn or needs to learn. The learner adopts mental processes and may experience mental states as they work towards achieving learning outcomes.

*Mental process* includes information processing types and information processing approaches. The *Information processing types* are comprehension through evaluation based on Bloom and Krathwohl’s taxonomy (1956). Individuals show strategic and stylistic differences in their information processing approaches. Such differences are affected by an individual’s mental state.

*Mental states* relate to an individual’s level of knowledge, motivational orientations, self-efficacy and anxiety. It may be affective – relating to feelings, attitudes and emotions or cognitive – relating to knowledge and reasoning. They may affect both learners’ perceptions and their ability to address particular learning tasks.

For *information processing*, Ford reported that if information required to fuel the processes is not within the individual’s capacity, the information must be either provided, or processed through information seeking. *Information seeking* was said to “chart broader contextual factors that may feed into and enable the individual to judge the effectiveness of such processes” (2004, p. 208). An information need may be expressed as a parameter.

*Information needs* are affected by differences in the information processing types and the information processing approaches and strategies, which may be further affected by the nature of the task, and the mental states, such as motivation, anxiety and levels of knowledge and experience. One essential parameters of information need is that of being *cognitively ergonomic*, where the learner processes understanding of the basic concepts on which he or she builds the further understanding that constitutes the intended learning content of an information source. For the acceptance and valuing of new information to take place, Ford combined it with the learner’s existing attitudes, values and critical capacity.
Figure 2-9: Ford’s (2004) model of learning-related information behaviour

As learners differ in the ways they process information from basic comprehension through analysis and synthesis to critical evaluation, the nature of their information needs will also be affected. For example, Ford stated that the information needs and patterns of information seeking for holist learners will be “very different from their serialist counterparts, who will from the start focus more narrowly and insensitively on the individual sub-topics before establishing the overview” in the learning process (2004, p. 210). The model examined individual perceptions of which information needs are realized by the learning process.
processing goals and preferences are “appropriate to address particular learning
tasks” (2004, p. 206). However, the emphasis of the model was on mapping those
factors that affect processes rather than detailing each process and approaches. How
these factors affect the information behavioural processes was not established in the
model.

Ford’s (2004) model of learning-related information behaviour suggested that
learning takes place using various information processing approaches and strategies
that are matched with their styles, such as having a holist or a serialist, divergent or
convergent, and verbal or imagery. The model showed that there is a relationship
between users’ cognitive styles and their information behaviour. However, it is not
made clear in the model how users’ cognitive styles affected their learning and
information behaviour. More empirical findings need to be included to support and
establish the relationship between users’ cognitive styles and their information
behaviour.

This thesis addressed the current gap in Ford’s (2004) model and established inter-
relationships between users’ cognitive styles and their Web search behaviour through
analyses of the qualitative and quantitative data. Two models of associations between
Web search behaviour and cognitive styles were developed based on the empirical
findings that emerged from the study.

2.4.7. Knight and Spink’s (2008) Web-based Model of IB

Knight and Spink (2008) proposed a theoretically based, contextualised, macro
model for investigating Web-based information behaviour. The model, illustrated in
Figure 2-10, shows that user information behaviour begins with an information need,
as indicated in the use of specific information seeking or information searching. The
figure shows a user’s cognitive style to be the influencing factor in their system IR
strategies; users entering the IR process with a pre-existing information seeking or
information searching knowledge.

The model distinguishes between information seeking and information searching as
alternative entry-level strategies to IR on the Web. Information searching and query
formulation types are two aspects of information seeking behaviour. Important
components of the macro model are the behaviour and query results. The information
seeker uses query results to make judgements regarding both the system and the relevancy of the content to meet their information need.

Figure 2-10: Knight and Spink’s (2008) macro model of Web-based information behaviour

The intervening variables such as users’ cognitive styles, level of system experience, and knowledge of the topic, and activating mechanisms such as technology, have an influence on the judgement that the user makes. Knight and Spink (2008) suggested that by examining a user’s changes in behaviour within the context of the activating mechanisms and the intervening variables, a better understanding of the user’s specific information behaviour choices could be studied.

Knight and Spink’s (2008) model, drawn from several existing models, includes important components of Web-based information behaviour, such as information needs, user cognitive styles, search strategies, query results, and information retrieval. However, how these components are inter-connected is neither explicitly explored nor illustrated in the model. Users’ cognitive style was shown to have effects on the judgement that the user makes during information seeking and information searching. But how information seekers’ and searchers’ cognitive styles influence their information seeking and searching behaviour was not explained clearly.
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This study examining the influence of users’ cognitive styles on their Web search behaviour developed a model of associations between cognitive styles and Web search behaviour (Figure 5-6).

2.4.8. Summary of User Modelling

The above section presented some of the relevant user models that provide the basis for this study. Several models were developed to understand and provide adaptive user support while performing a Web search. However, few empirical studies exist that extensively explored user–Web search interactions from the user perspective. This study aimed to explore, extensively, how users perform their Web searches and satisfy their information needs. The main goal of this study was to develop models depicting the inter-relationships between users’ Web search behaviour and their cognitive styles.

The previous sections reviewed the studies that have identified several factors that influence user–Web search interactions. Among such factors influencing users’ Web search behaviour, the most important factor was their cognitive styles. The following section reviews separately the studies conducted on users’ cognitive styles, which was the focus of this study.

2.5. Users’ Cognitive Styles

This section presents studies, theories and models of cognitive styles. As illustrated in Figure 2-1, Web searching should integrate an information searcher’s cognitive styles to provide a user-oriented support. This is an important gap in the current research to establish inter-relationships between users’ cognitive styles and their Web search behaviour.

Different individuals seek and process information using different strategies; these different strategies may be more or less effective for different people in different contexts (Hsu et al., 2011). The user’s cognitive style is the most important contextual factors that affects the user’s interaction with the search engines.

Within information science, cognitive style is defined as an individual’s “preferred and habitual approach to organising”, perceiving, remembering, and “representing
information” (Riding & Rayner, 1998, p. 8). It affects the ways in which an individual deals with and responds to information, and thus will affect ideas and attitudes (Riding, 1998). Individuals with a certain cognitive style differ in the manner they perform tasks and retrieve information. As a result they differ in their Web search behaviour and search task performance.

The following section outlines some cognitive style terminology used by information researchers.

2.5.1. Terminology of Cognitive Styles

Different authors refer to cognitive style with different terms such as field-dependent/independent (Witkin, et al., 1977a), divergent-convergent (Hudson, 1968); leveller-sharpener (Holzman & Klein, 1954), holist-serialist (Pask, 1976), verbaliser-visualiser (Richardson, 1977), and wholist-analytic/verbal-imagery (Riding & Cheema, 1991).

Many instruments have been developed to investigate and assess individual cognitive styles, such as:

- Revised Approaches to Studying Inventory (RASI) (Tait, Entwistle, & McCune, 1998);
- Embedded Figure Test (EFT) (Thurstone, 1944);
- Group Embedded Figures Test (GEFT) (Witkin et al., 1971);
- Cognitive Style Index (CSI) (Allinson & Hayes, 1996);
- Verbaliser-Visualiser Questionnaire (Richardson, 1977);
- Verbal-Imagery Code Test (Riding & Calvey, 1981);

Between the 1940s and the 1980s, many researchers have developed their own theories and instruments to assess cognitive styles (Riding, 2000). This has led to the development of a large variety of cognitive style labels, theories and models in the last four decades. Rayner and Riding (1997) grouped the organisation of cognitive style models into three groups, wholist-analytic, verbaliser-imager, and an integration of both the wholist-analytic and verbal-imager dimensions. The categorised groups consist of several models of cognitive styles, which are summarised in Table 2-2.
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<thead>
<tr>
<th>Label</th>
<th>Description</th>
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<tr>
<td><strong>Key dimension: Wholist-Analytic</strong></td>
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<tr>
<td>Constricted-flexible control</td>
<td>Tendency for distraction or residence to interference.</td>
<td>Klein (1954)</td>
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<tr>
<td>Broad-narrow</td>
<td>Preference for broad categories containing many items rather than narrow categories containing few items.</td>
<td>Pettigrew (1958), Kogan and Wallach (1964)</td>
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<tr>
<td>Analytical-non analytic</td>
<td>A conceptual response, which differentiates attributes or qualities conceptualising rather than a theme or total effect.</td>
<td>Kogan and Wallach (1964); Messick and Kogan (1963)</td>
</tr>
<tr>
<td>Levelling-sharpening</td>
<td>Tendency to assimilate detail rapidly and lose detail or emphasise detail and changes in new information.</td>
<td>Klein (1954); Gardner, et al. (1959)</td>
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<tr>
<td>Field-dependency/field independency</td>
<td>Individual dependency on a perceptual field when analysing a structure or form which is part of the field.</td>
<td>Witkin and Asch (1948a, 1948b); Witkin (1961); Witkin (1971); Witkin et al. (1977)</td>
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<tr>
<td>Cognitive-complexity</td>
<td>A tendency for the multi-dimensional or simplicity or unidimensional processing of information.</td>
<td>Harvey, et al. (1961); Gardner and Schoen (1962)</td>
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<tr>
<td>Converging-diverging</td>
<td>Narrow, focussed, logical, deductive thinking rather than broad, open-ended, associational thinking to solve problems.</td>
<td>Hudson (1966; 1968); Guilford (1967)</td>
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<tr>
<td>Serial-holist</td>
<td>The tendency to work through learning tasks or problem solving incrementally or globally and to assimilate detail.</td>
<td>Pask and Scott (1972); Pask (1976)</td>
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<td>Splitters-lumpers</td>
<td>A response to information and interpretation, which is either analytical and methodical or global.</td>
<td>Cohen (1967)</td>
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<tr>
<td>Adaptors-innovators</td>
<td>Adaptors prefer conventional, established procedures; innovators prefer restructuring or new perspectives in problem solving.</td>
<td>Kirton (1976; 1994)</td>
</tr>
<tr>
<td>Concrete sequential concrete random/abstract sequential/abstract random</td>
<td>The learner learns through concrete experience and abstraction ether randomly or sequentially.</td>
<td>Gregorc (1982)</td>
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<tr>
<td>Reasoning-intuitive active-contemplative</td>
<td>Preference for developing understanding through reasoning and/or by spontaneity or insight and learning activity, either allows active participation or passive reflection.</td>
<td>Allinson and Hayes (1996)</td>
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<tr>
<td><strong>Key Dimension: Verbal-Imagery</strong></td>
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<tr>
<td>Abstract versus concrete</td>
<td>Preferred level and capacity of abstraction.</td>
<td>Harvey, et al. (1961)</td>
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<tr>
<td>Tolerance for unrealistic experience</td>
<td>Individual readiness to accept perceptual variance with conventional reality or ‘truth’.</td>
<td>Klein, et al. (1962)</td>
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<tr>
<td>Verbaliser-visualiser</td>
<td>The extent to which verbal or visual strategies are used when processing information.</td>
<td>Palvio (1971); Riding and Taylor (1976); Richardson (1977)</td>
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<tr>
<td><strong>Key Dimension: Wholist-Analytic and Verbal-Imagery</strong></td>
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Table 2-2: Description of style dimension, adapted from Rayner and Riding (1997)
Some of the cognitive style theories and models that are closely related or adopted in this study are reviewed in the following sections. These models are fundamental to the way we conceptualise our study, analyse the data, and present the findings.

2.5.2. Holist-Serialist Thinking

Pask’s (1976) work is related to the learning of complex subject matter, how people think and its effects on learning. Pask identified two cognitive learning styles: holist and serialist. A holist tends to adopt a global approach to learning; has a preference for seeing the task in a broad approach; and looks for higher order interrelationships between topics in the learning process and in building a broad conceptual overview. They learn by relating material to their own experience, relating theoretical and practical aspects of the subject learned, and using visual imagery to build up understanding. They like to have several things going on at the same time and proceed in an exploratory fashion.

In contrast, serialists use a narrow step-by-step learning approach, tending to examine one thing at a time in detail, concentrating on each step and testing out simpler hypothesis for each next move. They learn new material by linking a logical sequence together and placing a greater emphasis on memory.

2.5.3. Field-Dependent and Field-Independent Cognitive Styles

Of several studies, which examined the role of cognitive styles in learning, one is by Witkin and his team (Witkin, et al., 1977a; Witkin et al., 1977b). Field-dependence-independence describes the degree to which the surrounding field affects an individual’s perception or comprehension of information. In a study to investigate the influence of cognitive styles on academic development, they reported that the relatively field-independent (analytic) individuals prefer impersonal domains requiring cognitive restructuring skills (e.g. sciences), while relatively field-dependent (holist) students favoured interpersonal domains which do not require such skills (e.g. elementary education).

The field-independent individuals perceive part of a field as discrete from the surrounding field as a whole and experience the components of a structured field analytically, rather than embedded in the field (Witkin, et al., 1977a). They find it
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easier to locate information from its surrounding field, and experience items as more or less separate from the surrounding field. They tend to prefer a hypothesis-testing approach to learning and excel in fields requiring a greater analytical power. They tend to be easily dominated by salient cues and are more likely to be distracted in hypermedia systems where information units are presented through a variety of different, attractive media forms.

On the contrast, field-dependent individuals tend to rely on the external environment and are less capable of at structuring and analytic activity. Their perception is strongly dominated by the prevailing field. They find it difficult to locate the information, as other information tends to mask what they are looking for. They prefer a spectator approach to learning, organising the content and sequences of the learning process. They prefer to learn in groups and to interact frequently with one another. The field-dependent individuals, less dominated by salient cues, perform better in searching information on hypermedia systems. It is interesting to note that women, on average, tend to be more field dependent than men (Witkin, et al., 1977a).

Field-independent persons tend to learn more than field-dependent people under conditions of intrinsic motivation. Witkin, et al. (1977b) reported that the relatively field-independent individuals prefer impersonal domains requiring cognitive restructuring skills (e.g. sciences), while relatively field-dependent students favoured interpersonal domains which do not require such skills (e.g. elementary education).

In 1991, Riding and Cheema (1991) redefined the terms ‘field-dependent’ and ‘field-independent’ as global/wholist and analytic by, as is described in the following section.

2.5.4. Wholist-Analytic and Verbal-Imagery Cognitive Styles

Different researchers categorise cognitive dimensions into different cognitive styles. Riding and Cheema (1991) grouped the cognitive dimensions into two principal cognitive dimensions: wholist-analytic and verbal-imagery. The wholist-analytic (WA) dimension of cognitive styles describes the habitual way in which people think about, view and structure information in wholes or parts. The verbal-imagery (VI)
The dimension of cognitive styles describes an individual’s tendency to process information either in words or in a visual mode of representation and thinking.

The two dimensions of cognitive styles are illustrated in Figure 2-11. While the vertical axis represents WA dimension, the horizontal axis represents the VI dimension of cognitive style.

2.5.4.1. **Wholist–Analytic (WA) Dimension of Cognitive Style**

The concept of wholist-analytic (WA) emerged from the work of Pask’s (1976) holists-serialists dimension of cognitive styles, and that of Witkin’s field dependence-independence cognitive styles (Witkin & Goodenough, 1981; Witkin, et al., 1977a), previously discussed in Section 0 and Section 2.5.3 respectively.

The WA dimension affects the ways individuals learn and organise information. Based on their position on the WA dimension, as illustrated in Figure 2-11 by the vertical axis, people can be classified as wholists, analytics, or intermediates. Some of the characteristics of wholists, analytics and intermediates from Web searching perspective are outlined below.

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**Figure 2-11: Cognitive style dimensions**
**Wholists**

*Wholists* tend to see a situation as a whole ‘picture’ (Riding & Pearson, 1994), to retain a global or overall view of the information, and to view ideas as complete wholes. A schematic view of information perceived by wholists and analytics is presented in Figure 2-12. Wholists can have a balanced view and see situations in their overall context (Riding, 2002). They are better at structuring and analysing, and benefit more than analytics from external mediation, and from structuring in problem-solving and learning.

Wholists prefer a broad-based approach to Web searching and are characterised by lower levels of distraction by irrelevant information (Ford & Miller, 1996). They search better with prompts in the form of contextual information relevant to the search; are likely to be good at Boolean searching (Ford, Miller, & Moss, 2005b); and tend to follow the given Web links and to use search options more often than analytic users. However, wholists have their own weakness separating ideas into discrete parts or identifying the issues that make up the whole of a situation. They are less systematic, and less logical compared to analytics, and encounter more difficulties and confusion during Web searching (Wang, et al., 2000).

![Figure 2-12: Wholist and analytic views](image)

**Analytics**

*Analytics* see a situation as a collection of parts and focus on one or two aspects of the situation at a time. They learn and structure information or concepts in parts and analyse a situation and apprehend ideas in the parts. They are good at seeing similarities, detecting differences, and providing their own structuring in intellectual activity.
During Web searching, analytics display more consistency and more systematic logical thoughts with their search transformations to a greater extent onto the more complex phrase-oriented expressions (Ford et al., 2009). They access more screens, spend less time per screen, and use a greater number of new terms (Wood et al., 1996). However, analytic individuals have difficulty integrating ideas into complete wholes. This may have the effect of distorting or exaggerating information. They are relatively less capable at structuring and analysing, and at perceiving a complex phenomenon globally. They are likely to be linked with a low level of Boolean searching.

**Intermediates**

*Intermediates* lie between the mean position of wholists and analytics. They tend to have a range of both the wholist and analytic characteristics.

### 2.5.4.2. Verbal–Imagery (VI) Dimension of Cognitive Style

The verbal–imagery (VI) dimension of cognitive styles describes an individual’s tendency to process information either in verbal, or verbal mode of representation and thinking. In Figure 2-11 the VI dimension of cognitive styles is illustrated by the horizontal axis. VI refers to ways in which an individual would represent knowledge, in words (verbal) or mental pictures (images). If a person reads a novel, he or she can represent the actions and scenes in terms of word associations or by constructing a mental picture of what is read.

Based on the position on the VI dimension, as illustrated in Figure 2-11 by the horizontal axis, people can be classified as verbalisers, imagers or bimodals. Some of the characteristics of verbalisers, imagers and bimodals are outlined below.

*Verbalisers*

*Verbalisers* are individuals who think in terms of words and consider the information they read, see or listen to, in words or verbal associations. They prefer and perform best on verbal tasks, tend to have a good verbal memory, and are verbally articulate and fluent compared with imagers.
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During Web searching, verbalisers display a greater number of distinctive search transformations than imagers. They tend to be more oriented to and be good at the use of language as opposed to images (diagrams, charts, and figures) with greater use of distinctive linguistic search transformations with good combinations of keywords (Ford, et al., 2009). However, verbalisers tend to give the impression that they know more than they do. Although they share work with others and tend to be ready to delegate, it is likely that they may leave too much work for others to do.

*Imagers*

*Imagers* are individuals who think in terms of mental pictures. When they read or listen, they retain the information in mental pictures either of the representations of the information itself or of associations with it. They are good at writing, and at working with visual, spatial and pictorial information. They perform best on concrete, descriptive, and imaginable tasks, and find concrete and readily visualised information easier than semantically and acoustically complex details.

On the other hand, imagers also have their own weaknesses. They view social groups as more distant from themselves and may be less socially aware. They find it harder to delegate work and tend to do much work themselves.

*Bimodals*

*Bimodals* fall in between the extremes of verbaliser and imager, and tend to have the characteristics of both. That is, individuals who score in the middle range of the verbal-imager dimension are deemed to be bimodal.

2.5.4.3. **Strength of the WA and VI Dimensions of Cognitive Style**

As discussed in the previous sections, several theories on cognitive style were proposed, such as holists-serialist (Pask, 1976), field-dependent/independent (Witkin, et al., 1977a), and wholist-analytic/verbal-imagery (Riding & Cheema, 1991). This study adopted Riding and Cheema’s (1991) theory of WA and VI cognitive styles. There are several advantages of the WA and VI cognitive style framework over other cognitive style theories, some of which are highlighted below:
• Riding and Cheema’s WA and VI cognitive style framework includes both the WA dimension of cognitive style of whether an individual tends to process information in wholes or in parts, and the VI cognitive style of whether an individual is inclined to represent information either verbal (words) or in images.

• The WA and VI dimensions of cognitive style have been shown to possess a degree of construct validity (Riding, 1997). Riding reported that the validity of the construct of cognitive style is supported by the evidence that the cognitive style dimensions are “independent of one another, separate from intelligence, independent of, but interacting with, personality; and related to observed behaviours, such as learning performance, learning preferences, subject preferences and social behaviour” (1997, p. 44).

Riding and Cheema’s (1991) theory of WA and VI cognitive styles is important to understanding the design of this study, which draws upon Riding’s (1991) CSA test to measure participants’ cognitive styles, which is described in Chapter 3.

The following section reviews the related literature on self-efficacy and affective behaviour.

2.5.5. Self-Efficacy and Affective Behaviour

Many theories have been proposed to explain the developmental changes that human undergo over the course of their lives. One of the prominent psychologists is that of Albert Bandura (1977, 1986, 1989). According to Bandura (1989), behaviour, cognitive, and other personal factors and environmental influences all operate as interacting determinants that influence each other bidirectionally. Bandura’s (1989) model of Triadic Reciprocal Determinism is illustrated in Figure 2-13. Some factors may be stronger than others as well as it takes time for a causal factor to apply its influence on others.

Perceived self-efficacy is the belief in one’s capabilities to organize and execute the courses of action required to manage prospective situations (Bandura, 1995, p. 2). In other words, self-efficacy is a person’s belief in his or her ability to succeed in a specific situation. Self-regulation is when a person has his or her own ideas to
constantly monitor and evaluate his or behavior in order to see how well it fits internal and external standards. Perceived self-efficacy plays a vital role for self-regulation process because it affects actions not only directly but also through its impact on cognitive, motivational, decisional, and affective determinants (Bandura et al., 2003).

Self-regulation of motivation and behaviour involve a cognitive comparison process between internal standards and personal attainments (Bandura, 1989, p. 47). The motivational effects originate from several self-reactive influences, which include affective self-evaluation of one’s attainments, perceived self-efficacy to fulfil one’s standards and adjustment of personal standards.

In this study, participants’ perception of success, satisfaction, and difficulty were explored to investigate the impact of these factors on their search performance and search strategies, and how they felt about each search task and search response time.
2.5.6. Summary of Cognitive Styles

This study aimed to examine the relationships between users’ Web search behaviour and their cognitive styles. The literature review in the previous section revealed that cognitive style has been a well-received field of study. Several theories of cognitive styles, such as field-dependent/independent, divergent-convergent, holists-serialist, verbaliser-visualiser, and wholist-analytic/verbal-imagery, were developed.

Several instruments and tools were developed to measure and investigate individual cognitive styles. Some examples of these tools are the Revised Approaches to Studying Inventory (RASI), the Group Embedded Figures Test (GEFT), the Cognitive Style Index (CSI), the Verbaliser-Visualiser Questionnaire and the Cognitive Style Analysis (CSA) test.

While the previous section highlighted studies and theories on user cognitive styles in general, the following section reviews current and past studies that explored cognitive styles and Web search behaviour.

2.6. Cognitive Styles and Web Search Behaviour

Exploring the studies that examined user contextual factors and information searching can provide insights into understanding different information search behaviour from a searcher’s perspective. The following sections highlight some of the important research and models, developed for Web searching and user’s cognitive styles in the last two decades, that are important for the current study.

A number of studies have been conducted to explore cognitive styles among different information and Web users. Kim and Allen (2002) studied the impact of differences in users’ cognition and search tasks on Web search activities and outcomes. Their study was designed to address how individual cognitive characteristics, such as cognitive ability, cognitive style, and problem-solving style, interact with task differences to influence Web searching behaviour and outcomes.

Their study’s findings indicated strong task effects on search activities and outcomes. Different tasks were associated with different levels of search activities and outcomes. Search activities, such as the use of specific search and navigation
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features, time spent in searching, number of sites viewed, and number of bookmarks created, were all found to be influenced by an interaction between cognitive and task variables. For completing a task, searchers spent more time for the subject search task than for the known-item search task and viewed more Web pages for the subject search task than for the known-item search task.

Ford, et al. (2002) investigated the relationships between cognitive styles and problem solving and their association with information seeking behaviour. The study found correlations between the independent variables relating to cognitive styles and the dependent variables relating to information seeking and problem-solving behaviour. The study found that field-independent researchers report clearer and more focussed thinking when describing and explaining the problem to the intermediary. They perceived themselves to be in an earlier problem-solving phase and to take a less passive approach to research. On the contrary, the field-dependent researchers have less differentiated views of the problem to be solved. They were less likely at a given point in time to be aware of a number of discrete stages of problem solving solutions.

Friás-Martínez, Chen, & Liu (2008) investigated the effects of cognitive styles on user’s behaviour and perception when interacting with digital libraries. The study, conducted on fifty (50) students at the Brunel University, used Riding’s (1991) CSA, Webquilt (Hong et al., 2001), and questionnaires as data collection instruments. Riding’s (1991) CSA test was used to test field-dependence/field-independence and verbal/imager. The Webquilt Proxy Server is a proxy system that gathers click stream data as users complete search tasks. Several short tasks were assigned to search information from the Brunel library catalogue.

The study results reported that field-dependent users utilised only the basic search option combined with author/title/periodical and to some extent with word or phrase. Intermediate users utilised both basic and advance options with author/title/periodical, and word and phrase search options. On the other hand, field-independent users utilised the basic search option as the main search option and relied more on author/title/periodical than on word or phrase. There were no significant differences between verbaliser, imager and bimodal user behaviours.
In assessing the user perception, the study indicated that intermediate users and verbalisers have positive perceptions towards the library catalogue. Frias-Martinez, Chen, & Liu (2008) believed that such positive perception may be the reason why intermediate users and verbalisers completed the tasks in effective ways, as indicated by less time spent and fewer transactions completed.

The study provided insights in understanding user behaviour from aspects of user cognition. However, the study analysed on a small scale the Brunel library catalogue users’ behaviour and their perception towards the library. The study was more focused on the Brunel library catalogue and its interface rather than on the user and information needs. It may not be possible to generalise user search behaviour and perception based on their interaction with the library catalogue, and relate to their cognitive style. The orientation, design, user interface, and simplicity of the library catalogue might have influenced the user’s behaviour and perception.

2.6.1. Ford et al. (2009) Sensitising model

Of the studies examining the influence of users’ individual differences on their Web searching, as discussed in the previous section, a current model that attempted to model users’ cognitive styles and different search strategies is that of Ford, Eaglestone, Madden, & Whittle (2009), illustrated in Figure 2-14.

Ford, et al. (2009) investigated interactions between a number of human individual differences, the use of different search strategies, and levels of perceived search difficulty and success of a sample of the general public among 91 general Web searchers. The individual differences considered were users’ cognitive styles, domain experience, and gender. The cognitive style dimensions were based on Riding and Cheema’s (1991) theory of two cognitive dimensions: wholist-analytic (WA), and verbaliser-imager (VI). The experiences considered were the levels of domain knowledge, the Web experience, and the search experience. The study’s participants were asked to recall an occasion when they had faced difficulties searching the information using a search engine. They were asked to repeat this search in the experimental sessions. After completing the self-selected task, searchers were randomly assigned two of the five search tasks. The data about search strategies were
collected using search logs based on a temporal data modelling approach (Eaglestone, Holton, & Rold, 1996).

The study’s findings indicated a significant inter-correlation between gender and verbaliser/imager cognitive style. Analytic-Verbalisers were characterised by phrase-oriented searching, while Wholist-Verbalisers were characterised by word-oriented searching. The study also found significant correlations between the experienced male analytic verbaliser and the perceived success in two of the five search tasks. Although more experienced searchers displayed a greatest number of distinctive search transformations, verbalisers displayed more than imagers. Verbalisers tended to be more oriented and adapted to the use of language than to images (diagrams, charts, and figures). Wholists were less systematic, and less logical in their thinking. They tended to benefit with prompts in the form of contextual information relevant to a search. Based on the findings of the study, a ‘sensitising’ conceptual model depicting possible influence of cognitive styles, search experience and gender on searchers’ search transformation strategies, was proposed (see Figure 2-14).

The model provided substantial information about Web searching. However, how different variables are linked and related is not clearly indicated. The model was described as ‘sensitising’, as it was based on the authors’ understanding of searching behaviour. The concept of ‘individual difference’ is too abstract and broad term to be used and considered with a small cluster of variables. The study suggested a number of points to be considered for future research:

- More accurate and reliable measures of relevant variables to be included;
- Better identification of appropriate variables may help to understand the situation;
- There is a need to model complex non-linear relationships between variables to understand highly complex information behaviour.

Our study, built upon the current studies, attempted to overcome these limitations. Based on the results from empirical analyses and observations, the current study aimed to develop models that depict the relationships between users’ cognitive styles and their Web search behaviour.
Several studies attempted to examine and model cognitive styles and Web searching (examples include: Ford, et al., 2009; Ford, Miller, & Moss, 2001; Frias-Martinez, et al., 2008; Kim & Allen, 2002). These studies provided valuable insights into Web search behaviour and cognitive styles research. However, limited empirical research exists that shows how users’ cognitive styles exhibit themselves in the Web searching process. Few studies have explicitly explored the influence of users’ cognitive styles on their Web search behaviour.

![Figure 2-14: Ford et al. (2009) Sensitising model of relationships between individual differences, search characteristics, search strategies, and the experience of search difficulty and success.](image)

Ford, et al. (2009) investigated interactions between a number of human individual differences, the use of different search strategies, and the levels of perceived search difficulty and success of a sample of the general public. They built a model from the results of the study (Figure 2-14). However, besides a number of shortcomings identified by the authors, the model had two main limitations. Firstly, the model did not indicate clearly how different components of the model, such as cognitive styles and search strategies, are linked. Secondly, the model included only a small portion of Web search behaviour, such as word-oriented and phrase-oriented query transformations and browsing. The Web search aspects of the model included only low-level components, such as experience of search success. The model failed to
include high-level components of Web search behaviour, such as query reformulation and navigational styles.

The current limitations found in the literature revealed the research gap, relating to cognitive styles and Web search behaviour, for this study.

2.7. Theoretical Assumptions

Several theoretical assumptions, that are drawn from the literature review and inherent in this research, have implications for the overall process of the study.

Assumption 1

A user has a unique cognitive style.

Studies show that individuals differ in their cognitive thinking and the way they access and organise information (Kittur, Chi, & Suh, 2008, p. 453). Researchers have identified various cognitive styles, including field-independent and field-dependent cognitive styles (Witkin, et al., 1977a); holist and serialist (Pask, 1976); wholist, analytic, verbaliser and imager (Riding and Cheema, 1991). A description of style dimensions, adapted from Rayner and Riding (1998) is shown in Table 2-2.

Assumption 2

Users with different cognitive styles employ different Web search behaviour.

Individuals process certain types of information differently; they prefer to learn either through pictures or through words (Rayner & Riding, 1997). Similarly, web users with different cognitive styles show different Web search behaviours and use different search strategies, such as search options, query formulations and navigational styles, given the same assigned information search task. This is based on the fact that cognitive styles affect the ideas, attitudes, and ways in which an individual deals with and responds to information (Hsu, et al., 2011).

Assumption 3
Users with a certain cognitive style may find it easier to search and retrieve specific types of information (Riding, 1998; Riding & Rayner, 1998).

This may be measured in terms of session length, number of terms submitted, query reformulations and retrieval effectiveness.

**Assumption 4**

There exists a relationship between users’ cognitive styles and their Web search behaviours.

User studies reported that relationships exist between an information searcher’s behaviour and their cognitive style (Ford, et al., 2009; Jenkins, Corritore, & Wiedenbeck, 2003). These relationships and patterns can be represented through a Web search model.

Although several theoretical assumptions are referred to, this study is not a hypothesis-based research. The theoretical assumptions, formulated following the literature review, are to guide and provide valuable insights into interrelationships between users’ cognitive styles and their Web search behaviour.

### 2.8. Chapter Summary

This chapter identified key studies, theories and models of information behaviour and cognition dimensions, including various terms and concepts. Several studies proposed theories and models on information behaviour, Web searching behaviour, and cognitive styles.

Knight and Spink’s (2008) theoretically based and contextualised model, drawn from several existing models, included important components of Web-based information behaviour, such as user cognitive styles, query results, and information retrieval. However, how these components are inter-connected was neither explicitly explored nor illustrated.

Wilson’ (1981) model of information behaviour included information user, information need, and information environment (that is, work, socio-cultural and physical environment). The model identified several factors that influence
information seeking behaviour, such as information need and environment barriers. Important contextual factors, such as users’ cognitive styles, were not included in the model.

Ford’s (2004) model of learning-related information behaviour identified mental processes, mental states, information needs and information processing, and factors that affect these attributes, such as cognitive styles. However, the model did not clearly illustrate how information behaviour processes and attributes were affected by those factors.

The models outlined in this chapter guided the development of models based on the results of this study (see Figure 5-5 and Figure 5-6 in Chapter 5). Some of the components of the models were drawn from the models of Knight and Spink (2008), Wilson (1981) and Ford (2004).

Through a review of the existing research, this chapter has justified the need for integrated models that depict the inter-relationship between users’ Web search behaviour and their cognitive styles. There are few studies that have investigated Web searching from users’ cognitive aspects. An in-depth study is required in order to investigate the effects of users’ cognitive styles on their Web searching, using complex and meaningful measures, across a range of different types of search tasks. There is a need to model complex non-linear relationships between Web search behaviour and cognitive styles in order to understand highly complex information behaviour. Human interaction with information is a complex phenomenon because of the variability inherent to human cognitive processes (Fidel & Pejtersen, 2004). Therefore, modelling of relationships between users’ cognitive styles and their Web search behaviour can help to understand complex information behaviour and how users search information on the Web.

This chapter also included theoretical assumptions that have implications for the overall process of the study. These assumptions were drawn from the literature review presented in the previous sections.

Figure 2-15 summarises and illustrates the associations between research inputs, theoretical models, research design framework, theoretical assumptions and research outputs. The model is drawn from several existing studies, some of which are
indicated in the figure. The figure shows how research inputs, framed by the research questions, are guided, processed and optimised by the theoretical models, assumptions and research design framework to produce research outputs.

The next chapter describes the research design employed in this study, including the data collection method and data analysis techniques.

Figure 2-15: Associations between research inputs, theoretical models, theoretical assumptions and research outputs
Chapter 3: Research Design

*Design is not just what it looks like and feels like. Design is how it works.*

Steve Jobs

3.1. Introduction

Chapter 2 reviewed the existing studies, theories, and general models in the fields of information behaviour, Web searching and user cognitive styles.

This chapter provides an overview of the research design, including the research paradigm. This study adopted a mixed methods approach, which involved collecting and analysing an array of qualitative and quantitative data in order to address the following main research question:

What are the relationships between users’ cognitive styles and their Web search behaviour?

The sub-questions emerged are:

i. How do users perform Web searching to achieve their information needs?

ii. What are the effects of users’ cognitive styles on their Web search behaviour?

iii. How can the interrelationships between users’ cognitive styles and their Web search behaviour be effectively modelled?

Figure 3-1 provides an overview of the whole research process. It illustrates the relationships between the research questions this study addressed, the key variables, and the data collection instruments and data analysis techniques utilised. The figure illustrates how the key variables identified, the data collection instruments and the data analysis techniques employed relate to each research question addressed in this study. Each of these components will be discussed in the later sections.

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3 Steve Jobs (1955–2011), American businessman, designer and inventor
Prior to discussion of the actual approaches to the research process and the research procedures in section 3.3, the following section provides brief background information on the research paradigm, concepts and theories of the research methodology.

![Diagram of Research Design](image)

Figure 3-1: Research Design showing the Relationships between the research questions, key variables, and data collection techniques and data analysis

### 3.2. Research Paradigm and Approach – Concept and Theories

The following sections discuss two research design approaches: interpretive and positivist.

#### 3.2.1. Interpretive and Positivist Research

There are broadly two research approaches to research design: positivist and interpretive. Positivist research methods are aimed at theory (or hypotheses) testing, while interpretive methods, such as action research and ethnography, are aimed at theory building (Bhattacherjee, 2012). Positivist methods employ a deductive approach to research, in which theories and theoretical postulates are tested using empirical data. Examples of positivist research are experiments and surveys. Interpretive research methods utilize an inductive approach that starts with data and tries to derive a theory about the phenomenon of interest from the observed data.
Most researchers who use an interpretive approach believe that human social life is based less on objective and factual reality than on the ideas, beliefs and perceptions of people’s interactions and responses, based on what they believe to be real rather than what is objectively real (Neuman, 2007). Therefore, interpretative researchers can only study the appearance of a thing rather than the thing itself. In contrast, positivist researchers see social science research as fundamentally the same as natural science research. They assume that social reality is made up of objective facts that value-free researchers can measure precisely with use of statistics to test causal theories and hypothesis. Neuman (2007) believes that social scientists will be able to understand social life only if they study how people construct social reality.

Positivist research is often described as quantitative (Kaplan & Duchon, 1988, p. 573), but can also include qualitative data (Bhattacherjee, 2012), while interpretive research mainly relies on qualitative data, but can sometimes benefit from including quantitative data. Combining qualitative and quantitative data may help to generate a complex social phenomenon and unique insights that are otherwise not available from either type of data. Thus, a mixed methods research approach that combines qualitative and quantitative data collection and analysis is often highly desirable.

This study utilizes a mixed methods research design to investigate the effects of users’ cognitive styles on their Web search behavior. The following section provides an overview of a mixed methods research approach.

### 3.2.2. Mixed Methods Research

Mixed methods research, involving the collection and analysis of both qualitative and quantitative data, is becoming increasingly popular in information science studies. Creswell, et al (2003) described a mixed methods research design as:

> The collection or analysis of both quantitative and qualitative data in a single study in which the data are collected concurrently or sequentially, are given a priority, and involve the integration of the data at one or more stages in the process of research (p. 212).
Chapter 3: Research Design

The efficiency of this type of approach is demonstrated by Sandelowski (2000, p. 254), who defines mixed method research as “a dynamic option for expanding the scope and improving the analytic power of studies”.

This study adopted a mixed method approach to collect and analyse an array of qualitative and quantitative data. While the quantitative data gave rise to detailed findings about users’ Web searching and cognitive styles, the qualitative data enriched the findings with illustrative examples. This study adopted a mixed method approach for three main reasons:

- Many studies in information retrieval and Web searching (e.g. include: Ellis, et al., 2002; Jansen et al., 2009c; Koshman, Spink, & Jansen, 2006; Kules & Shneiderman, 2008; Oard, He, & Wang, 2008; Toms et al., 2003) have used a mixed method approach in a single study and have produced successful study results.

- This study is aimed at investigating various aspects of Web search behaviour in general and the influence of users’ cognitive styles on their Web search behaviour in particular. Several variables were identified to reflect users’ search characteristics and Web search behaviour. As a result, several data collection instruments and data analysis techniques had to be implemented. The nature of the study demanded a mixed methods research approach. Users’ information searching strategies, navigational styles and information processing approaches were best examined through qualitative analyses of content and participant observation transcripts, while their query reformulation behaviours were best investigated through quantitative analyses of Web search session logs.

- Qualitative and quantitative methods can often be used to complement each other. Studies suggested that the use of multiple data collection instruments and data analysis techniques could increase and improve the reliability and validity of the study. Combining both qualitative and quantitative research methods in a single study can expand the scope of a study and provide insights into different levels or units of analysis (Tashakkori & Teddlie, 1998).
Researchers argue that qualitative methods can make important contributions to quantitative studies, and vice versa. Researchers seeking answers to questions about human information behaviour, particularly psychologists, have found experimental and quantitative methods to be insufficient on their own in explaining the phenomenon they wish to study (Kaplan & Duchon, 1988). Qualitative observations could support quantitative analysis and assist in interpreting statistical relationships, and thus validate the results. Similarly, researchers using qualitative methods could make use of quantitative techniques to systematise observations, utilise sampling techniques, and develop quantifiable schemes for coding complete data sets (Jick, 1979).

In the social sciences, mixed methods research is considered a legitimate and stand-alone research design (Creswell, 2009). One type of analysis complements and supports the other thus increasing research-finding reliability. In information systems (IS) and usability studies, a mixed methods research design is becoming increasingly popular. Mingers (2001) argued for adoption of a pluralist approach in IS studies and suggested that research results would be richer and more reliable if different research methods are combined together.

The following sections further elaborate qualitative and quantitative research designs that constitute a mixed methods research design. It is important to understand the concepts of qualitative and quantitative research design in order to understand and utilise a mixed methods research approach.

3.2.3. Qualitative Research

Qualitative research refers to a systematic and detailed study of individuals in natural settings, often referred to by a variety of terms, such as “field research”, “naturalistic research”, “interpretive research”, “phenomenological research”, and “action research” (Kaplan & Maxwell, 2005, p. 32). Qualitative research methods are being used increasingly in evaluation studies, not only in social science but also in computer systems and information technology (Kaplan & Maxwell, 2005).

Qualitative data analysis is defined as a process of making meanings, such as the understanding or interpretation of qualitative data, such as interviews. Miles and Huberman (1994) define qualitative analysis as consisting of three concurrent flows
of activity: data reduction, data display, and conclusion drawing/verification. The overview of their qualitative data analysis is illustrated in Figure 3-2.

Data reduction refers to the process of selecting, focussing, simplifying, abstracting, and transforming the data that appear in written-up transcriptions. Data display is an organised, compressed assembly of information that permits conclusion drawing and action. The most frequent form of the display for qualitative data in the past has been extended text (Miles & Huberman, 1994, p. 11). Conclusion drawing and verification, the third stream of analysis activity, involves noting regularities, patterns, explanations, possible configurations, causal flows and propositions. As illustrated in the model, these three activities of data analysis and data collection form an interactive and cyclical process.

Kaplan and Maxwell (2005) relate qualitative data analysis to an iterative process that starts by developing an initial understanding of the environment which is then tested and modified through cycles of data collection and analysis activities. They describe the qualitative analysis process:

The purpose of (qualitative) data analysis is to develop an understanding or interpretation that answers the basic question of what is going on here. This is done through an iterative process that starts by developing an initial understanding of the setting and perspectives of the people being studied. That understanding then is tested and modified through cycles of additional data collection and analysis until an adequately coherent interpretation is reached (2005, p. 41).
Maxwell (2005) proposed an interactive model for qualitative research design (Figure 3-3). The model has five components: goals, conceptual framework, research questions, methods and validity. The goals describe the purpose of the research. The conceptual framework discusses the theories, beliefs, and prior research results that will guide or inform the research. Research questions form the main questions the study attempts to address. The methods component defines the approaches and techniques for data collection and analysis involved in carrying out the study, and the validity describes the evaluation process that validates its results. The different components of the model form an integrated and conceptualised model.

For this study, various techniques of qualitative data analysis are used, such as think-aloud protocol analysis and content analysis.

![Figure 3-3: A model of qualitative research design (Maxwell, 2005)](image)

3.2.4. Quantitative Research

In social science, quantitative research refers to a systematic empirical investigation of quantitative properties and phenomena, and their relationships. Quantitative research design can be broadly divided into two types, exploratory research and conclusive research (Singh, 2007). Exploratory research allows researchers to explore issues in detail to familiarise themselves with the problem or concept to be
studied, thus helping researchers to formulate research hypothesis. Singh (2007) argues that exploratory research relies more on secondary research, such as case studies, and thus cannot provide a conclusive answer to research problems or decision-making.

Conclusive research can be further classified into descriptive research and causal research. Descriptive research enumerates descriptive data about the population being studied. It helps in determining the descriptive statistics about a population. Case studies are examples of descriptive research. On the other hand, causal research emphasises the determination of a cause and effect relationship, such as research to determine which variable might be causing particular behaviour. Experimental studies and quasi-experimental studies are examples of causal research.

Almost all quantitative researchers adopt a positivist approach to social science (Kaplan & Duchon, 1988; Neuman, 2007). They follow a linear research path and place more emphasis on measuring variables and testing hypothesis that are linked to a general causal explanation (Neuman, 2007, p. 85). Variables are of two types: independent and dependent. Independent variables are the factors that affect other factors, known as ‘dependent variables’, or that influence the outcome of the experiment. Examples of independent variables are factors that affect the searcher’s Web search interactions, such as cognitive style. Dependent variables are factors that are affected during an experiment or factors that depend on the independent variables chosen. In quantitative research study, the primary aim is to determine the relationship between an independent variable and a dependent variable in a population (Hopkins, 2000). This study included quantitative methods of CSA test and questionnaires.

3.3. Research Process and Procedures

The main aim of the study was to examine how users’ cognitive styles influence their Web searching behaviours. Certain Web search behaviours were examined through qualitative analyses of content and observation transcripts, while certain other behaviours were investigated through the quantitative analyses of questionnaires and Web search session logs. Therefore, this study adopted a mixed method approach, involving both qualitative and quantitative data analyses.
While the previous section presented a brief background on research philosophy, and concepts of research design adopted in this study, the following sections discuss the research process and procedure followed in the study.

A model of study process was designed. Figure 3-4 illustrates the complete study process, which involves 3 phases:

Figure 3-4: Planning, Data Collection and Data Analysis Process of the Research
Chapter 3: Research Design

- Phase I: Planning the research process and procedures, including identifying key variables;
- Phase II: Collecting data to examine users’ Web search behaviour and their cognitive styles. This stage also provides information on identifying key variables to reflect users’ cognitive styles, characteristics and Web search behaviour;
- Phase III: Analysing the data to confirm and establish relationships between users’ Web search behaviour and their cognitive style.

In Figure 3-4, the green component represents the planning phase (Section 3.3.1); the blue region represents the data collection phase (Section 3.3.2); and the yellow area illustrates the data analysis phase (Section 3.3.3).

Three components of the study process are inter-connected; the arrow in Figure 3-4 shows the interconnection of the three components. For example, if some data are missing during the data analysis process, the researcher can refer back to planning and data collection to ensure that the required data are identified. Each of these phases is presented separately in the following sections.

3.3.1. Phase I: Planning

The Planning stage describes the study participants, study settings and procedures. This section also includes designing and developing search tasks.

3.3.1.1. Study Participants

A total of 50 volunteers participated in this study. The research sample size was chosen based on the prevailing research practice in user studies. Many user study researchers tended to use a small group of participants, fewer than 70 participants (in studies: Ford, et al., 2001; Ford, Miller, & Moss, 2005a; Ford, et al., 2005b; Hölscher & Strube, 2000; Lazonder, Biemans, & Wopereis, 2000; Moss & Hale, 1999; Spink & Dee, 2007; Spink, et al., 2006a).

The sampling target of the study was the general university population. It is believed that students, academics and professional staff of a university can be expected to represent the target population. Therefore, an invitation to participate in the study
was initially sent out via the university email to the students, academic and professional staff within the Faculty of Science and Technology (FAST), Queensland University of Technology (QUT), Brisbane, Australia (see Appendix A.1). The recipient of the original invitation later forwarded the invitation to other students and staff.

Sixty-five (65) responses were received either by phone or email return; 50 participants comprising of higher degree research students, academics and professional staff were recruited for the study. Therefore, the response rate was 76.92%. The target population was approximately 5000 staff and students. As illustrated in Table C-1 (in Appendix C.1), 25 of the participants, that is, 50%, were students, 13 participants (26%) were staff and 11 of them (22%) were both students and staff from QUT, while one participant was from outside QUT. Efforts were made to include equal number of males and females across different age groups and occupations (student, academic or professional staff); this was done following the responses from the prospective participants prior to participation in the study.

3.3.1.2. Participant Recruitment and Data Collection Procedures

The QUT research policy requires obtaining a human ethical clearance prior to the commencement of a study. An application for ethical clearance for human involvement in the research submitted to the university human research ethics committee was given a low risk human ethical clearance on 17 February 2010 (see Appendix D).

An invitation to participate in the study was sent via email (see Appendix A.1). Participation was voluntary; participants could withdraw from the study at any time. As noted, this study required a quiet environment, so an individual meeting with the prospective participant for the study participation was scheduled as per the participant’s availability. The study participation was carried out individually at a different time for each participant to ensure that they were not disturbed from their normal duties.

The whole data collection procedures and process, including data collection instruments and data analysis techniques, was first tested during a pilot testing.
Chapter 3: Research Design

Following the pilot study, necessary changes to the research design were made, which are outlined in Appendix B. The entire data collection procedure is illustrated in Figure 3-5. First, each participant was briefed with the participant guidelines (see Appendix A.2). Each participant was asked to complete a consent form (Appendix A.3). It was important that each participant understand the ethical issues and the conduct of the study.

Next, participants were asked to complete a pre-Web search questionnaire (see Appendix A.4) and undergo a cognitive style test using Riding’s (1991) Cognitive Styles Analysis (see Appendix A.6). Following the cognitive style test, each study participant was assigned three sets of search tasks, illustrated in Table 3-1 and was then invited to participate in the Web search task. For this task, each participant was provided with a laptop with Internet access.

![Figure 3-5: Procedure for the study participation](image)

For the Web search task, study participants had the liberty to use any search engines and search options of their choice, and to search at their own speed. Although the participants were never stopped while performing their search tasks, it was recommended that they spend between 10 and 15 minutes on each search task. The participants were reminded to save or bookmark the information retrieved. More explanations were given to those who did not clearly understand the search task topics. Participants were also requested to think aloud while they were performing their search tasks (see Appendix A.5).

Participants’ Web interactions with the search engines, including think-aloud, were logged using Camtasia Studio software (TechSmith, 2009) for ‘think-aloud’ protocol analysis and Web search logs analysis (see examples of search result pages in Appendix C.2).

Once the Web search was completed, each participant was asked to complete a post-Web search questionnaire (see Appendix A.8). The post-Web search questionnaire
collected information regarding participant satisfaction and perception with the Web search process and outcomes.

As an appreciation of their time and efforts, each study participant received a gift voucher worth AUD $30, funded by QUT.

3.3.1.3. Data Collection Settings

This study required a quiet environment as participants needed to verbalise and to perform searching tasks without any disturbance. In addition, the researcher and the study participant needed to discuss certain issues privately. Therefore, for each of the participants the study participation and search task experiments were carried out at different times. A time schedule was discussed and drawn up for each participant to suit his or her convenience. A meeting room was then booked for 2 hours for each participant.

The computer used for the search task was an Intel Core 2 Duo CPU P4800 Dell Latitude E6500 Laptop with 2.26 GHz, 2 GB RAM. The machine had inbuilt Web-cam, microphone and speaker, and Microsoft Windows XP Professional Service Pack 3 was pre-installed as the operating system. The Web browsers installed on the laptop were Microsoft Internet Explorer 8, Mozilla Firefox 3.5, Google Chrome 3, Safari 5.0.3, opera 10.53, Netscape Navigator 9.0.0.6, and Maxthon 2.5.13. The computer was connected to Internet via wireless.

Camtasia Studio program (TechSmith, 2009) and Wrapper (Jansen et al., 2006) were also installed on the machine. The Camtasia program recorded desktop screenshots including keyed search terms, websites visited, and think-aloud protocol.

3.3.1.4. Key Variables

This study aimed to investigate users’ Web search behaviours in general and the impact of their cognitive styles on their Web search behaviour in particular. The first step was to identify variables that reflect users’ characteristics and Web search behaviours. In other words, variables were identified to group data into certain closely related categories.
Figure 3-6 illustrates some of the important variables for Web search behaviour and users’ cognitive styles. The figure shows a relationship between users’ cognitive styles and their Web search behaviour. Based on the nature, variables were grouped into two categories: independent variables and dependent.

![Diagram](image.png)

**Figure 3-6: Web Search Behaviour and User’s Cognitive Styles Variables**

### 3.3.1.4.1. **Independent Variables**

Factors that affect other factors or dependent variables, or that influence the outcome of the experiment, were identified as independent variables. Independent variables are factors that affect the searcher’s Web search interactions, such as cognitive style.

**User’s Cognitive Style (COGNITIVE)**

COGNITIVE indicates a user’s cognitive style, which was determined by Riding’s (1991) Cognitive Styles Analysis (CSA) test. Participants were classified as wholist or analytic, based on their score on the wholist-analytic scale. Similarly, based on their score on the verbal-imager scale, participants were classified as verbaliser or imager.

### 3.3.1.4.2. **Dependent Variables**

Dependent variables are factors that are affected during an experiment or factors that depend on the independent variables chosen. For example, in a study to test how gender of a shopper affects the amount of time spent on shopping, the gender would
be the independent variable, and the time spent, which is what is affected in the study, would be the dependent variable.

In this study, a number of dependent variables that indicate or measure Web search patterns during user-Web interactions were identified for investigation. For the study each of these dependent variables formed a separate unit of analysis, which would reveal valuable information about the Web search patterns and the relationship between users’ cognitive styles and their Web search behaviour.

**Web Search Strategies**

*Boolean Operators (BOOLEAN)*

BOOLEAN indicates the number of Boolean operators used (e.g. sports AND soccer, Sports OR soccer). The use of Boolean operators is an indication that the user is capable of using logical commands.

*Use of quotation marks (QUOTE)*

QUOTE measures the number of quotation marks used (e.g. “Web search behaviour”, Web “search behaviour”). Using quotation marks around phrases can narrow down search results. This was suggests that searchers who use quotation marks have better search skills than those who do not use them. Some authors (Ford, et al., 2009; Spink et al., 2001) relate the use of quotation marks to phrase-oriented searching.

**Navigational Strategies**

*Page Visits (PAGEVISITS)*

PAGEVISITS is the total number of Web pages visited during the navigation session. It can be also measured qualitatively through Web search log analysis.

*Navigation Button Clicks (BUTTONCLICKS)*

BUTTONCLICKS is the total number of how many times each navigational button was clicked during the navigation session. It is calculated as the sum of number of navigational buttons clicked, such as back button, home button, forward button,
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history list and stop button. It could be used to measure search “efficiency” as it links to a “passive” way of navigation (Palmquist & Kim, 2000, p. 564). It can be also assessed through observable data such as Web search session logs.

Search Terms (TERM)

TERM indicates the total number of terms submitted to accomplish a search task. A term is a series of characters, separated by white space or any other separator, that is submitted in a single query. In-depth analysis of co-occurrence of search terms will reveal the types of information and query topics people are seeking on the Web (Spink, et al., 2001).

Search Query (QUERY)

QUERY is the number of queries submitted to complete assigned tasks successfully. A query is made up of all the terms submitted in a single search submission. Researchers are investigating the average number of words submitted per query and the number of queries included in the average user session (Silverstein et al., 1999). This study will further explore search queries submitted and investigate correlations between the queries submitted and cognitive styles.

Session Time (TIME)

TIME measures the time taken by a user to complete three assigned tasks successfully. It is assumed that the average amount of time spent to accomplish a search task successfully will indicate a user’s searching performance and efficiency. The data is also analysed using time spent for each task. Therefore, the TIME variable is used depending on the nature of the investigation.

Self Efficacy

Perceptions of success and difficulty (PERCEPTION)

PERCEPTION measures a user’s perception of his or her success and difficulty of information searching and expected interactions, on a scale of 1 to 5. The purpose of measuring this variable is to investigate the impact of the searcher’s perceptions of success and difficulty on their search performance and search strategies. Participants’
perception of level of success and difficulty is measured by a post-search questionnaire.

*Search Satisfaction (SATISFACTION)*

SATISFACTION indicates a user’s level of satisfaction, on a scale of 1 to 5. Studies have shown that a user’s level of satisfaction influences their performance in Web searching (Ford, et al., 2009; Frias-Martinez, et al., 2008). It is assumed that each user will have a different level of perception and satisfaction. Measuring users’ levels of satisfaction will provide insights not only on how they are thinking about Web search but also on the associations of user demographic factors and Web searching behaviour.

Participants’ satisfaction about the information searching and information retrieved is measured through think-aloud, Web search session logs, and the post-search questionnaire.

*Relevance of information retrieved (RELEVANCE)*

RELEVANCE indicates the relevance of the retrieved information to a user, measured on a scale of 1 to 5. This facet of information retrieval is represented by Spink and Wilson’s (1999) model of situated actions, interactive session and time that includes relevance judgments using a scale of highly relevant, partially relevant, partially not relevant, and not relevant. Measuring a participant’s perception on the relevance of the retrieved information could also increase the validity and reliability of the data gathered through Web search logs and think-aloud.

In general, dependent variables were identified to represent users’ Web search behaviours, while independent variables represented the users’ characteristics or contextual factors. The ultimate goal of the analyses was to find effects of the independent variables on the dependent variables and subsequently, to map cognitive styles with Web search behaviour.
3.3.2. Phase II: Data Collection

The first step was to identify the variables to be investigated. The second step was to define methods to investigate these variables, such as data collection and data analysis. This study used multiple data collection instruments, such as pre- and post-search questionnaires, cognitive styles analysis test, Web search session logs and think-aloud, which are described below in the manner they were carried out. Figure 3-4 illustrates the complete study process, with the blue area representing the data collection phase.

3.3.2.1. Search Task Design

As illustrated in Table 3-1, three types of search tasks were developed: Factual, Exploratory and Abstract. The factual task is a fact-finding search task, such as finding three laws on child safety while travelling in vehicles.

<table>
<thead>
<tr>
<th>Task Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factual Task</td>
<td>You have recently moved to Austin, Texas, The U.S., and would like to know the relevant laws passed by the Texas State government regarding child safety while travelling in vehicles. Identify three such rules.</td>
</tr>
<tr>
<td>Exploratory Task</td>
<td>You, with your two friends, are planning a trek for one week in Solukhumbu in Nepal. The trekking will occur next month. You are told that tourists trekking in the place may get high-altitude illness. You decide that you should know more about the place, and the symptoms, seriousness and prevention of high-altitude sickness.</td>
</tr>
<tr>
<td>Abstract Task</td>
<td>You recently heard about the Bermuda Triangle mystery, and you are curious and want to know more about it. So you want to search any relevant information (articles, images and videos) about it and what effect it has on the travellers in the region.</td>
</tr>
</tbody>
</table>

Table 3-1: Search Tasks
The exploratory task is more open-ended. There are no specific answers to such task type unlike the factual task. In an abstract task, the information need is abstract and a concrete, direct solution may not exist. The abstract search task is more open-ended than the exploratory task (see Appendix A.7 - Instructions and Suggestion for completing the search tasks).

3.3.2.1.1. **Assigned Task**

This study gathered participants’ search terms, search queries, query formulations, query reformulations strategies, navigational style and session time. It was assumed that the topic bias could be minimised by assigning the same search tasks to all participants. The researcher believed it would be difficult to compare participants’ searching if different sets of search tasks were given to the participants. Therefore, the study deliberately chose to assign the same three sets of search tasks to all study participants to assure its validity, regardless of participants’ subject background. Moreover, the tasks were designed to present a realistic situation and each searcher’s interpretation of the situation would be different from that of other searchers.

3.3.2.1.2. **Situational environment**

Based on Borlund and Ingwersen’s (1997) concept of a “simulated work task situation” or scenario, the search tasks were designed to ensure that these tasks would be as close as possible to real world situations. The simulated work task situation provides each searcher with the context, which ensures “a degree of freedom” to react in relation to his or her interpretation of the given situation (1997). This approach has been widely used by several researchers in information seeking studies (examples include: Borlund, 2003; Kim, 2009; Liu et al., 2010).

3.3.2.1.3. **Task Complexity**

The search tasks were designed with different levels of difficulty and complexity, and with a diverse area of topics. The main aim of choosing different task complexity was to suit participants with different search experience and skills. It was assumed that the factual task has the least complexity, in that the participants were asked to identify any three rules on child restrain while travelling in vehicles in Austin, Texas, which required them to use basic searching skills.
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The exploratory task was more complex and required a higher level of search experience than for the factual task, in that the participants were asked to search for more information on various topics, such as place (Solukhumbu in Nepal), illness (symptoms of high-altitude illness) and safety measures (preventions of high-altitude illness).

The abstract task presented relatively more abstract and complex scenarios compared to the factual and exploratory tasks. The participants needed to organise and structure their search terms carefully by using a more advanced level of search skills and problem solving skills. They needed to find relevant information (that is, articles, images and videos) about the Bermuda Triangle mystery, and its effect on the travellers in the region.

In order to validate the researcher’s assumption with task complexity, he also asked the participants at the completion of the search tasks to rate their level of success and difficulty for each search task (see Appendix A.7). Based on the observation made during the pilot study, in order to break a hierarchical level of task complexity, the exploratory task of second level complexity was issued first, followed by the exploratory and abstract tasks (see Appendix B for summary of lessons learned from the pilot study).

3.3.2. Questionnaires

Questionnaires are one of the most frequently used methods of collecting research data. They are often designed to allow for statistical analysis of the responses. Several information user study researchers extensively used questionnaires to collect a wide range of information from Web users (examples includes: Frias-Martinez, et al., 2008; Kelly, Harper, & Landau, 2008; Spink & Dee, 2007). There are both advantages and disadvantages of using questionnaires as data collection instruments in research. Gillham (2000) summarises the advantages and disadvantages of using a questionnaire:

Advantages

- Low cost in time and money
- Easy to get information from a lot of people very quickly
Respondents can complete the questionnaire when it suits them
Analysis of answers to closed questions is straightforward
Less pressure for an immediate response
Respondents’ anonymity
Lack of interviewer bias
Standardisation of questions
Can provide suggestive data for testing a hypothesis

Disadvantages

- Problems of data quality (completeness and accuracy)
- Typically low response rate unless sample ‘captive’
- Problems of motivating respondents
- The need for brevity and relatively simple questions
- Misunderstandings cannot be corrected
- Questionnaire development is often poor
- Seeks information just by asking questions
- Assumes respondents have answers available in an organised fashion
- Lack of control over order and context of answering questions
- Question wording can have a major effect on answers
- Respondent literacy problems
- People talk more easily than they write
- Impossible to check seriousness or honesty of answers
- Respondent uncertainty as to what happens to data (Gillham, 2000, pp. 7-8)

For this study, the advantages outweighed the disadvantages. This research is a mixed methods study, and questionnaires were used to gather demographic information from the study participants. This research used self-administered pre- and post-Web search questionnaires.

3.3.2.2.1. Pre-Web Search Questionnaire

Users demographic information and prior Web search experience details were gathered using a pre-search questionnaire. Participants were given a pre-search questionnaire to complete prior to their Web searching experiment (see Appendix
A.4). This questionnaire has two parts: Part A about demographic and Part B about Web search experience.

The information measured by the pre-Web search questionnaire were:

- Demographic information including gender, age group, status (student or staff), Web search experiences measured in terms of number of years;
- Search engine and browser most frequently used;
- Association with social networks; and
- Level of experience in Web searching using (1) keyword searching, (2) Boolean searching, and (3) Advanced searching, each measured by a five-point Likert scale.

3.3.2.2.2. **Post-Web Search Questionnaire**

Once the participants had completed their search task experiments, they were given a post-Web search questionnaire to complete (see Appendix A.8). The post-search questionnaire consisted of three parts. The main aim of the post-Web search questionnaire was to collect data about the participant’s satisfactions with (Part A) and perceptions (Part B) of the Web search process and outcomes, and their assessment of the relevance of the information retrieved (Part C). The specific measures assessed by the post-Web search questionnaire, using a five-point Likert scale, are:

- Perception of and satisfaction with Web searching of the search tasks, adapted from Liaw, et al. (2006);
- Level of difficulty and success of the three search tasks;
- Contribution of the Web searching to the resolution of each search task; and
- Relevance of the retrieved information to the resolution of each search task.

A series of measures were taken to guarantee the reliability and validity of the questionnaires. A pilot study was conducted to test data collection instruments, including pre-/post-search questionnaires. These measures are discussed in detail in Section 3.4. Both the pre- and post-search questionnaires gathered valuable information about the participants and their characteristics. Thus, the questionnaires became an important data collection tool in this study.
3.3.2.3. Cognitive Styles Analysis (CSA) Test

This study aimed at exploring the influence of users’ cognitive styles on their Web search behaviour. The Riding (1991) *Cognitive Styles Analysis* (CSA) test was used to measure users’ cognitive styles. This section describes the concept of the CSA test, including its reliability and validity, and how the test was used in the study.

With the various families of cognitive style dimensions, there was a need to develop a test to assess both the wholist-analytic (WA) and verbal-imagery (VI) dimensions of cognitive styles (see Section 2.5.4 for more information on WA and VI dimensions of cognitive style). In 1991, Riding (1991) developed the CSA test to measure the WA and VI dimensions of cognitive styles (Riding & Cheema, 1991).

The CSA is a computer presented test. It indicates the position of an individual on each of the fundamental style dimensions by means of a ratio. The ratios typically range from 0.4 through to 4.0 with a central value around 1.0. The two fundamental dimensions of cognitive styles are both continual, but for descriptive convenience the dimensions may be divided into groups by dividing the population on each dimension into three groups. The cut-off points of the ratios on each dimension are given in Figure 3-7.

![Figure 3-7: Cognitive Styles Analysis (CSA) Style Map (Three groups)](image-url)
Chapter 3: Research Design

The CSA comprises three sub-tests. The first part assesses the VI dimension by presenting a series of statements, one at a time, to be judged true or false. For example:

- GOLF and TEA POT are the same type
- BREAD and BUTTER are the same colour
- NURSE and BED are the same type.

Half of the statements contain information about conceptual categories; the other half describe the appearance of items. Half of the statements of each type are true. It was assumed that imagers would respond more quickly to the appearance statements as the objects could be readily represented as mental pictures and the information for the comparison could be easily obtained from these images. For conceptual categories, Riding (1991) assumed that the verbaliser would have a shorter response time as the semantic conceptual category information is verbally abstract in nature and cannot be represented in visual form. The computer records the response time to each of the statements and calculates the VI ratio. A low ratio (below 0.98) corresponds to a verbaliser and a high ratio (1.09 and above) to an imager; the intermediate position is described as ‘bimodal’.

The second and third sub-tests assess the WA dimension of cognitive style. The second sub-test presents items containing pairs of complex geometrical figures: the individual is required to judge the figure as either the same or different (see Figure 3-8). It was assumed that those who were relatively wholists would respond to this test in a short time as the task involves graphical judgments about the similarity of the two figures. Individuals were not made aware of the response time; Riding believed the intention to be that they perform the tasks in their usual manner of processing information, and that the overall response time does not influence the style results as ratios are used.

The third sub-test presents items comprising of a simple geometrical shape and a complex geometrical figure. The test requires individuals to judge whether the simple shape contained within the complex figure is the same as that of the simple shape displayed, or not (Figure 3-9). It was assumed that an analytic would respond more quickly compared to a wholist. The computer records the response time and
calculates the WA ratio. A low ratio (below 1.03) corresponds to a wholist and a high ratio (1.36 and above) to an analytic. Individuals scoring between 1.03 and 1.36 are classified as intermediates (Figure 3-7).

![Diagram](image1)

**Figure 3-8:** Example: Users are asked to determine if shape (i) is the same shape as shape (ii).

![Diagram](image2)

**Figure 3-9:** Example: Users are asked to indicate if shape (i) is contained in shape (ii).

3.3.2.3.1. **Dichotomous Classifications of Cognitive Styles**

The WA and VI dimensions of cognitive styles are independent of one another, with both continual, but for descriptive convenience the dimensions may be divided into groups by dividing the population on each dimension into three groups. Position on one dimension of cognitive style does not affect the position on the other (Riding et al., 2003). However, the way individuals behave will be the result of the joint influence of both dimensions.

The style types are grouped into nine cognitive styles: wholist-verbaliser, wholist-bimodal, wholist-imager, analytic-verbaliser, analytic-bimodal, analytic-imager, intermediate-verbaliser, intermediate-bimodal, and intermediate-imager, as
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illustrated in Figure 3-7. Thus individuals can be assigned to one of the nine groups. However, many researchers tend to use dichotomous classifications by grouping into four cognitive style types: wholist-verbaliser, wholist-imager, analytic-verbaliser, and analytic-imager (see Figure 3-10).

If a particular cognitive style dimension is not appropriate to perform a task, individuals use another cognitive style (Riding & Rayner, 1998, p. 118). For instance, a wholist-imager whose wholist style aspect would not provide an overview of a situation or information could attempt to employ the analytic-view aspect of imagery to make up the deficiency.

![CSA Map (Dichotomous classifications – two groups)](image)

3.3.2.3.2. Reliability and Validity of the CSA Test

A few studies have reported the CSA test having some reliability and validity issues (Parkinson, Mullally, & Redmond, 2004; Peterson, Deary, & Austin, 2003). Parkinson, Mullally, and Redmond (2004) reported that the reliability of the WA dimension is stable, but low with the test-retest correlation $r = 0.34$, which is below the commonly accepted value of $r = 0.8$ for test-retest. They reported that the VI dimension was quite unstable.

Peterson, Deary, and Austin (2003) investigated the stability of the CSA test. They found that the CSA test of the WA style was stable at mean $r = 0.69$, but that the VI
style ratio remained unreliable at mean $r = 0.36$. However, Riding (2003) argued/justified the test-retest reliability result reported by Peterson, et al. (2003) as invalid on the basis that the study did not use the original copy of the CSA, and that the retest interval of 8.5 days was too short for the CSA test. A 6-month to 1-year interval for a test–retest reliability measurement is recommended (Riding & Rayner, 1998). Therefore, the limitations put up by these studies (Parkinson, et al., 2004; Peterson, et al., 2003) were not strong enough to consider the CSA test unsuitable.

For this study, the strength outweighed the limitations of the CSA test. Based on Riding and Cheema’s (1991) theory of WA and VI cognitive styles, this study utilised Riding’s (1991) CSA test to measure participants’ cognitive styles (permission to use the CSA test was obtained from Richard Riding on 14 August 2009). The CSA test was chosen based on the following arguments:

- The CSA test is relatively new compared to the Embedded Figure Test (Thurstone, 1944) or the Verbaliser-Visualiser Questionnaire (Richardson, 1977);

- The CSA test has been shown to have good reliability and validity by a good number of studies that have used the test (examples includes: Ford, et al., 2009; Ford, et al., 2001; Frias-Martinez, et al., 2008);

- CSA assesses both ends of the style dimensions (i.e. WA and VI cognitive style dimensions); and

- CSA test is a computer-administered test, which often makes it more attractive to participants and also makes data collection easier for researchers.

Each participant was provided with a pre-test instruction sheet (see Appendix A.6). They were asked to record their cognitive styles and WA and VI ratios at the end of the test. Based on the WA and VI ratios, participants were classified as wholist or analytic and verbaliser or imager, as illustrated in Figure 3-10. Participants scoring below 1.20 on the WA scale were classified as wholist, and those scoring 1.20 or above as analytic. Similarly, participants scoring below 1.03 on the VI scale were classified as verbaliser and those scoring 1.03 or above as imager.
3.3.2.4. Think-Aloud Protocols

A highly effective method of reading cognitive thinking of a user is to ask him or her to verbalise what he or she is thinking. This method is known as think-aloud or protocol analysis. It is used as data collection and analysis mainly to understand the thoughts of users while they are performing some assigned tasks (Ericsson & Simon, 1993). It requires the users to think aloud as they perform specified search tasks.

The think-aloud application is most commonly used in psychological and educational research on cognitive processes, and in user-oriented and cognitive IR research (examples: Davey, 1983; Van Someren, Barnard, & Sandberg, 1994). Think-aloud is also used in usability studies (Haak, De Jong, & Schellens, 2003; Nielsen, Clemmensen, & Yssing, 2002).

There are many advantages of collecting data through think-aloud. Think-aloud data provides real-time information about the subject under review. It also allows researchers to learn about what is actually going on in the learner’s mind and to provide insight into their cognitive problem-solving activity (Sun, 2003). Think-aloud reduces problems associated with memory failure, as the participants do not have to memorise anything for thinking aloud (Young, 2005).

In this study, the participants’ cognitive responses were collected through the think-aloud method. Think-aloud data, in addition to Web search session logs, provided rich information about the participants’ cognitive process. While completing their search tasks, participants were asked to think their thoughts, actions and emotions aloud as they interacted with the Web search engine. They received the instructions described in Appendix A.5.

In order to familiarise the participants with the process, some examples of thinking aloud were also demonstrated to them:

- I am going to use quotations to narrow down my search results.
- I want to find synonyms for ‘consequences’.
- I like to open search result pages in separate browser tabs.
The goal of the think-aloud instrument was to support data gathered by Web search session logs. Thus, thinking aloud should not affect the participant’s search performance and should not violate the research’s validity. Therefore, extra care was taken to ensure that the participants were not disturbed from their normal search task due to think-aloud. A label with ‘Think-Aloud’ was displayed below the computer monitor. It was assumed that such a sign would help to remind the participants to think aloud aloud without obstructing their search tasks.

The next section describes Web Search Session logs and monitoring user–Web search interactions.

### 3.3.2.5. Web Search Session Logs

This study used Web search session logs, similar to the Web logs analysis described in Section 2.3.4, to examine the interactions between the participants and the search engines.

For this study, a standard search log file format with the following fields, similar to those of Jansen (2006), was adopted:

- User Identification: A unique number used to identify a participant
- Date: The date of the interaction
- The Time: The duration of the interaction
- The URL: The URL of the Web site visited
- Search Terms: The query terms as entered by the user

Unlike Web server search logs, the data were manually entered into these fields to form search session logs. Some examples of Web search session logs created in this study are illustrated in Table 3-2. Subsequently, participant observation transcriptions were created with information from these records and think-aloud protocols. The prepared data from the search session logs were then analysed quantitatively.
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<table>
<thead>
<tr>
<th>User_ID</th>
<th>Date</th>
<th>Time</th>
<th>URL</th>
<th>Search Terms</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>03/02/10</td>
<td>14:00</td>
<td><a href="http://www.google.com.au">www.google.com.au</a></td>
<td>Bermuda Triangle + effects it has on travellers in the region</td>
</tr>
<tr>
<td>40</td>
<td>03/02/10</td>
<td>14:00</td>
<td><a href="http://www.google.com.au">www.google.com.au</a></td>
<td>Bermuda Triangle + effects on travellers</td>
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<td><a href="http://www.google.com.au">www.google.com.au</a></td>
<td>hypoxia and prevention</td>
</tr>
<tr>
<td>40</td>
<td>03/02/10</td>
<td>14:03</td>
<td><a href="http://www.google.com.au">www.google.com.au</a></td>
<td>hypoxia</td>
</tr>
</tbody>
</table>

Table 3-2: Examples of Web Search Session Logs

3.3.2.6. Monitoring User-Web Interactions

Participants’ Web interactions, including think-aloud and Web search session logs, were captured by using a monitoring program, Camtasia Studio software (TechSmith, 2009). This program was chosen because:

- It has advanced features and useful functionalities.
- The trial version of the program is freely available online for use.
- It can record both think-aloud and log Web search sessions by recording computer desktop screenshots, including keyed search terms, websites visited, and audio and video records of the user.
- Many researchers in user studies have used it to capture user-Web interactions (examples include: Kao, Lei, & Sun, 2008; Martzoukou, 2008; Spink, et al., 2006a).

The output of the program is a video record that can be played and replayed at any time for transcription and analysis. An example of the output video can be found on YouTube (http://tinyurl.com/kinley1) or on Kinley’s blog. For privacy purpose, the audio sound is disabled in this video.

The captured user-Web interactions for each participant were played and replayed several times to create 1) Search Session Logs, and 2) Participant observation transcriptions, which are both described in the following sections.

---

3.3.2.7. Data Compilations

Participants’ Web interactions were captured using a monitoring program. The captured user-Web interactions for each participant were played several times to create a record of each participant’s Web interactions. The record combines data associated with the search session logs, think-aloud stamps, and observations made by the researcher. A total of 150 individual records for the three search tasks of 50 study participants were created. Some examples of the participant observation records are given in Appendix E. (The records for the remaining study participants are withheld in the university and may be made available on request.) These records were then analysed qualitatively to obtain beneficial information (presented in Chapter 4 of this thesis).

3.3.3. Phase III: Data Analysis

The success of a research project depends on the analysis of the data in order to achieve something interesting and important (Gibson & Brown, 2009). This study implemented a mixed methods approach, involving both qualitative and quantitative data analyses. Certain observations were analysed using a single method – qualitative or quantitative – while others were analysed using both types of the analyses. Combining both the qualitative and quantitative research methods in a single study can provide insights into different levels or units of analysis (Tashakkori & Teddlie, 1998).

Figure 3-4 illustrates the study’s complete research process, with the yellow region representing data analysis. The theory and concepts related to mixed methods, qualitative and quantitative research have been discussed in Section 3.2. The following sections describe how qualitative data and quantitative data were analysed to inform the findings of the study.

3.3.3.1. Qualitative Analysis

In this study, the qualitative data collected through think-aloud and Web search session logs were transcribed, coded and analysed using elements of content analysis (Julien, 1996; Schamber, 2000) and protocol analysis (Ericsson & Simon, 1993).
3.3.3.1.1. Content and Protocol Analysis

Krippendorff (2004) defined content analysis as “a research technique for making replicable and valid interferences from texts to the contexts of their use” (2004, p. 18). Content analysis is a well-established set of techniques for making conclusions from text about its sources of the information, content, or receivers of information (Schamber, 2000). The analysis is more appropriate in studies based on a grounded theory approach or studies in which theories are developed from data (Ingwersen & Järvelin, 2005, p. 97). Nevertheless, it is widely used in social sciences and library, and information sciences to study the contents of texts and draw conclusions. Krippendorff (2004) identified four main advantages of using content analysis in a research project:

- It is an unobtrusive technique;
- It can handle unstructured matter as data;
- It is content sensitive and therefore allows the researcher to process data as data texts that are significant, meaningful, informative, and even representational to others; and
- It can cope with large volumes of data. (2004, pp. 40-43)

In this study, content analysis of the pre- and post-search questionnaires, the search session logs, and the think-aloud protocols captured during the search sessions helped in identify users’ Web search behaviour and any differences in their Web search interactions.

Participants were required to verbalise their thoughts, motivations, and any actions while they were searching on the Web. The think-aloud protocols were transcribed and combined with participant observation records. Some examples of the records are given in Appendix E. Strong and important quotes and verbal statements were carefully analysed to examine and inform any significant observations in the participant’s Web search behaviour and in how they reacted with each search task.

The transcribed Web search session logs were analysed to measure each dependent variable identified earlier. For example, frequencies of search quotes utilised during the Web search were manually recorded to assign values to respective dependent
variables. These variables were then analysed within and against the independent variables to investigate patterns in Web searching and to measure any impact.

3.3.3.1.2. **Open Coding for Qualitative (Content) Analysis**

Once participants’ search session logs and think-aloud protocols were transcribed to form data compilation records, the records were thoroughly examined for qualitative content analysis. The data record contents were analysed and coded. Open coding, a process of “breaking down, examining, comparing, conceptualizing and categorising data” (Strauss & Corbin, 1990, p. 61), was utilised to code the data. This process generates new concepts, which are later put together to make sense of the data.

Figure 3-11 is an example of open coding extracted from a participant’s transcribed data records, a combination of the participant’s think-aloud data and associated search session logs (see Appendix E for an example of participants’ transcribed data records). The figure illustrates only the segments from the participant’s transcribed data records that were coded.

3.3.3.1.3. **Quantification of the Qualitative Data**

As briefly discussed earlier, certain qualitative data gathered via Web search session logs and think-aloud protocols were quantified in terms of a number of their occurrence by assigning a value. For instance, if a participant used a Boolean operator ‘and’ five times, the dependent variable ‘BOOLEAN’ for the participant was assigned a value of 5. Similarly, the value for each of the other dependent variables, QUOTE, TERM, QUERY and TIME, were tabulated manually. Quantification of these variables was necessary in order to analyse these data statistically.
3.3.3.2. Quantitative Analysis

In this study, the quantitative analysis focused on the data collected through the CSA test results, questionnaires, Web search session logs and the quantified data. The quantitative data were analysed statistically using SPSS (statistical package for social science) tool version 18\textsuperscript{5}. A series of statistical analyses was conducted to examine the findings of the study. The analyses involved both the basic frequency tabulations and advanced methods. Advanced statistical methods, such as analysis of variance (ANOVA), correlation analysis, and factor analysis were applied to identify the effects of the various independent variables on the dependent variables.

\textsuperscript{5} SPSS versions 17 and later are called PASW (Predictive Analytics SoftWare) statistics
Before discussing advanced statistical analysis, the following section describes normalisation of data, which is required for quantitative analysis.

3.3.3.2.1. Normalisation of Data

As shown in Table 4-1 and Appendix C.1, the numbers of participants in each type of gender and of cognitive styles were not equal. As a result it was difficult to make inferences. For example, if 26 male and 24 female participants submitted a total of 440 and 432 queries respectively, it is difficult to make a conclusion whether male or female participants submitted a higher number of queries. The solution to this problem is to normalise the two discourses to a favoured number or instances, say 100. These types of data and numerical counts were normalised by calculating the ‘normalising factor’ (NF). Once the NF is calculated, multiplying the actual number by the NF gives the normalised data.

Normalising factor (NF) defined as:

\[
NF = \frac{100}{N}
\]

For example, the normalising factors for male participants and female participants are calculated as:

\[
NF \text{ (Male)} = \frac{100}{26} = 3.85.
\]
\[
NF \text{ (Female)} = \frac{100}{24} = 4.17.
\]

As an example, Table 3-3 illustrates the normalising factor for male and female participants. Once the normalising factor is calculated, the normalised data (per 100 instances) is then found by multiplying the actual number by the respective normalising factor. Therefore, in the example above, the normalised queries submitted by male (per 100) and female participants (per 100) are calculated as:

\[
\text{Normalised Queries (Male)} = NF \times \text{Actual Queries}
\]
\[
= 3.85 \times 440
\]
\[
= 1692 \text{ (round to whole number)}
\]
Normalised Queries (Female) = NF x Actual Queries

= 4.17 x 432

= 1801 (round to whole number)

From the normalised data, we see that 100 male participants submitted 1692 queries, while 100 female participants submitted 1801 queries. Throughout the analysis process, these types of raw data were normalised where appropriate and applicable, and then analysed statistically.

<table>
<thead>
<tr>
<th>Gender</th>
<th>No. of Participants</th>
<th>NF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>26</td>
<td>100/26 = 3.85</td>
</tr>
<tr>
<td>Female</td>
<td>24</td>
<td>100/24 = 4.17</td>
</tr>
</tbody>
</table>

Table 3-3: Example of Normalizing Factor for Gender

3.3.3.2.2. Statistical Analysis

A brief description of some of the advanced statistical methods and tests that were performed on the quantitative data, including the definitions, are follows.

3.3.3.2.3. Chi-Square

The Chi-Square test for independence is a statistical test that compares two sets of categories to determine whether the two groups are distributed differently among the categories. It is a statistical test to check whether there is a relationship between two types of variables (Gravetter & Wallnau, 2008).

A Chi-Square for independence tests was performed to determine whether there was a significant difference between the frequencies in each query reformulation type. In other words, a Chi-Square test was used to check whether there was any difference in participants’ query reformulations across five types.

3.3.3.2.4. Correlation Analysis

Correlation analysis in statistics measures the degree of association (variation) between two or more variables. Correlation coefficient \( r \) is a measure of the linear relationship between two sets of data. The most widely used type of correlation coefficient is Pearson \( r \) (StatSoft, 2010). Pearson \( r \) is also known as linear or
product-moment correlation. Correlation coefficients can range from -1.00 to +1.00. The value of -1.00 represents a perfect negative correlation while a value of +1.00 represents a perfect positive correlation. A value of zero (0.00) represents a lack of correlation.

In this study, *Pearson r* was carried out to investigate correlations (1) within the independent variables, (2) between dependent variables across different independent variables, and (3) between independent variables and dependent variables. A parametric Pearson analysis was also performed to establish correlations between the various types of query reformulations.

### 3.3.3.2.5. Analysis of Variance (ANOVA)

ANOVA is a statistical method of analysing data variability between the variables or within the groups. The ANOVA method is an appropriate method when the groups of observations are created by categorical independent and dependent variables (Iversen & Norpoth, 1987, p. 8).

In this study, a series of one-way and two-way ANOVA were conducted to determine the effects of participants’ cognitive styles on their Web search behaviour, such as query reformulations.

### 3.3.3.2.6. Multivariate Analysis of Variance (MANOVA)

Multivariate statistical analyses have grown increasingly popular over the past twenty-five years (Grice & Iwasaki, 2009). Multivariate analysis of variance (MANOVA) is one particular technique to test the effect of one or more independent variables on a set of two or more dependent variables. MONAVA, a generalised form of univariate analysis of variance (ANOVA), is used when there are two or more dependent variables. The primary use of MANOVA is to assess the impact of an independent categorical variable on multiple dependent variables that are correlated with each other.

In this study, a series of MANOVA were performed to:

- Investigate to what extent the search task types influence participants’ query reformulations. A series of MANOVA were conducted with search task type
Chapter 3: Research Design

as independent variable and five types of query reformulations as dependent variables.

3.3.3.2.7. Factor Analysis

Factor analysis is used to investigate whether a number of observed variables are linearly related to a smaller number of unobserved factors. Each factor represents an area of generalisation that is qualitatively distinct from those represented by any other factor (Gorsuch, 1974). A measure of variability found between individual variables and individual factors is referred to as a factor loading. Factor loadings reflect quantitative relationships between the variable and the factor.

Factor analyses are performed by examining the pattern of correlations between the observed measures (DeCoster, 1998). Measures that are highly correlated (either positively or negatively) are likely to be influenced by the same factors, while those that are relatively to be uncorrelated are likely influenced by different factors.

There are two classes of factor analysis, exploratory factor analysis (EFA) and confirmatory factor analysis (CFA). EFA attempts to discover the nature of the constructs influencing a set of responses while CFA tests whether a specified set of constructs is influencing responses in a predicted way (DeCoster, 1998).

In EFA, the researcher may not have any specific expectations regarding the number or the nature of underlying constructs or factors (Thompson, 2004). Even if the researcher has such expectations, the EFA does not require the researcher to declare these expectations, and the analysis is not influenced by these expectations. CFA requires that the researcher must have specific expectations regarding (a) the number of factors, (b) which variables reflect given factors, and (c) whether the factors are correlated (Thompson, 2004).

Sample size in factor analysis is important and can have an adverse effect on the outcome of the factor analysis. Several studies have reviewed and recommended minimum sample size in factor analysis. There are basically two types of standards on which sample size can be based: the absolute number of cases (N) and the subject-to-variable ratio (p) (MacCallum et al., 1999). Gorsuch (1983) recommended p of 5 (that is, five subjects per variable), with a minimum of 100 subjects (MacCallum, et
Comrey and Lee (Comrey & Lee, 1992) suggested the following range in determining the adequacy of sample size: 100 = poor, 200 = fair, 300 = good, 500 = very good, 1,000 or more = excellent.

Henson and Roberts (2006) reviewed 60 exploratory factor analyses across four journals: Educational and Psychological Measurement, Journal of Educational Psychology, Personality and Individual Differences, and Psychological Assessment. They reported a minimum sample size of 42. Fabrigar, Wegener, MacCallum, and Strahan (1999) reviewed articles that used EFA in two journals: Journal of Personality and Social Psychology (JPSP) and Journal of Applied Psychology (JAP). They reported that the sample sizes of 30 articles (18.9%) in JPSP and 8 articles (13.8%) in JAP were 100 or less.

In this study, EFA was used to identify any complex relationships between participants’ cognitive styles and their Web search behaviours. In particular, the factor analysis was utilised to test whether the participants’ cognitive styles (as an independent selection variable) influenced a group of query reformulation types (dependent variables). The sample size was 150 cases, equivalent to 150 scenario-based search tasks, which ensured a required minimum sample size according to prior studies (Gorsuch, 1983; Hatcher, 1994).

3.3.3.2.8. Path Analysis (PA)

Path analysis (PA) is an approach for modelling explanatory relationships between observed variables (Raykov & Marcoulides, 2006, p. 63). PA method is considered to be a member of the Structural Equation Modeling (SEM) family (Kline, 2011). SEM analyses are based on correlation data to examine the relationships among two or more variables and constructs.

In this study, path analysis was used to reconfirm the associations established by the correlation analysis between query reformulation types, and then to construct a path model to graphically represent the relationships.

3.3.3.3. Integrating Qualitative and Quantitative Analysis

The qualitative data and quantitative data were analysed separately. Some results from the two analyses were reported separately, while other results from the two
methods were combined at an interpretive level of research to support the findings from each other and expand the scope of the study. The qualitative analyses were done using content analysis, while quantitative analyses were carried out statistically using SPSS.

In Chapter 4 – Result, the results from the qualitative analyses of Web search session logs, think-aloud, and protocols displayed during Web searching, and the results from the quantitative analysis of query reformulations, including how search task types affected query reformulation behaviour, were combined to establish the relationships between the participants’ cognitive styles and their Web search behaviour.

3.4. Ensuring the Quality of the Research Design: Validity and Reliability

The quality of research depends on the way the research design techniques are applied in practice. In any study objectivity, the essential basis of all good research, is the measure of reliability and validity of the research (Kirk & Miller, 1986, p. 20).

The impact of the research depends on its research validity and reliability. Both the validity and the reliability are important aspects of the research methodology, not only to get a better understanding of the research but also to ensure the quality of the research design. They are the checklists used to evaluate whether the research provides a good measure.

3.4.1. Validity

Validity is the extent to which the findings are interpreted in a correct way (Kirk & Miller, 1986, p. 20). The validity refers to the accuracy of a measurement and its findings.

In qualitative research validity assessments are more challenging due to validity and data overload problems. Kaplan & Maxwell (2005) argue that:

The problem of data overload is in some ways more intractable. The evaluator must continually make decisions about what data are relevant and
may change these decisions over the course of the project. The evaluator must work to focus the data collection process, but not to focus it so narrowly as to miss or ignore data that would contribute important insights or evidence. (2005, p. 39)

There are two types of validity: internal and external. Internal validity seeks to demonstrate that the explanation of a particular issue or set of data provided is actually sustained by the data (Cohen et al., 2007). It often means accuracy of the research design, that is, there are no internal errors to the design of the research.

External validity is “the degree to which the results can be generalised to the wider population, cases or situations” (Cohen, et al., 2007, p. 136). External validity is the ability to generalize findings from a specific setting and small group to a broad range of settings and people (Neuman, 2007, p. 121). If the Web search experiment is conducted in a university setting, such as this research, can the findings from the experiment and the research be applied to a general public? These issues, along with measures taken to increase the validly of the study, are discussed in the following section.

### 3.4.2. Reliability

Reliability signifies the issue of consistency of measures, that is, the ability to measure the same thing each time it is being used (Singh, 2007). It suggests that the same thing is repeated or occurs under identical or very similar conditions. In other words, if the results of a study can be reproduced under similar conditions, then the research design is considered to be reliable.

Neuman (2007, p. 115) suggests four ways to increase the reliability of measures:

i. Clearly conceptualize constructs (clear theoretical definitions)
ii. Use a precise level of measurement (more specific information)
iii. Use multiple indicators
iv. Use pilot-tests

In this study a series of measures were taken to guarantee the validity and reliability of the study.
A detailed research process and procedure were outlined and followed. The same experiment settings, procedures and standardized data collection instruments were followed for all the study participants. These efforts ensured the internal validity of the study design.

This study employed a mixed research method involving both qualitative and quantitative forms of data collection and data analysis. One type of analysis complements and supports the other, thus increasing research-finding reliability.

The study data were analysed both manually and using a software tool in order to increase its reliability.

50 student participants, comprising students, academics and professional stuff from the Queensland University of Technology, took part in the study. These participants were recruited regardless of their demographic background, disciplinary or academic status. However, efforts were made to include equal number of males and females across different age groups and occupations (that is, student, academic or professional staff). Therefore the study participants can be considered to be representative of the target population.

Initially, 65 responses were received for participation in the study; 50 participants were recruited. Due to the richness of the data being collected, many user studies tended to use a small group of participants, less than 70 participants (in studies: Ford, et al., 2001, 2005b; Hölscher & Strube, 2000; Lazonder, et al., 2000; Spink & Dee, 2007). This arrangement ensured the external validity of the study.

Prior to the main experiment, a pilot study was carried out to test the research instruments. Based on the feedback from the pilot study, the data collection instruments, data analysis techniques, and research conduct process and procedures were improved (summary points of the lessons learnt from the pilot study are illustrated in Appendix B). The use of the pilot test prior to the main study ensured the reliability of the study (the partial preliminary findings from the pilot study were reported in a published conference paper (Kinley, Tjondronegoro, & Partridge, 2010)).
Throughout the study process, efforts were made to ensure the validity and reliability of the study in general and the research design in particular. Limitations of the study are discussed in Chapter 6, Section 6.4.

### 3.5. Chapter Summary

Chapter 3 has primarily focused on identifying the research variables and methods of gathering and analysing data. A mixed method approach, involving both qualitative and quantitative techniques, was chosen for data collection and data analysis.

Section 3.3 described how the actual research methods – data collection instruments and data analysis techniques – were implemented. A three-fold research process model was designed to conduct the study (see Figure 3.4), which involved three phases: Planning, Data Collection, and Data Analysis. Qualitative data collected through the CSA test, think-aloud and Web search session logs were transcribed, coded and analysed using elements of content analysis and protocol analysis.

The quantitative data collected through questionnaires, Web search session logs and quantified qualitative data were analysed using advanced statistical analyses, such as ANOVA and factor analysis. User-Web interactions, including think-aloud and Web search session logs, were captured using a monitoring program (Camtasia Studio software). A series of data collection instruments and data analysis techniques were utilised to assure the validity and reliability of the research methods in particular and the study findings in general.

The next chapter reports empirical results from the analysis of qualitative and quantitative data using techniques described in this chapter.
Chapter 4: Results

There is no such thing as failure. There are only results.

Anthony Robbins

4.1. Overview

The previous chapter described the research methodology used in this study, including data collection instruments, data analysis techniques, and validity and reliability issues. A mixed methods approach, using both qualitative and quantitative data collection instruments and data analysis techniques, was utilised in the study. The entire research process involved three phases: Planning, Data Collection and Data Analysis.

This chapter reports the empirical results from analyses of a Web search experiment in which 50 volunteers participated. The results were acquired through qualitative analysis of Web search sessions, think-aloud protocols and cognitive styles test; and from quantitative statistical analysis of pre- and post-search questionnaires, a cognitive styles test and part of the Web search sessions.

The research questions addressed in this study were:

- How do users perform Web searching to achieve their information needs?
- What are the effects of users’ cognitive styles on Web search behaviour?
- How can the interrelationships between users’ cognitive styles and their Web searching be effectively modelled?

The study result analyses are reported under three main sections: user characteristics, Web search behaviour and from integrated analyses of Web search behaviour and cognitive styles. Section 4.2 reports the results on the user characteristics and

6 Anthony Robbins (born 1960), an American author, actor and professional speaker
demographic information about the participants. Section 4.3 reports the results from the qualitative and quantitative analyses of participants’ Web search behaviour and their cognitive styles.

4.2. Results on User Characteristics and Demographic

This section reports results of user characteristics and demographic information.

4.2.1. Study Participants

A total of 50 participants comprising students, academics and professional staff from the Queensland University of Technology participated in the study. Appendix C.1 summarises the demographic information of the study participants. As shown in the table, participants comprised both student and staff of the university; 78% (N=39) of them were from the Faculty of Science and Technology (FAST). Initially the invitation email was sent to the students and staff within the Faculty of Science and Technology, and later forwarded to some students and staff of other disciplines by the email recipients (see Appendix A.1).

Table 4-1 illustrates participant distributions by gender and age group. Out of 50 participants, 26 were males, accounting for 52% of the study sample, and 24 were females (48%). More than 58% of the participant population were aged between 26 and 35 years of age. Three participants were under 20 years of age; two participants were between 46 and 55 years of age; one of the participants was over 56 years of age. The study benefited by including participants from different age groups; it was therefore not focused on a particular age group, but rather targeted users of all ages.

<table>
<thead>
<tr>
<th>Gender</th>
<th>Under 20</th>
<th>20-25</th>
<th>26-30</th>
<th>31-35</th>
<th>36-45</th>
<th>46-55</th>
<th>56 plus</th>
<th>Total</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>2</td>
<td>3</td>
<td>8</td>
<td>9</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>26</td>
<td>52</td>
</tr>
<tr>
<td>Female</td>
<td>1</td>
<td>7</td>
<td>6</td>
<td>6</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>24</td>
<td>48</td>
</tr>
<tr>
<td>Total</td>
<td>3</td>
<td>10</td>
<td>14</td>
<td>15</td>
<td>5</td>
<td>2</td>
<td>1</td>
<td>50</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 4-1: Distribution of participants by gender and age
4.2.2. Web Search Experiences

Participants’ Web search experience was measured in terms of 1) number of years of search experience, 2) level of experience with keyword, Boolean and advanced searching, and 3) level of success and difficulty; these are reported in the following sections.

4.2.2.1. Search Experience in Years

Table 4-2 illustrates participants’ prior search experience in years; 98% of the users had more than 1 year of Web search experience. As illustrated in the table, more than 80% of the participants had over 5 years of Web search experience; 36% of the users had more than 10 years of Web search experience. All these users regularly search the Web for information in the course of their academic, personal or administrative activities.

<table>
<thead>
<tr>
<th>Experience In Years</th>
<th>Number of participants (N)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 1 year</td>
<td>1</td>
<td>2%</td>
</tr>
<tr>
<td>1-2 years</td>
<td>1</td>
<td>2%</td>
</tr>
<tr>
<td>3-5 years</td>
<td>7</td>
<td>14%</td>
</tr>
<tr>
<td>6-10 years</td>
<td>23</td>
<td>46%</td>
</tr>
<tr>
<td>More than 10 years</td>
<td>18</td>
<td>36%</td>
</tr>
</tbody>
</table>

Table 4-2: Prior Search Experience in Years

4.2.2.2. Level of Experience with Keyword, Boolean, and Advanced Search

The frequencies of participants who scored between 1 (no previous experience) and 5 (extensive experience) on a five-point Likert scale are illustrated in Figure 4-1. The descriptive statistics (i.e., means and standard deviations (SD) of the participants’ level of Web searching experience with Keyword searching, Boolean and advance Web searching on a five-point scale) are illustrated in Table 4-3.

As shown in Figure 4-1, participants’ level of experience with keyword Web searching was quite good, with a mean of 4.5 on a five-point scale and with 31 participants (62%) with extensive keyword search experience, 6 (12%) with average skill, and 13 participants (26%) with between average and extensive experience.
Chapter 4: Results

However, as illustrated in Table 4-3, their searching skill with the use of Boolean and advanced Web search features was not as good compared to their keyword search experience; the means for Boolean and advanced search were 3.42 and 3.16 respectively. Out of 50 participants, only 12 participants (24%) and 6 participants (12%) had extensive experience in Boolean and advanced searching respectively.

![Figure 4-1: Descriptive frequencies of participants who have scored 1 (no previous experience) to 5 (extensive experience) on a five-point Likert scale for their level of Web searching Experience](image)

<table>
<thead>
<tr>
<th>Statement</th>
<th>Min</th>
<th>Max</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level of experience with keyword</td>
<td>3</td>
<td>5</td>
<td>4.50</td>
<td>.707</td>
</tr>
<tr>
<td>Web search</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Level of experience with Boolean</td>
<td>1</td>
<td>5</td>
<td>3.42</td>
<td>1.197</td>
</tr>
<tr>
<td>Web search</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Level of experience with advance</td>
<td>1</td>
<td>5</td>
<td>3.16</td>
<td>1.167</td>
</tr>
<tr>
<td>Web searching</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 4-3: Descriptive frequencies and statistics (means and standard deviations) on a five-point Likert scale for participant’s level of Web searching Experience
4.2.2.3. Level of Participants’ Success and Difficulty

The participants’ levels of success and difficulty for each search task were measured by a post-search questionnaire. The study participants’ perceived satisfaction with the search efficiency and their level of success and difficulty for each search task were measured using a five-point Likert scale, 1 being the least and 5 being the most. Table 4-4 illustrates the response rating (N.B.: one participant did not fill up the response for this section). It was assumed that each participant would have a different level of perceptions and satisfaction.

<table>
<thead>
<tr>
<th>Statement</th>
<th>N</th>
<th>Min</th>
<th>Max</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>I am satisfied with the response time when using search engines to find needed information.</td>
<td>49</td>
<td>2</td>
<td>5</td>
<td>4.10</td>
<td>.848</td>
</tr>
<tr>
<td>I am satisfied with the performance when using search engines to find needed information.</td>
<td>49</td>
<td>2</td>
<td>5</td>
<td>4.02</td>
<td>.829</td>
</tr>
<tr>
<td>I am satisfied with the retrieved information</td>
<td>49</td>
<td>2</td>
<td>5</td>
<td>3.86</td>
<td>.645</td>
</tr>
<tr>
<td>I will use search engine to find needed information in future</td>
<td>49</td>
<td>2</td>
<td>5</td>
<td>4.45</td>
<td>.679</td>
</tr>
<tr>
<td>I will use different search engines to find needed information in future</td>
<td>49</td>
<td>1</td>
<td>5</td>
<td>2.88</td>
<td>1.184</td>
</tr>
<tr>
<td>Level of difficult for Exploratory Task1</td>
<td>49</td>
<td>1</td>
<td>5</td>
<td>2.88</td>
<td>1.495</td>
</tr>
<tr>
<td>Level of difficult for Factual Task2</td>
<td>49</td>
<td>1</td>
<td>5</td>
<td>2.63</td>
<td>1.167</td>
</tr>
<tr>
<td>Level of difficult for Abstract Task3</td>
<td>49</td>
<td>1</td>
<td>5</td>
<td>2.53</td>
<td>1.430</td>
</tr>
<tr>
<td>Level of success for Exploratory Task1</td>
<td>49</td>
<td>1</td>
<td>5</td>
<td>3.86</td>
<td>.957</td>
</tr>
<tr>
<td>Level of success for Factual Task2</td>
<td>49</td>
<td>1</td>
<td>5</td>
<td>3.88</td>
<td>.857</td>
</tr>
<tr>
<td>Level of success for Abstract Task3</td>
<td>49</td>
<td>1</td>
<td>5</td>
<td>3.73</td>
<td>1.169</td>
</tr>
</tbody>
</table>

Table 4-4: Perception, Satisfaction and Relevance Means distributions

In general the participants were satisfied with the response time and performance of the search engines, as indicated by their score (mean of 4.10 on a five-point scale). This could be due to the fact that nearly 50% of the participants had prior experience of 6-10 years and 36% had over 10 years of search experience. The table also illustrates that among the three search tasks, the factual task was the most successful task (mean = 3.88), while the exploratory task was the least successful (mean = 2.88). This indicated that participants found the closed type fact-finding search task much easier; the factual task required them to find specific answers to the search task. The factual task was assumed to have the least complexity, in that the
participants were asked to find three rules on child restraint while travelling in vehicles in Austin, Texas.

It was assumed that the exploratory search task would be more complex than the factual task but less difficult than the abstract task. However, participants found the exploratory task to be the most difficult, not the abstract task. This may be due to the fact that the exploratory task was an open-ended type search task, where there were no specific answers to such a search task.

4.2.2.4. Choice of Search Engines and Web Browsers

According to Global Market Share Statistics (NETMARKETSHARE, 2011) the Web search engine market, as of July 2011, was dominated by Google (83.62%), followed by Yahoo (6.21%), Baidu (4.64%), Bing (3.57%), Ask (0.51%), and AOL (0.38%). The global browser market share was dominated by Microsoft’s Internet Explorer with 53.68%, followed by Mozilla Firefox (21.67%), Google Chrome (13.11%) and Safari (7.48%).

In this study, when participants were asked which search engine they use most frequently, all the participants opted for Google: Google was the most preferred search engine. This finding coincided with the market share data (NETMARKETSHARE, 2011).

Figure 4-2 illustrates the distribution of participants according to their indicated preferred Web browsers for Web searching. Among the browsers, Internet Explorer (IE) remained the most popular; 44% of the participants (N = 22) indicated IE as their preferred Web browser. The second most frequently used browser was that of Mozilla Firefox at 36% (N = 18). Google’s Chrome accounted for 16% (N = 8).

4.2.3. Search Performance Time

Table 4-5 illustrates the time allocation for each search task type. As shown in the table, the total duration of the Web search experiment performed by 50 participants was 26 hours 13 minutes and 50 seconds (rounded to 1574 minutes). An average of 10 minutes and 30 seconds was spent on each search task, with a variation of
approximately 4 minutes. The minimum searching time spent on a task was 3 minutes and 30 seconds; the maximum time spent was 23 minutes and 25 seconds.

<table>
<thead>
<tr>
<th>Tasks</th>
<th>Mean</th>
<th>SD</th>
<th>Min</th>
<th>Max</th>
<th>Total</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exploratory</td>
<td>00:12:47</td>
<td>00:04:04</td>
<td>00:06:05</td>
<td>00:23:25</td>
<td>10:39:51</td>
<td>41%</td>
</tr>
<tr>
<td>Factual</td>
<td>00:09:01</td>
<td>00:03:42</td>
<td>00:03:30</td>
<td>00:19:40</td>
<td>07:31:18</td>
<td>29%</td>
</tr>
<tr>
<td>Abstract</td>
<td>00:09:39</td>
<td>00:03:46</td>
<td>00:03:47</td>
<td>00:21:35</td>
<td>08:02:41</td>
<td>31%</td>
</tr>
<tr>
<td>All Tasks</td>
<td>00:10:30</td>
<td>00:04:10</td>
<td>00:03:30</td>
<td>00:23:25</td>
<td>26:13:50</td>
<td>100%</td>
</tr>
</tbody>
</table>

Table 4-5: Time Duration for Search Task in hh:mm:ss

On average, participants took relatively less time to complete the factual task (mean = 9 minutes) compared to the exploratory or the abstract task. This may be because the researcher believed the factual task to have the least complexity. The participants were required to find only facts that existed: fact-finding tasks are easier to solve because a searcher knows what he or she needs to find. On the contrary, participants spent a longer time on the exploratory task (mean =12 minutes and 47 seconds) because the exploratory task is an open-ended task requiring more time to locate information on the topic.
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In the abstract task, which was assumed to be at the highest level of difficulty, participants spent an average of approximately 10 minutes to complete the task. Overall, the participants spent 41% of their time on the exploratory task, 29% on the factual task and 31% on the abstract task. Although the participants found the abstract task harder, on average they spent less time on doing it than doing the exploratory task. It may be that the abstract nature of the task provided limited direction for the participants to search on.

4.2.4. Search Queries

During the scenario-based search task experiment, 50 participants submitted 872 unique search queries to complete three search tasks. A query is defined as the string of terms submitted to a search engine per search session.

As illustrated in Table 4-6, 350 queries were submitted for the exploratory task, 226 for the factual task and 296 for the abstract task. Participants submitted fewer queries for the factual task, which accounted for 26%; the reason is probably that this is a fact-finding task, which required fewer searching skills. Participants completed a higher number of queries while carrying out the exploratory task (40%) because it is believed that the exploratory task, being open-ended and requiring searching skills to complete, required more queries to be reformulated. The average number of search queries submitted to complete a task was 5.73.

<table>
<thead>
<tr>
<th>Tasks</th>
<th>Mean</th>
<th>SD</th>
<th>Min</th>
<th>Max</th>
<th>Total</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exploratory</td>
<td>7.00</td>
<td>3.61</td>
<td>1</td>
<td>16</td>
<td>350</td>
<td>40%</td>
</tr>
<tr>
<td>Factual</td>
<td>4.52</td>
<td>3.57</td>
<td>1</td>
<td>19</td>
<td>226</td>
<td>26%</td>
</tr>
<tr>
<td>Abstract</td>
<td>5.92</td>
<td>3.49</td>
<td>1</td>
<td>17</td>
<td>296</td>
<td>34%</td>
</tr>
<tr>
<td>All Task</td>
<td>5.73</td>
<td>3.61</td>
<td>1</td>
<td>19</td>
<td>872</td>
<td>100%</td>
</tr>
</tbody>
</table>

Table 4-6: Frequency of search queries for each task type

4.2.5. Search Terms

A term is defined as a series of characters delimited by a white space. As shown in Table 4-7, 50 participants submitted 3613 search terms to complete three search tasks each. The average number of search terms submitted to search engines was 4.14 per
query, a query length of 4.14. Early Web search studies, between 1997 and 2002, reported an average query length between two and three terms (Hair et al., 2010, p. 6; Jansen, Spink, & Saracevic, 2000). This is something that we intend to explore in detail in future work.

On average, a participant submitted approximately 24 search terms to complete a single search task (minimum 3; maximum 126 search terms). However, there was a vast variation in the number of queries being submitted (SD =21.21). This indicated that variations exist amongst the participants in their query processing. Table 4-8 illustrates some examples of search terms randomly extracted from the search session logs.

<table>
<thead>
<tr>
<th>Tasks</th>
<th>Mean</th>
<th>SD</th>
<th>Min</th>
<th>Max</th>
<th>Total</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exploratory</td>
<td>25.46</td>
<td>18.102</td>
<td>4</td>
<td>78</td>
<td>1273</td>
<td>35%</td>
</tr>
<tr>
<td>Factual</td>
<td>26.68</td>
<td>26.105</td>
<td>4</td>
<td>126</td>
<td>1334</td>
<td>37%</td>
</tr>
<tr>
<td>Abstract</td>
<td>20.12</td>
<td>19.890</td>
<td>3</td>
<td>119</td>
<td>1006</td>
<td>28%</td>
</tr>
<tr>
<td>All Task</td>
<td>23.72</td>
<td>21.21</td>
<td>3</td>
<td>126</td>
<td>3613</td>
<td>100%</td>
</tr>
</tbody>
</table>

Table 4-7: Frequency of search terms for each task type


* Child safety regulations passed by Texas state government in Austin, texas, USA -> child safety regulations passed by Texas state government in Austin, texas, USA for travelling in vehicles -> child safety regulations passed by Texas state government in Austin, texas, USA (Participant ID 21)*

Table 4-8: Examples of search queries (submitted by Participant ID 15 and Participant ID 21)

In summary, Figure 4-3 presents the overview of relationships and patterns between search time, search query, and search term across search task types. Participants showed similar behaviour in terms of search time spent and search query executed
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across the three search tasks. They spent a relatively longer search time and a higher number of search queries for the exploratory task than for the other two tasks; and spent s relatively shorter time and fewer queries for the factual task.

On the other hand, participants showed contradictory behaviour while submitting search terms. They submitted a relatively higher number of search terms while completing the factual task and the least number of search terms for the abstract task. This indicated that the participants seemed to submit longer queries to search facts on the Web, which may be because they were told what facts to find and they could easily use the given keywords as search terms.

Figure 4-3: Search time, search query and search terms by search tasks
4.2.6. User Cognitive Styles

On the basis of their scores from Riding’s (1991) Cognitive Styles Analysis (CSA) test, the participants were classified as wholist or analytic on the WA dimensions and verbaliser or imager on the VI dimensions of cognitive style. The CSA test indicates the position of an individual on the WA and VI cognitive style dimensions by means of a ratio. The background information on the WA and VI cognitive style dimensions and CSA test was presented in Section 2.5.4 in Chapter 2 and in Chapter 3 respectively.

Table 4-9 illustrates the distribution of participants according to their cognitive styles on the WA and VI dimensions of cognitive styles, which are discussed in the following sections. The fourth column in the table represents the number of participants in WA dimensions of cognitive styles, while the fourth row indicates the number of participants according to their VI cognitive styles.

Participants scoring below 1.20 on the WA scale were classified as wholist, and those scoring 1.20 or above as analytic. Of the 50 participants, 23 were classified as having a wholist cognitive style while 27 participants were identified as analytic. Participants scoring below 1.03 on the VI scale were classified as verbaliser, those scoring 1.03 or above as imager. As illustrated in the last row in Table 4-9, 24 participants were classified as verbal users, 26 participants were imagers.

As illustrated in Table 4-9, when WA and VI dimensions of cognitive styles were combined, 11 participants were identified as wholist-verbalisers, 12 as wholist-imagers, 13 as analytic-verbalisers and 14 as analytic-imagers. The results of the influence of participants’ cognitive styles on their Web search behaviour are reported in section 4.3.

<table>
<thead>
<tr>
<th>Cognitive Styles</th>
<th>Verbaliser</th>
<th>Imager</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wholist</td>
<td>11</td>
<td>12</td>
<td>23</td>
</tr>
<tr>
<td>Analytic</td>
<td>13</td>
<td>14</td>
<td>27</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>24</strong></td>
<td><strong>26</strong></td>
<td><strong>50</strong></td>
</tr>
</tbody>
</table>

Table 4-9: Distributions of participants in the Wholist-Analytic (WA) and Verbal-Imager (VI) dimensions of cognitive styles
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Some studies reported that cognitive style is connected to participant’s search experience. For example Palmquist and Kim (2000) reported that cognitive style (field-dependent and field-independent) influenced the search performance of novice searchers relatively greater than the influence on those searchers who had on-line database search experience.

However, in this study participants in each cognitive style groups were almost equally distributed in the number of experience in years. Table 4-10 illustrates the distribution of participants according to their cognitive style groups and prior search experience in number of years. The table indicated that between 75 % and 88% of the participants in each cognitive style group had more 5 years of search experience. Therefore, the influence of search experience on a particular cognitive style group was not considered as an important factor in this study.

<table>
<thead>
<tr>
<th>Cognitive Styles</th>
<th>Less than 5 Years</th>
<th>More than 5 Years</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>%</td>
</tr>
<tr>
<td>Wholist</td>
<td>5</td>
<td>22%</td>
</tr>
<tr>
<td>Analytic</td>
<td>4</td>
<td>15%</td>
</tr>
<tr>
<td>Verbaliser</td>
<td>6</td>
<td>25%</td>
</tr>
<tr>
<td>Imager</td>
<td>3</td>
<td>12%</td>
</tr>
</tbody>
</table>

Table 4-10: Distributions of participants according to their cognitive style groups and prior search experience (in number of years)

4.2.7. Summary of User Characteristics and Demographic

The above section reported on the results of the user characteristics and demographic information, including detail on the study participants. This study recruited 50 study participants, comprising students, academics and professional staff from the Queensland University of Technology, Brisbane Australia. Of the 50 participants, 26 were males, while 24 were females. On the wholist-analytic dimensions of cognitive styles, 23 of them were wholists and 27 were analytics. On the verbal-imagery dimensions, 24 were classified as verbalisers, while 26 were imagers.
During the search experiment, 50 participants submitted 3613 search terms and 872 unique search queries to complete three search tasks. They took an average of 10 minutes and 30 seconds to complete a single search task and spent 31 minutes and 29 seconds to complete the three search tasks.

The following section reports of the results on the users’ Web search behaviour and their cognitive styles.

4.3. Results of Web Search Behaviour and Cognitive Styles

The findings about Web search behaviour, which emerged from the qualitative and quantitative analyses, focus on four key aspects:

- *Information Searching Strategies*, based on how a user performs information searching;

- *Query Reformulation Strategies*, based on how users formulate and reformulate their queries during Web searching;

- *Web Navigation Styles*, based on how users navigate during Web searching; and

- *Information Processing Approaches*, based on how they view and process search results or retrieved result pages.

While the data about the participants’ information searching strategy, navigational behaviour and information processing approaches were mainly analysed qualitatively, their query reformulation behaviour was analysed statistically. Open coding was utilised to code the qualitative data. The process of open coding was described in Chapter 3; an example of open coding of the segments that combined a participant’s think-aloud data and the associated search session logs is illustrated in Figure 3-11.

The following sections first report results on each aspect of the Web search behaviour and then establish associations between participants’ individual aspects of the Web search behaviour and their cognitive styles. To support and validate the findings, examples of coded scenarios, extracted from the participant’s data records by open coding method, are provided where applicable. The quantitative data were analysed using both basic and advanced statistical methods.
4.3.1. Information Searching Strategies (ISS)

*Information Searching Strategies* (ISS) refer to participants’ behaviour while locating information on the Web, and how they approach information searching. Participants’ ISS were identified through qualitative analyses of Web search session logs and transcribed data. Based on the outcome of the open coding themes derived from the participants’ data records, participants were categorised as having top-down, bottom-up, or mixed searching strategies.

4.3.1.1. Top-Down Approach

The *Top-down* search approach is defined as a search strategy where users search for a general topic and then gradually search for specific information. During the Web search, a group of participants were found searching for general information using fewer search terms; for example, ‘Solukhumbu’ (Participant ID 2), which retrieved a huge amount of results, about 382,000 (see Figure C-1 in Appendix C.1 for examples of search results retrieved by a user following a top-down search approach). The participant then refined the search query to retrieve more specific information by adding some keywords, for example, ‘solukhumbu altitude’, which retrieved about 96,300 search results; these search terms were used as qualifying factors for the query. Table 4-11 illustrates an example of a search log in which a top-down approach is performed by the participant ID 2.

| (Google Web) solukhumbu -> Solukhumbu altitude -> Solukhumbu altitude-sickness -> Solukhumbu “high altitude-sickness” -> Solukhumbu “high altitude-sickness” July -> “symptoms of high-altitude sickness” -> symptoms “high-altitude sickness” |

Table 4-11: An example of a Top-down approach as exhibited by Participant ID 2

Examples of a top-down information searching scenario, extracted from the participants’ observation records, using open coding, are provided below.

- *First, the participant started with a single search keyword ‘Solukhumbu’ to search for general information on the place, which retrieved many results.*

  *Having found general information on Solukhumbu from Wikipedia, the user*
then added additional criteria by adding keywords (e.g. solukhumbu trek safety) to search information on trekking. She then reformulated her search terms again to find more information on high altitude sickness and its symptoms. (Participant ID 2).

- **While completing the exploratory task, after having found general information on Solukhumbu, Participant ID 5 decided to search specific information on trekking. She added some search terms to the “Solukhumbu” to form “trekking in Solukhumbu”. (Participant ID 5)**

### 4.3.1.2. Bottom-Up Approach

In contrast to that of a top-down approach, in a *bottom-up approach* users first search for specific information and then move to a more general search. They also scrolled down the results until they found the required information, or they reduced search terms, which acted as the criterion to increase search results on a general topic. Table 4-12 illustrates an example of the top-down approach performed by the study participant ID 50.

<table>
<thead>
<tr>
<th>(Google Web) Nepal, trekking, altitude-sickness, symptoms, treatment, prevention</th>
<th>(Google Web) Nepal trekking altitude-sickness symptoms treatment prevention “altitude sickness” site:.edu, .gov</th>
<th>(Google Web) Nepal trekking altitude-sickness symptoms treatment prevention “altitude sickness” site:.gov</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nepal, trekking, altitude-sickness, symptoms, treatment, prevention</td>
<td>Nepal trekking altitude-sickness symptoms treatment prevention “altitude sickness” site:.edu, .gov</td>
<td>Nepal Solukhumbu trekking “altitude sickness” site:.gov</td>
</tr>
<tr>
<td>nepal.trekking.altitude-sickness.symptoms.treatment.prevention</td>
<td>nepal.trekking.altitude-sickness.symptoms.treatment.prevention</td>
<td>nepal.solukhumbu.trekking.alternate.sickness</td>
</tr>
</tbody>
</table>

**Table 4-12: An example of a Bottom-Up search session log as exhibited by Participant ID 5**

Below is an example of the bottom-up searching approach, which is extracted from the participants’ observation transcripts.

- **During the factual task, the first query the participant submitted was very long – ‘Texas and “state law” or “state law” and “vehicles” or “vehicle” and child safety’. She read the Google search result page and was not happy about the results. Most of the results were irrelevant as the search engine**
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retrieved using ‘vechicle’ as one of the search terms (the participant meant ‘vehicle’). So she decided to reformulate her query and try a shorter query ‘Texas and (“state law” or “state laws”)’. (Participant ID 10)

- The participant reformulated her query to search only from government websites. The new query “Nepal trekking altitude-sickness symptoms treatment prevention “altitude sickness” site:.edu, .gov” retrieved many results on attitude sickness and safety trekking from dot gov websites, which are mostly from the US. The last thing the user wanted to search was to find any specific information about solukhumbu. She said, “The last thing I want to search is any specific information around that spot (Solukhumbu).” She navigated back to the advanced search and changed her query to “Nepal solukhumbu trekking”. (Participant ID 50)

4.3.1.3. Mixed Approach

While performing Web searching, some participants were found to be using both top-down and bottom-up search strategies in parallel during their course of searching. Following are some examples of scenarios extracted from the observation records.

- Having found general information on Solukhumbu from Wikipedia, the participant decided to look for other information such as accommodation and hotels. The participant tried an advanced search with the query “Solukhumbu “hotel” food” and scanned through the result page. The reformulations from a simple query (i.e., “Solukhumbu Nepal”) to an advanced search query (i.e., “Solukhumbu “hotel” food) indicated that the participant followed a top-down search strategy.

He was not happy with the results retrieved. So, he reformulated his query to “Solukhumbu hotel food”. This was in contrast to what he did in the previous query reformulations. He reformulated his query from an advanced search (indicated in the log by the use of quotes) to a simple search, which resulted in a bottom-up search because by removing quotes, the participant is actually reducing ‘conditions’ for the search engine. (Participant ID 18)
• While performing the search task, the participant followed a mixed search strategy. First, the participant searched on general information on Bermuda Triangle and then on a more specific topic, using the query “the Bermuda Triangle Equinox Programme”. Having found some information on the equinox programme, the participant searched for information on the show’s producer John Simmons. During the course of Web searching, the participant followed a mixed search strategy, using both top-down and bottom-up strategies in parallel. (Participant ID 37)

The researcher believes that a mixed search strategy occurred when a participant had a doubt about the usefulness of the results retrieved (e.g., Participant ID 18) or was not happy about their search results (e.g., Participant ID 45).

Table 4-13 illustrates the distribution of participants according to their ISS: 21 participants adopted a top-down search strategy; 18 participants followed a bottom-up search approach; and 11 of the participants employed a mixed search strategy using both top-down and bottom-up styles during their course of searching.

<table>
<thead>
<tr>
<th>Information Searching Strategies</th>
<th>Number of Participants (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top-down</td>
<td>21</td>
</tr>
<tr>
<td>Bottom-up</td>
<td>18</td>
</tr>
<tr>
<td>Mixed</td>
<td>11</td>
</tr>
<tr>
<td>Total</td>
<td>50</td>
</tr>
</tbody>
</table>

Table 4-13: Distributions of participants by information searching strategies (ISS)

4.3.1.4. Associations between Information Searching Strategies and Cognitive Styles

Table C-1 (Appendix C.1) illustrates the study participant profile; the eighth column shows participants’ ISS. Table 4-14 further illustrates the distribution of participants in each cognitive style category of the WA and VI dimensions by their ISS. On the WA dimensions, 13 wholists out of 23 adopted a top-down approach, while four of
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the wholists preferred a bottom-up approach. On the other hand, 14 of 27 analytics followed a bottom-up approach and 8 of them followed the top-down approach.

On the VI dimensions, 12 verbalisers showed a top-down approach, while 8 of the verbalisers showed a top-down behaviour. There was not much difference in the number of imagers in their preference to information searching; 10 of them followed a bottom-up strategy and 9 imagers displayed a top-down approach to information searching.

As the number of participants in each cognitive style group varied, we normalised the distribution of participants. Figure 4-4 (the normalised version of Table 4-14) illustrates the normalised distribution of participants in each search approach category. The figure shows that:

- On the WA dimensions of cognitive style, more than half of the study participants with wholist cognitive style (57%) showed a top-down search approach to searching.
- More than half of the study participants with analytic cognitive style (52%) demonstrated a bottom-up approach.
- On the VI dimension of cognitive styles, half of the verbalisers (50%) exhibited top-down search behaviour, while 38% of the imagers followed bottom-up search methods.

In general, wholist and verbalisers tended to prefer a top-down searching strategy, while analytic and imagery participants preferred a bottom-up approach. More details are given in the following sections.

<table>
<thead>
<tr>
<th>Cognitive Styles Dimensions</th>
<th>Top-down</th>
<th>Bottom-up</th>
<th>Mixed</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>WA</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wholist</td>
<td>13</td>
<td>4</td>
<td>6</td>
<td>23</td>
</tr>
<tr>
<td>Analytic</td>
<td>8</td>
<td>14</td>
<td>5</td>
<td>27</td>
</tr>
<tr>
<td>VI</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Verbaliser</td>
<td>12</td>
<td>8</td>
<td>4</td>
<td>24</td>
</tr>
<tr>
<td>Imager</td>
<td>9</td>
<td>10</td>
<td>7</td>
<td>26</td>
</tr>
</tbody>
</table>

Table 4-14: Frequencies of participants according to their cognitive styles by their Information Searching Strategy
4.3.1.4.1. **Wholists and Verbalisers prefer a Top-Down Approach**

Wholist and verbal participants were observed to employ a top-down strategy to information searching. A top-down search approach is a search strategy where users search for a general topic and then gradually search for specific information. Examples of a top-down information searching scenario, extracted from the participants’ observation records using open coding are provided below.

- **First, the participant started with a single search keyword ‘Solukhumbu’ to search for general information on the place, which retrieved many results.** Having found general information on Solukhumbu from Wikipedia, the user then added additional criteria by adding keywords (e.g. Solukhumbu trek safety) to search information on trekking. She then reformulated her search terms to find more information on high altitude sickness and its symptoms. Table 4-11 illustrates the participant’s Web session logs. (Participant ID 2).

- **With the first single worded query “Solukhumbu”, the participant opened three links. She then changed her search query to “Solukhumbu Hotels “and opened three more result links in a new window. She preferred to use separate windows for each topic. The participant continuously added search**
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terms to the preceding queries and also used Boolean ‘AND’ to combine phrases – “Solukhumbu trekking AND high-altitude sickness”. This type of searching behaviour can be referred to ‘Berrypicking’ search (Bates, 1989), where the user moves through many actions before a goal of satisfaction of the search related to an information need is achieved. (Participant ID 15)

The first query “Texas child safety laws“ retrieved many results on child safety rules. However, she reformulated her query by adding “passenger” to her previous query. Next she added some more search terms to the previous query to find “three rules” on Texas child safety. (Participant ID 40)

4.3.1.4.2. Analytics and Imagers prefer a Bottom-Up Approach

During the information searching experiment, through qualitative analysis of the search session logs and think-aloud, it was observed that, in general, analytics and imagers employed a bottom-up approach to information searching in which they first searched for specific information and gradually move to general search. This is indicated by their behaviour in reducing search terms. The fewer the search terms, the larger the number of search results retrieved, which may be on general topic. Examples of the scenarios extracted from the participants’ observation transcripts support the findings of the study.

• Participant ID 21 wanted to search pages where keywords ‘child safety regulations’ and ‘Texas state government’ should appear by using quotes. He knew that using quotes would specify a search and retrieved results should contain these keywords. However, the search engine could not retrieve any results with the query. He then reformulated his query by removing the second quote, but the search did not match any documents. The participant again reformulated his long query by adding more quotes. It seemed the participant preferred bottom-up searching strategy, as he preferred long query and frequent use of quotes, which specify a search within the keywords in the quotation. (Participant ID 21)

• For Participant ID 24, the first query “high-altitude illness” retrieved many results on high altitude sickness and illness from Wikipedia, familydoctor.org, Princeton.edu, and altitude.org. Having found some
general information on high altitude sickness, the participant then decided to look more information on the place and on trekking. He then reformulated his query. The second query “Solukhumbu trekking” retrieved many results on trekking in Solukhumbu and in Nepal. He then opened the second result page on Solukhumbu trekking from colorfulnepa.com. The page contains a brief description of Solukhumbu trekking and Mt. Everest, however most of the information was on monasteries located in the lower and upper Solukhumbu. As a result, the participant navigated back to the search result page and then reformulated his query. He reduced the search terms to “Solukhumbu”, which retrieved many results on Solukhumbu, including Google images and videos. (Participant ID 24)

- Participant ID 43’s first query ‘Bermuda Triangle travel’ retrieved many results, including images and videos. The participant had a quick glimpse of the search result descriptions. However, she was not happy about the search results. So she reformulated her query by removing the term ‘travel’ from the search query. (Participant ID 43)

- Participant ID 50 reformulated her query to search only from government websites. The new query “Nepal trekking altitude-sickness symptoms treatment prevention “altitude sickness” site:.edu, .gov” retrieved many results on altitude sickness and safety trekking from dot gov websites, which are mostly from the US. The last thing the user wanted to search was to find any specific information about Solukhumbu. She said, “The last thing I want to search is any specific information around that spot (Solukhumbu).” She navigated back to the advanced search and changed her query to “Nepal Solukhumbu trekking”. (Participant ID 50)

These scenarios are examples of the participants’ information searching behaviour and illustrate the different approaches identified by the statistical analysis. They illustrate that the wholists and verbalisers prefer a top-down search approach while the analytics and imagers prefer the bottom-up approach to information searching on the Web.
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4.3.1.5. Summary of Information Searching Strategies

Participants’ information searching strategies were categorised as having top-down, bottom-up, or mixed. The Top-down search approach is defined as a search strategy where users searched for a general topic and then gradually searched for specific information. In contrast to that approach, in a bottom-up approach users first search for specific information and then move to general search. Some participants were found using both top-down and bottom-up search strategies in parallel during their course of searching.

Wholists and verbalisers followed the top-down search approach while searching information on the Web. On the other hand, analytics and imagery users preferred the bottom-up approach during Web searching. The following section reports on users’ navigational styles.

4.3.2. Web Navigational Styles

There are two main approaches to locating information on the Web: users either navigate the Web pages or use queries to search relevant information. The quality of the search results depends on the quality of the user’s navigation. Navigation refers to a browsing behaviour in which the user accesses the content by following a series of links or pages. Users’ navigational approaches are important elements of the Web search behaviour because they are the paths towards a successful Web searching and information retrieval. They are like tools that can add extra leverage in searching and retrieving the required information.

In this study, in order to assess the types of user navigational styles the study participants adopted, the researcher identified two types of measures: (1) qualitative measures, and (2) quantitative measures. Qualitative measures are those attributes that are assessable through the analysis of think-aloud, observation participatory memos and qualitative search sessions. Open coding was used to code the qualitative data (see Figure 3-11 for an example of open coding outcome). Aspects of the navigational behaviours considered in the qualitative measures are:

a) Sequence of navigation,

b) Scanning-reading,
c) Systematic-unpredicted behaviour, and
d) Switch between browsers tabs and windows.

Quantitative measures are those variables that are derived, collected and analysed from raw and quantified quantitative data. Following are some of the variables considered to represent the quantitative measures aspects.

- **PAGEVISITS**: The number of Web pages visited during the navigation session.
- **BUTTONCLICKS**: The number of navigational buttons clicked during the navigation session.

Based on the analyses of the qualitative measures and quantitative measures, two types of navigational styles were identified: these sporadic and structured navigations bear some similarities to those suggested in previous studies (Gwizdka & Spence, 2007; Juvina & Oostendorp, 2004).

### 4.3.2.1. Sporadic Navigational Style

Sporadic navigational style refers to those behaviours in which participants performed an unstructured navigation during Web searching.

a) Sequence of the navigation

Participants who followed a sporadic navigational style tended to navigate back and forward more often – they formulated queries, read first few lines, navigated back to the search result page, and then reformulated the query; they seemed to repeat the same procedure again and again. They also took a relatively longer time to decide on which search terms to use, and which links and pages to be visited or clicked.

b) Scanning-Reading

Participants tended to open many search result pages while locating information on the Web. They tended to prefer scanning in order to access information. As a result they spent a lesser time on a single result page.

Examples extracted from users’ data compilation records using open coding:
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- In general, the participant tended to use more search terms, opened more result pages, and on an aggregate spent a lesser time on a page, and scanned through lots of pages. (Participant ID 3)

- Most of the time the participant was found formulating her query, quickly reformulating, opening few result pages, scanning them quickly, and back to search result page. The behaviour seemed to look as if she was in hurry or someone was chasing after her. (Participant ID 9)

c) Systematic-unpredicted behaviour

Participants in this category tended to view only the first few search result pages and seldom clicked on the ‘Next’ button of the search results page. They also tended to visit the homepage more frequently and more often used the ‘back’ button, which is an indication that they felt uncertain about their searching.

Examples of open coding outcomes:

- At a certain point, the participant was found reading the opened page for some time. But he released that the page did not contained much information he was looking for. So he clicked ‘back’ button and started exploring other result pages. He preferred to explore several pages to see if the pages contained the needed information; he opened almost all the search result pages from the first page of the Google search page and then moved to the second search result page. (Participant ID 17)

- The participant seemed to prefer to open a search result in the same window and use back button more frequently to navigate back to the search result page. She switched between the tabs, read some search result pages and saved them before moving to next task. (Participant ID 45)

d) Switch between browsers tabs and windows

Sporadic Web searchers were found frequently visiting numerous links and pages; they frequently switched between browser tabs and windows, and were thereby characterized by a shorter duration between any two consecutive nodes.
Some examples of participants’ scenarios with sporadic navigational styles are given below.

- The participant reformulated her query, scanned through Google search results page, and opened a few pages in separate tabs. She switched between tabs, and between reviewed opened pages, and spent a minute (approximately) scrolling and scanning each of these opened pages. (Participant ID 10)

- The participant opened several links/tabs in a single window. She preferred to have a few windows opened at a time so that she could look for hotels, food, etc. in one window, and activities in another window. (Participant ID 15)

4.3.2.2. Structured Navigational Style

Structured navigation style refers to those behaviours where systematic steps were followed during the course of Web navigation. Participants seemed to feel confident about their searching and navigation performance.

a) Sequence of the Navigation

Participants searched information carefully and followed an organized step-by-step procedure while performing Web search.

Examples of open coding outcomes extracted from the participants’ data records:

- The participant opened three links in three tabs with the first query. She then refined her search query on the Google search. (Participant ID 7)

- “This person trekked to Sagarmatha National Park. I don’t know what this is, so I have no idea about this place. I need to go back and have a better understanding of Solukhumbu, geographical part of it and understand map of it “. (Participant ID 14)
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b) Scanning-Reading

In general, participants who followed structured navigations seemed to prefer reading to scanning. They focused on a fewer pages and read carefully in detail.

Examples of open coding outcomes (scenarios):

- The participant read the page carefully, looking at pictures and scrolling down the page. She spent approximately 3 minutes reading the page. (Participant ID 4)
- She opened the search result page in the same window; every step was made carefully. The page contained relevant information on Texas occupant restraint laws, transportation code, child passenger safety seat systems, and more. The participant spent approximately two minutes reading the page before navigating back to the Google search result page. (Participant ID 25)

c) Systematic-unpredicted behaviour

Participants in this category were found performing one task at a time, spent adequate time on a single task and navigated cautiously from one page/search to another.

Examples of open coding outcomes (scenarios):

- “My search will start with the name of the place and I type in Solukhumbu. Currently, (there are) lots of things but in order to plan for trek, firstly I need to know my plan which means my visit, my place, and second to see if anybody has stayed there”. (Participant ID 1, think-aloud)
- “Now that I know general information about Solukhumbu, I like to search information and need to know about trekking agency, if I can see any information about trekking in Solukhumbu.” (Participant ID 42)

4.3.2.3. Associations between Web Navigational Styles and Cognitive Styles

Based on the analyses of the qualitative measures and quantitative measures, two types of navigational styles were identified: sporadic and structured navigations.
The following sections report results on the relationships between participants’ cognitive styles and their Web navigational behaviour from analysis of qualitative and quantitative measures.

4.3.2.3.1. Wholists, Analytics and Imagers prefer a Structured Navigational Approach

On the WA dimension, both wholists and analytics tended to follow a structured navigational approach while browsing search results on the Web. Table 4-15 illustrates the normalised distribution of participants according to their navigational styles: 14 wholists (61%) showed a structured navigation approach while 9 (39%) followed a sporadic navigation. On the other hand, 13 analytics (48%) exhibited sporadic navigation and the remaining 14 showed structured navigation (52%). Most of the wholists (61%) and analytics (52%) demonstrated structured navigation behaviour. This indicated that in general both wholist and analytic participants tended to follow a structured navigation.

<table>
<thead>
<tr>
<th>Cognitive Style</th>
<th>Sporadic</th>
<th>Structured</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>Normalised</td>
<td>N</td>
</tr>
<tr>
<td>Wholist</td>
<td>9</td>
<td>39</td>
<td>14</td>
</tr>
<tr>
<td>Analytic</td>
<td>13</td>
<td>48</td>
<td>14</td>
</tr>
<tr>
<td>Verbaliser</td>
<td>13</td>
<td>54</td>
<td>11</td>
</tr>
<tr>
<td>Imager</td>
<td>9</td>
<td>35</td>
<td>17</td>
</tr>
</tbody>
</table>

Table 4-15: Actual number (N) and normalised number of participants according to their cognitive styles by their navigational approaches

On the VI dimension, while verbalisers tended to display sporadic navigational styles, imagery participants appeared to follow a structured navigational strategy while searching information on the Web. As illustrated in Table 4-15, 69% of the imagers showed structured navigation behaviour. They browsed a single page at a time and visited fewer links but they read them in detail. They seemed to be more organized with their Web searching and followed systematic (step-by-step) navigations.

Examples from the open coding outcomes (scenarios):
• The first page Participant ID 4 opened in the same window was a page on trekking in Solukhumbu, trekking in Everest, with landscape images. She read the page carefully, looking at pictures and scrolling down the page. She spent approximately 3 minutes reading the page. (Participant ID 4)

• Participant 14, who is an imager, followed a systematic Web navigation. While conducting Web search during task 1 experiment, Participant 14 said,

“This person trekked to Sagarmatha National Park. I don’t know what it [the park] is and I have no idea about this place. I need to go back and have a better understanding of Solukhumbu, geographical part of it and understand map of it.”

Having found the map of Nepal with Solukhumbu district and having a better understanding of Solukhumbu, the participant then searched for other information.

“Let me have a look on the Map of Nepal. This one [map] has the map of Solukhumbu. Sagarmatha National Park [map] in Solukhumbu has blue area [shaded with blue colour] showing me where Solukhumbu is. That is very good. So I have now a better understanding of Solukhumbu. Solukhumbu district is a part of Sagarmatha zone. I have now a better understanding of what that area is. Next, I need to search where to stay”. (Participant ID 14).

• Participant ID 37 preferred to open first a few search result pages and then he ensured he read them in details, switching between these pages from time to time. (Participant ID 37)
4.3.2.3.2. **Verbalisers adopt Sporadic Navigational Style**

On the VI dimensions of cognitive style, it has been observed that the verbal participants tended to show sporadic navigational styles. (Preliminary and partial findings from the analysis of the data from 18 participants on navigational behaviour and information processing were reported in a published conference paper, (Kinley & Tjondronegoro, 2010).) Table 4-15 illustrates that 54% of verbalisers showed sporadic navigation behaviour, while 46% of them navigated in a structured manner.

Verbalisers were also found to be impatient with their search: they frequently scanned the result pages, which seemed to make them confused. Examples of scenarios extracted from the participants’ observation transcripts are given below.

- *The participant was found struggling with the search tasks in hand. Opening more pages at a time and scanning them quickly seemed to make him more confusing and frustrating.* (Participant ID 3)

- *Most of the time the participant reformulates the query, and quickly scans the result page description without opening any result page.* (Participant ID 9)

Verbalisers also reported some sort of dissatisfactions and frustrations with their searches while locating information on the Web.

- “*I think I will give up for the images (Bermuda Triangle images). I don’t think I can find real images because it’s still a mystery. So, I think I have reasons to believe [that] I can find lots of paintings but not the real photos of what happened in the accidents there*”. (Participant ID 1)

- “*This [best trekking page] is not what I was looking for... I am not happy with that (retrieved page)*”. (Participant ID 9)

Verbalisers tended to use multiple navigational features, such as clicks, back button, home button, and history. They seemed to employ trial and error strategies to find the needed information.

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7 Video clips, demonstrating how a verbaliser and an imager navigate the Web, are available at [http://kinleyk.com/2010/12/02/adcs2010/](http://kinleyk.com/2010/12/02/adcs2010/). Note that the audio is disabled.
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- After scanning through the search results, Participant ID 16 opened the second result in the same window. She scanned the page and closed. She then moved back to Google search result page and opened a link on high altitude sickness. She also scanned through the page and realized that the page contained information about the history of Nepal, which she was not looking for. So she decided to navigate back to the Google search result page and reformulate her query. (Participant ID 16)

- The participant tended to prefer to open search result page in the same window and to use the back button to navigate back to the Google search result page. (Participant ID 40)

In order to test statistically the effect of participants’ cognitive styles on their Web navigation behaviour, in terms of page visits and button clicks, a series of one-way ANOVA was conducted. The test showed little difference in the navigational styles amongst the wholists and analytics, and verbalisers and imagers; there was no significant difference between cognitive styles and their page visits and button clicks. However, it has been found that the means of page visits and button clicks varied amongst the participants of different cognitive style groups. Table 4-16 illustrates mean and standard deviation (SD) of page visits and button clicks for different cognitive style categories.

On the WA dimension, as found in the previous studies (Ford & Chen, 2000), analytics relatively clicked more pages, links and buttons than their wholist peers. Ford and Chen (2000) reported field-dependent (wholists) individuals using a fewer number of back/forward buttons, while field-independent (analytics) individuals were found implementing a high use of back/forward buttons.

On the VI dimension, verbalisers were found to be using relatively higher number of page clicks and button clicks than their imagery peers. This may be due to the fact that they were found to be sporadic in nature while navigating on the Web, where they used multiple navigational menus and processed information by scanning the search result page.

In general, analytics and verbalisers submitted a higher number of page visits and navigational button clicks.
### Cognitive Styles

<table>
<thead>
<tr>
<th>Cognitive Styles</th>
<th>PAGECLICKS Mean</th>
<th>PAGECLICKS SD</th>
<th>BUTTONCLICKS Mean</th>
<th>BUTTONCLICKS SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wholist</td>
<td>31.65</td>
<td>15.17</td>
<td>11.70</td>
<td>9.81</td>
</tr>
<tr>
<td>Analytic</td>
<td>32.44</td>
<td>12.86</td>
<td>13.81</td>
<td>12.02</td>
</tr>
<tr>
<td>Total</td>
<td>32.08</td>
<td>13.83</td>
<td>12.84</td>
<td>11.00</td>
</tr>
<tr>
<td>Verbaliser</td>
<td>32.17</td>
<td>12.50</td>
<td>13.13</td>
<td>13.03</td>
</tr>
<tr>
<td>Imager</td>
<td>32.00</td>
<td>15.21</td>
<td>12.58</td>
<td>8.99</td>
</tr>
<tr>
<td>Total</td>
<td>32.08</td>
<td>13.83</td>
<td>12.84</td>
<td>11.00</td>
</tr>
</tbody>
</table>

Table 4-16: Mean and standard deviation (SD) of total number of page visits and button clicks by cognitive style group

### 4.3.2.4. Summary of Web Navigational Styles

Two kinds of navigational styles were identified, sporadic and structured. Sporadic navigations were characterised by frequent ‘back’ and ‘forward’ navigations, frequent homepage visits, frequent switch between browser tabs and windows, and processed information by scanning.

Palmquist and Kim (2000) relate frequent usage of embedded links to a ‘passive’ way of navigation and use of Home button as an indication of ‘getting lost’ that is, stopping whatever they have been doing and starting over again. As per Palmquist and Kim’s interpretation, the findings of this study indicated that sporadic users get lost more frequently. On the other hand, participants who followed structured navigations adopted a systematic approach. They read a search result page in detail and thus spent adequate time on reading a page. They also tended to perform one search task at a time.

Based on the analyses of qualitative and quantitative measures, analytics and verbalisers submitted a relatively higher number of page visits and button clicks compared to their wholist and imagery peers. Verbalisers were found to show a sporadic navigational behaviour. On the other hand, wholists, analytics and imagers were tended to follow a structured navigational approach while browsing search results on the Web.
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4.3.3. Information Processing Approaches (IPA)

*Information Processing Approaches* (IPA) refer to strategies adopted by users to view, select and process information during Web searching. Examining participants’ information searching strategies allows us to draw some general conclusions about how the users locate the information on the Web. It is also equally important to understand how participants process the information retrieved by search engines. Are there any similarities and differences among participants in the way they select and process information?

Based on the analysis of 50 participants’ Web search behaviour, inferred from the qualitative analyses of Web search session logs and think-aloud protocols through open coding, the researcher identified broadly three categories of IPA: *scanning*, *reading* and *mixed*. Intrinsic factors and criteria, such as whether the participants were spending relatively more time on viewing a result page or not, were considered and coded to identify participants’ information processing behaviour.

Table 4-17 illustrates an overview of the participant distribution according to their IPA: 15 participants processed information through scanning, 19 participants adopted reading, while 16 used both scanning and reading.

<table>
<thead>
<tr>
<th>Information Processing Approach</th>
<th>Number of Participants (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scanning</td>
<td>15</td>
</tr>
<tr>
<td>Reading</td>
<td>19</td>
</tr>
<tr>
<td>Mixed</td>
<td>16</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>50</strong></td>
</tr>
</tbody>
</table>

*Table 4-17: Distribution of participants according to their information processing approach*

4.3.3.1. Scanning IPA

*Scanning* refers to browsing behaviour, where a user scans a result page for general information. In such a case, it is assumed that the user is more likely to use more search terms, make quick switch between topics, tabs and windows, and open relatively more result pages because he or she is not sure if he or she will be confronted with the needed information or not.
During the Web search experiment, some participants were found formulating and reformulating their queries more often. They clicked several links, opened numerous result pages and scanned them quickly. They were also found scanning hastily and switching between subject topics, and between browser tabs and windows.

Some examples of open coding outcomes (scenarios) extracted from the participants’ observation transcripts that demonstrate their scanning behaviour are illustrated below.

- The first thing Participant 1 did with the results from his first query during the factual task search was to quickly scan the search result descriptions, and then he formulated his query without opening or reading the result pages. (Participant ID 1)
- Most of the time the participant reformulates query, and quickly scans the result page description without opening any result page (Participant ID 9).
- The participant reformulated her query, scanned through Google search results page, and opened a few pages in separate tabs. She switched between tabs, and between reviewed opened pages, and spent a minute (approximately) scrolling and scanning each of these opened pages. (Participant ID 10)
- The participant opened a tab and searched with the query “altitude sickness symptoms”. He opened few search results in separate tabs and saved them without much reading. Most of time during the Web searching, the participant performed quick query reformulations and then quick scanning some of the search results. The Web searching is done in a systematic order. He seemed to prefer scanning. (Participant ID 28)

The above extracts from the participant observation transcripts confirm that there was a particular group of participants who processed information by scanning the search result pages.
4.3.3.2. Reading IPA

In contrast to scanning, *reading* refers to comprehensive searching, where a user reads a page in detail; such acts are characterized by a longer time spent on reading a page and by a smaller number of pages being visited in a given period.

During the information searching experiment, some participants were found processing information by reading. They were found reading pages in detail and spent relatively longer time to understand the content of the page. They visited a relatively fewer number of pages and spent a relatively longer time on a single page. They often opened links and pages in the same window, which indicated that they preferred to read a single page and accomplish one task at a given time.

Examples and scenarios extracted from the participants’ observation transcripts are outlined below.

- *It has been found that Participant ID 6 spent a considerable amount of time (few minutes) on reading a page carefully and thoroughly. On average, the participant spent approximately 2 minutes to read each search result page.* (Participant ID 6)

- *The first query retrieved several results by the search engine (i.e., Google). The participant read the Google search result descriptions very carefully. After reading for a minute, the participant opened a page on Solukhumbu district in the same window. She spent almost 3 minutes reading before saving the page.* (Participant ID 33)

- “*Usually I open only a few search result pages, but I make sure I get information about what it contains.*” (Participant ID 42, think-aloud)

- *With the query ‘texas child safety vehicle laws’ (second query), Participant ID 43 opened two search results in two tabs. The two search results i.e., Texas Department of Public and the Texas Department of Transportation, contained important and relevant information on child safety while travelling in vehicles. The participant spent almost 6 minutes reading these two pages.* (Participant ID 43)
4.3.3.3. Mixed IPA

A mixed strategy of information processing refers to information viewing behaviour which involves both scanning and reading. During the Web search experiment, some participants adopted both scanning and reading in parallel to process information. At a certain point of their searching and examination, some participants were found scanning and reading result pages either at the same time in multiple browser windows or at different stages of their searching.

Examples:

- Initially, participant ID 8 formulated and reformulated his queries several times. Most of the time the user followed repetitive search behaviour – formulating a query, scanning the search result descriptions, and reformulating the query without opening any retrieved result pages. However, at a certain point he was found reading a result page in detail for more than 3 minutes. (Participant ID 8)

- The participant scanned through the page; however, he quickly switched back to the opened Wikipedia page. The participant, this time spent approximately a minute to read the Wikipedia page in details. Earlier the participant was found scanning but this time, as the search progressed and more information poured in, the participant started to read them carefully. This was detected via a slow mouse movement over a result page. (Participant ID 18)

- While viewing a page she usually scanned through them but ensured to highlight and read key phrases. (Participant 40)

4.3.3.4. Associations between Information Processing Approaches and Cognitive Styles

In this section we investigate the degree to which the participants’ cognitive style influences their IPA.
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4.3.3.4.1. *Analytics and Verbalisers prefer Scanning*

During Web searching, analytics and verbalisers tended to prefer scanning. They scanned through the search result descriptions and result pages to see if they contained the required information or not. Table 4-18 illustrates the distribution of participants according to their IPA. On the WA dimension, 10 out of 27 analytics examined their information search results through scanning, while 9 preferred reading. On the VI dimension, 11 of the verbalisers resorted to scanning, 6 of them preferred reading and 7 of them processed information through both scanning and reading.

<table>
<thead>
<tr>
<th>Cognitive Styles</th>
<th>Scanning</th>
<th>Reading</th>
<th>Mixed</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wholist</td>
<td>5</td>
<td>10</td>
<td>8</td>
<td>23</td>
</tr>
<tr>
<td>Analytic</td>
<td>10</td>
<td>9</td>
<td>8</td>
<td>27</td>
</tr>
<tr>
<td>Verbaliser</td>
<td>11</td>
<td>6</td>
<td>7</td>
<td>24</td>
</tr>
<tr>
<td>Imager</td>
<td>4</td>
<td>13</td>
<td>9</td>
<td>26</td>
</tr>
</tbody>
</table>

Table 4-18: Frequencies of participants according to their cognitive styles by their information Processing Approaches

When analysed with the normalised data, as illustrated in Figure 4-5, 37% of analytics preferred scanning while 33% of them tended to prefer reading. On the VI dimension, 46% of verbalisers preferred scanning and 25% of them preferred reading.

Verbalisers are people who think in terms of words or verbal associations. They also tend to give the impression that they know more than they do. It seemed to be because of these characteristics that verbalisers, in this study, were found to adopt scanning. They liked to get a glimpse of the search and search result page.

Some examples of scenarios extracted from the participant observation transcripts through open coding of the think-aloud data and search session logs are given below:

- "Once again it is too long to read. I don’t want to read. ... no, this is not the one I want.” (Participant ID 1)
Participant ID 1 formulated and reformulated his queries more often, opened several result pages and scanned them quickly. This behaviour was repeated several times throughout the entire searching. (Participant ID 1)

Participant ID 3 was found struggling with the search tasks in hand. Opening more pages at a time and scanning them quickly, which seemed to make him more confusing and frustrating. (Participant ID 3)

The first page the Participant ID 23 opened was the second search result page on high altitude illness, including mountain sickness, which he opened in a new tab from uptodate.com. The participant scanned through the page, highlighted the keywords and finally saved the page. (Participant ID 23)

![Figure 4-5: Normalised distribution of participants (per 100 users) by their information processing approach](image)

### 4.3.3.4.2. Wholist and Imager prefer Reading

In general wholists and imagers tended to prefer reading. As illustrated in Table 4-18, 10 out of 23 wholists preferred reading, 5 of them resorted to scanning, while 8 wholists adopted a mixed method. On the VI dimension, 13 of the imagers preferred...
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reading, while 5 of them adopted scanning. As illustrated in Figure 4-5, on the WA dimension, 43% of wholists preferred reading and 22% of them preferred scanning; they engaged in reading rather than scanning while viewing search result pages.

Imagery participants tended to prefer reading; they were found reading result pages in detail and spent an adequate amount of time to understand the content of the pages. Imagers are individuals who think in terms of mental pictures and when they read they retain information in mental pictures. In this study, imagers were found adopting reading. It is believed that they preferred reading because they need to gather more information in order to construct the “mental pictures” to get an overview of the information contained within the Web page. They ensured that they read it and understand the content of the page.

Some examples of scenarios extracted from the participant observation transcripts through open coding of the think-aloud data and search session logs are given below:

- **While completing the exploratory task, the first page, which Participant ID 4 opened in the same window, was a page on trekking in Solukhumbu, trekking in Everest, with landscape images. She read the page carefully, looking at pictures and scrolling down the page. She spent approximately 3 minutes reading the page.** (Participant ID 4)

- **Throughout the search tasks, Participant ID 4 was found reading carefully and spent sufficient time (approximately 3 minutes) on each result page she opened. In fact, she spent more than 10 minutes on the first two queries while performing the Web search for the exploratory task. It was also observed that most of the time she opened the result page in the same window, which indicated that she preferred to read one page at a time.** (Participant ID 4)

- **Participant ID 14 was cautious about what she was searching for. She opened one page at a time and based on the information retrieved with the preceding query, she reformulated her query carefully. For instance, during having found general information, a map on Solukhumbu, she then searched for other information on accommodation.** (Participant ID 14)
• “Usually I open only few search result pages, but I make sure I get information about what it contains”. (Participant ID 42)

4.3.3.5. Summary of Information Processing Approaches

Based on how users view, select and process information during Web searching, three categories of information processing approaches were identified: scanning, reading and mixed. Scanning behaviour were characterised by quick switching between browser tabs and windows, frequent link clicks and more queries formulation. On the other hand, reading behaviour was characterised by a relatively longer time spent, a smaller number of result page visits, and a single task attempt at a time. Some participants were found both scanning and reading in parallel during web searching.

In general, wholists seemed to prefer reading, while their analytic peers tended to process information through scanning. From the analyses of the participants’ observation transcripts, verbalisers in general tended to process information through scanning, while their imagery peers adopted reading.

4.3.4. Query Reformulations

Query reformulations have emerged as an important component of Web search behaviour because a user’s success of IR depends on how he or she formulates queries. They reflect the user’s attempt to locate information on the Web. Studies have focused on query reformulations to assist users find the needed information (Fidel & Pejtersen, 2004; Liu, et al., 2010; Rieh & Xie, 2006; Tseng, Tjondronegoro, & Spink, 2009; Yoon & Chung, 2009). These studies show that effective query reformulations can help in locating relevant information.

The following sections report results on the associations (1) within the query reformulation types, (2) between the query reformulation types and search task types, and (3) of the impact of participants’ cognitive styles on their query reformulation behaviour. First we discuss query reformulation taxonomy and types adopted in this study.
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4.3.4.1. Query Reformulation Taxonomy

Similar to the previous works in query reformulation type (Hoang, Nguyen, & Tjoa, 2008; Jansen, et al., 2009a; Tseng, et al., 2009), the researcher constructed five reformulation categories based on the common and different search terms used in two successive queries: New, Add, Remove, Replace, and Repeat. Detailed definitions of each of these queries reformulation classifications with examples are illustrated in Table 4-19.

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
<th>Query Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>New</td>
<td>$Q_i$ and $Q_{i+1}$ do not contain any common terms. All new session terms are assigned as a new query.</td>
<td>$Q_i$: “tour” $Q_{i+1}$: “Solukhumbu trek”</td>
</tr>
<tr>
<td>Add</td>
<td>$Q_{i+1}$ is a super subset of $Q_i$ that is, all the terms in $Q_i$ are present in $Q_{i+1}$ and $Q_{i+1}$ contains more terms than $Q_i$.</td>
<td>$Q_i$: “Trekking Solukhumbu” $Q_{i+1}$: “Trekking Solukhumbu Nepal”</td>
</tr>
<tr>
<td>Replace</td>
<td>$Q_i$ and $Q_{i+1}$ contain at least one term in common and at least one different term.</td>
<td>$Q_i$: “Tour Nepal” $Q_{i+1}$: “Tour Solukhumbu”</td>
</tr>
<tr>
<td>Remove</td>
<td>$Q_{i+1}$ is a super subset of $Q_i$ that is, all the terms in $Q_{i+1}$ are present in $Q_i$ and $Q_i$ contains more terms than $Q_{i+1}$.</td>
<td>$Q_i$: “Solukhumbu tourist Nepal” $Q_{i+1}$: “tourist Nepal”</td>
</tr>
<tr>
<td>Repeat</td>
<td>$Q_i$ and $Q_{i+1}$ contain exactly the same terms; the order of these terms may be different.</td>
<td>$Q_i$: “trekking Solukhumbu Nepal” $Q_{i+1}$: “Nepal Solukhumbu trekking”</td>
</tr>
</tbody>
</table>

Note: $Q_{i+1}$ is the succeeding query that follows the query $Q_i$ in the same session.

Table 4-19: Classifications of query reformulations with examples

4.3.4.2. Query Reformulation Classifications

The researcher built a table (see Table 4-20) with the following fields:

- **UserID**: Unique ID for 50 participants (1 to 50)
- **TaskID**: Unique ID for three search tasks (1 to 3)
- **Query**: Actual query submitted by the participant
• **Number of Terms (Terms):** Number of terms in the query
• **Cumulative Query (CQ):** Cumulative sum of queries.
• **Cumulative Terms (CT):** Cumulative sum of terms
• **Query Reformulation Type (QRT):** Query classification type classified by the program.

The data in the first three fields were manually entered. The next three variables (i.e., Terms, CQ and CT) were tabulated automatically by Microsoft Excel functions. The researcher developed a Visual Basic program to automatically classify the queries into the five classifications, *New, Add, Remove, Replace,* and *Repeat* (see Table 4-19 for definitions), as reflected in the last field (QRT) of Table 4-20. Examples of Web search session logs with query reformulation classifications are illustrated in Table 4-20. Once the table was developed, it was easier to perform various statistical analyses.

<table>
<thead>
<tr>
<th>UserID</th>
<th>TaskID</th>
<th>Query</th>
<th>Terms</th>
<th>CQ</th>
<th>CT</th>
<th>QRT</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>3</td>
<td>Bermuda Triangle</td>
<td>2</td>
<td>732</td>
<td>3089</td>
<td>Repeat</td>
</tr>
<tr>
<td>40</td>
<td>3</td>
<td>Bermuda triangle</td>
<td>2</td>
<td>733</td>
<td>3091</td>
<td>Replace</td>
</tr>
<tr>
<td>40</td>
<td>3</td>
<td>Bermuda Triangle + images + articles</td>
<td>6</td>
<td>734</td>
<td>3097</td>
<td>Add</td>
</tr>
<tr>
<td>40</td>
<td>3</td>
<td>Bermuda Triangle + effects it has on travellers in the region</td>
<td>11</td>
<td>735</td>
<td>3108</td>
<td>Add</td>
</tr>
<tr>
<td>40</td>
<td>3</td>
<td>Bermuda Triangle + effects on travellers</td>
<td>6</td>
<td>736</td>
<td>3114</td>
<td>Remove</td>
</tr>
<tr>
<td>41</td>
<td>1</td>
<td>hypoxia and prevention</td>
<td>3</td>
<td>737</td>
<td>3117</td>
<td>New</td>
</tr>
<tr>
<td>41</td>
<td>1</td>
<td>hypoxia</td>
<td>1</td>
<td>738</td>
<td>3118</td>
<td>Remove</td>
</tr>
<tr>
<td>41</td>
<td>2</td>
<td>texasusa child safety laws</td>
<td>5</td>
<td>742</td>
<td>3133</td>
<td>New</td>
</tr>
</tbody>
</table>

**Note:** CQ: Cumulative Query; CT: Cumulative Terms; QRT: Query Reformulations Type

Table 4-20: Examples of Web search session logs with Query Reformulations Types (QRT)

### 4.3.4.3. Query Reformulation Distributions

Table 4-21 illustrates the distributions of query reformulation types. As illustrated in the table, our automatic classification program classified 872 unique search queries, submitted by 50 participants who engaged in 150 scenario-based search tasks, into
the five types of query reformulation types. The average query length was 4.14. As reported in prior works (Jansen, et al., 2009a; Tseng, et al., 2009), in this study the New, accounting for 29% of the total query reformulations, dominates amongst the query formulations while performing Web searching. Participants are more likely to submit new queries when they change their topic of searches. This indicated that the majority of participants either initiated new queries or changed their search terms completely.

Of the 872 queries, 25% were query modifications where some search terms were added during the course of Web searching. We see that 20% of the total queries occurred due to some sort of search keywords replacement; Replace was the third preferred form of query reformulations.

The least preferred form of query reformulations was that of Remove, which constituted only 12% of the total queries, nearly 20% smaller than the New query reformulations. The variation in the number of Replace queries (SD=3.61) by the participants was higher than the variation in any other query reformulations, the least being in Remove.

In general, participants tended to reformulate their queries by either adding completely new search terms, some new search terms or by replacing some terms, and were less likely to reduce their search terms during Web search sessions.

<table>
<thead>
<tr>
<th>Types</th>
<th>Number</th>
<th>Percentage</th>
<th>Min</th>
<th>Max</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>New</td>
<td>252</td>
<td>29%</td>
<td>2</td>
<td>11</td>
<td>5.04</td>
<td>2.080</td>
</tr>
<tr>
<td>Add</td>
<td>218</td>
<td>25%</td>
<td>0</td>
<td>13</td>
<td>4.36</td>
<td>2.724</td>
</tr>
<tr>
<td>Remove</td>
<td>102</td>
<td>12%</td>
<td>0</td>
<td>8</td>
<td>2.04</td>
<td>1.577</td>
</tr>
<tr>
<td>Replace</td>
<td>174</td>
<td>20%</td>
<td>0</td>
<td>16</td>
<td>3.48</td>
<td>3.610</td>
</tr>
<tr>
<td>Repeat</td>
<td>126</td>
<td>14%</td>
<td>0</td>
<td>8</td>
<td>2.52</td>
<td>2.023</td>
</tr>
<tr>
<td>Total</td>
<td>872</td>
<td>100%</td>
<td>0</td>
<td>16</td>
<td>3.49</td>
<td>2.40</td>
</tr>
</tbody>
</table>

Table 4-21: Occurrence of Query Reformulation Types
4.3.4.4. **Associations within the Query Reformulation Types**

A series of statistical analyses was carried out in order to establish associations within the five query reformulation types.

4.3.4.4.1. **Significant Difference in Query Distributions**

Applying a Chi-square test allows us to test whether there exists any relationship between two or more categorical variables. To determine whether there was a significant difference between the frequencies in each query reformulation type, a chi-square test was conducted. The test, illustrated in Table 4-22, showed a highly significant difference between the distribution of query reformulations in each type ($\chi^2(4) = 88.917, p = .000$). In other words, the distributions of queries varied across five query reformulation types.

<table>
<thead>
<tr>
<th>Number of Queries</th>
<th>88.917a</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chi-Square</td>
<td></td>
</tr>
<tr>
<td>df</td>
<td>4</td>
</tr>
<tr>
<td>Asymp. Sig.</td>
<td>.000</td>
</tr>
</tbody>
</table>

*Table 4-22: Chi-Square Test on the Query Reformulation Types*

4.3.4.4.2. **Significant Associations between Add and Remove, Add and Replace, and Remove and Replace**

The Chi-square test, as illustrated in Table 4-22, indicated that the frequencies of queries in the five categories differed significantly. Next, it was examined to check if there was any association between various query reformulation types by (1) creating scatterplots, (2) parametric Pearson correlation, and (3) path analysis.

A scatter plot reveals relationships between two variables. In this study, a series of scatterplots was created to locate a linear relationship between various pairs of the query reformulation types, one of which is illustrated in Figure 4-6. Figure 4-6 shows the scatterplot of Add against Remove query reformulation types. As illustrated in the figure, there was a significant association between Add and Remove. It means that an
increase in Add queries increases the Remove queries, and vice versa. This was further tested using parametric Pearson’s correlation analysis.

A Pearson correlation was carried out to find significant associations between different types of query reformulations. The analysis, demonstrated in Table 4-23, showed a significant positive correlation between Add and Remove ($r = 0.609$, $p < 0.01$), Remove and Replace ($r = 0.380$, $p < 0.01$), and Add and Replace ($r = 0.532$, $p < 0.01$). If participants added some search terms (Add), they also tended to remove (Remove) and replace (Replace) some search terms to their queries.

Figure 4-6: The Scatterplot of Add against Remove Query Reformulation Types

<table>
<thead>
<tr>
<th></th>
<th>Remove</th>
<th>Replace</th>
</tr>
</thead>
<tbody>
<tr>
<td>Add</td>
<td>Pearson Correlation $0.609^{*}$</td>
<td>$0.532^{*}$</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed) 0</td>
<td>0</td>
</tr>
<tr>
<td>Remove</td>
<td>Pearson Correlation $0.380^{*}$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed) 0.006</td>
<td></td>
</tr>
</tbody>
</table>

Only statistically significant correlation at $P < 0.05$ included.

Table 4-23: Parametric Pearson Correlation
A relationship is said to be a perfect positive if the increase in one variable increases in the other variable. For example in case of Add and Remove correlations, $37\% \ (r^2)$ of the variation in total Add queries submitted was due to the variation in Remove query reformulations and vice versa at a significance level $p<0.01$. The p-value $p<0.01$ indicated that there is only one chance in 100 that could have selected a sample that shows a relationship when none exists in the population (rejecting null hypothesis).

The Pearson correlation indicated that there was a significant association between Add, Remove and Replace query reformulations. We constructed a path model to represent the relationships between these query reformulation types. Path analysis is an approach to model explanatory relationships between observed variables (Raykov & Marcoulides, 2006, p. 63). Path analysis is also known as structural equation modelling (SEM).

Figure 4-7 illustrates the path model for Add, Remove and Replace query reformulations. It summarises the three–trio relationships between the three query reformulations. In the figure, the two-headed arrows represent the interrelationships among the Add, Remove and Replace query types. The integer number between any two-query types (say 0.609 between Add and Remove) represents a Pearson correlation value between them at $p<0.05$. There is a positive correlation between the variations of these three query types. The correlation between Add and Remove ($r = 0.609$) is higher than between Add and Replace ($r = 0.532$) or between Remove and Replace ($r = 0.380$).
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Note: All paths are statistically significant at $P < 0.05$

Figure 4-7: Path Model for Add, Remove and Replace Query Reformulations.

4.3.4.5. Associations between Search Task Types and Query Reformulation Behaviour

This section reports results to see how search task types influence the participants’ query reformulation behaviour during Web searching. The three search task types were factual, exploratory and abstract. A series of statistical analyses was conducted to examine the impact of search task types on query reformulations (the general relationship between search task and time allocation, search queries and search terms were described in Section 4.2). Queries, classified in five types of query reformulations, were further sub-grouped into three according to the three task types. Figure 4-8 illustrates the overall distributions of the five types of query reformulations across the three search task types.

Although all the participants completed all three sets of search tasks, the occurrence of each query types varied across three tasks. In the exploratory task, participants executed a higher number of New queries; the least was Repeat. While searching information on the Web, participants preferred to search with New queries and least with Repeat. Although the number of occurrence of each query type was relatively
higher in the exploratory task, the participants seemed to display similar behaviour in the *factual* task.

![Figure 4-8: Distributions of query reformulation types in the three search task types](image)

However, in the *abstract* task, the most preferred form of query reformulation was that of *Repeat*. There seemed to be two possible reasons for repeating search queries:

i. The researcher believed that because of the abstract nature of the *abstract* search task, the participants might have limited possible alternative key words. Therefore, they might have changed the order and used the same search terms.

ii. Due to the abstract nature of the task, the participants might have searched the information with the same search query on different search engines, such as Yahoo, Google video or Google images. A good number of participants (examples: Participant ID 1, Participant ID 5, Participant ID 7, Participant ID 10) were found repeating the same query either on Google Web, Google Image, or Youtube.
4.3.4.5.1. Search Task Types influence New and Repeat Query Reformulations

To investigate to what extent the search task type influenced participants’ query reformulations, a one-way multivariate ANOVA (MANOVA) was performed. The dependent variables considered were the five types of query reformulations (New, Add, Remove, Replace and Repeat) and the independent factor was the search task types. The test revealed a significant multivariate main effect for search task type, Wilk’s $\lambda = .208$, $F(10, 286) = 8.435$, $p < .001$, partial eta squared = .228.

Given the significance of the overall test, the univariate main effects were investigated. Significant effects for search task type were obtained for New, $F(2, 147) = 12.612$, $p < 0.01$; and Repeat, $F(2, 147) = 33.559$, $p < 0.01$. This indicated that search task types (i.e., exploratory, factual and abstract tasks), influenced the way the participants reformulated New and Repeat queries.

4.3.4.6. Associations between Query Reformulation Behaviour and Cognitive Styles

Table 4-24 illustrates an overview of the occurrence of query reformulation types in each cognitive style group. On the WA dimension, 23 wholists performed 127 New, 87 Add, 36 Remove, 70 Replace, and 58 Repeat query reformulations to complete three search tasks. On the other hand, 27 analytics submitted 125 New, 131 Add, 66 Remove, 104 Replace, and 68 Repeat. On the VI dimension of cognitive styles, 24 verbalisers performed 115 New, 105 Add, 52 Remove, 102 Replace, and 58 Repeat queries; 26 imagers executed 137 New, 113 Add, 50 Remove, 72 Replace, and 68 Repeat.

<table>
<thead>
<tr>
<th>Cognitive Style</th>
<th>New</th>
<th>Add</th>
<th>Remove</th>
<th>Replace</th>
<th>Repeat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wholist (N =23)</td>
<td>127</td>
<td>87</td>
<td>36</td>
<td>70</td>
<td>58</td>
</tr>
<tr>
<td>Analytic (N =27)</td>
<td>125</td>
<td>131</td>
<td>66</td>
<td>104</td>
<td>68</td>
</tr>
<tr>
<td>Verbaliser (N = 24)</td>
<td>115</td>
<td>105</td>
<td>52</td>
<td>102</td>
<td>58</td>
</tr>
<tr>
<td>Imager (N = 26)</td>
<td>137</td>
<td>113</td>
<td>50</td>
<td>72</td>
<td>68</td>
</tr>
</tbody>
</table>

Table 4-24: Occurrence of participants by their cognitive styles and query reformulations
Since the number of participants in each cognitive style category was not equal, we normalised the number of participants to 100. Normalising data makes it easier to compare the differences among the variables.

Figure 4-9 shows the graph of the normalised version, where the number of participants is normalised to 100. There are obvious differences in the number of queries submitted among the participants of different cognitive styles, which are discussed separately in the following sections. As illustrated in Figure 4-9, wholists tended to prefer New. This may be due to the fact that they are said to have problems separating ideas into discrete parts (Riding & Cheema, 1991), are less logical compared to analytics, and encounter more difficulties and confusion during Web searching (Wang, et al., 2000).

<table>
<thead>
<tr>
<th>Cognitive Style</th>
<th>New</th>
<th>Add</th>
<th>Remove</th>
<th>Replace</th>
<th>Repeat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wholist</td>
<td>552</td>
<td>378</td>
<td>157</td>
<td>304</td>
<td>252</td>
</tr>
<tr>
<td>Analytic</td>
<td>463</td>
<td>485</td>
<td>244</td>
<td>385</td>
<td>252</td>
</tr>
<tr>
<td>Verbaliser</td>
<td>479</td>
<td>438</td>
<td>217</td>
<td>425</td>
<td>242</td>
</tr>
<tr>
<td>Imager</td>
<td>527</td>
<td>435</td>
<td>192</td>
<td>277</td>
<td>262</td>
</tr>
</tbody>
</table>

Figure 4-9: Normalised (to 100 users) distribution of Query Reformulation Types by Cognitive Style Groups
On the contrary, the analytics preferred *Add* and *Remove*; they modified the existing queries by adding and removing some search terms. Analytics are said to perceive a situation as a collection of parts and focus on one or two aspects of the situation at a time (Riding & Cheema, 1991). Our findings are in line with what Ford, et al., (2009) have found. They reported that analytics display consistency and more systematic logical thought with their search transformations.

On the VI dimension, verbalisers submitted more queries in *Add*, *Remove*, and *Replace* compared to their imagery peers. The *Add*, *Remove* and *Replace* query reformulations involve the use of combinations of keywords. Our findings confirm previous studies that they tended to be quite good at the use of language as opposed to images, with greater use of distinctive linguistic search transformations and good combination of keywords (Ford, et al., 2009). The researcher believes that *Add*, *Remove* and *Replace* queries require greater use of linguistic search expression compared to *New* or *Repeat* queries. When compared with other groups of cognitive styles, verbalisers submitted a maximum number of *Replace* queries.

On the other hand, imagers completed a higher number of *New* and *Repeat* query reformulations compared to their verbal peers, and of *Repeat* when compared with other types of cognitive styles. They seemed to lack linguistic expression; therefore they tended to search with the same query (on Google Web, Google images, and Google videos). A series of advanced statistical analyses was conducted to examine the interrelationships between participants’ cognitive styles and their query reformulation behaviour.

**Significant associations between wholist-analytic and Remove query reformulation**

To find significant differences among the participants of different cognitive styles in their query reformulation behaviour (in terms of five types of queries), a series of One-way ANOVA was performed. Table 4-25 and Table 4-26 summarise the results from the one-way ANOVA tests. However, the results showed little difference among the searchers in their query reformulation behaviour. A significant difference was found among wholists and analytics in the *Remove* query reformulation behaviour, \( F (1, 48) = 4.103, p < 0.05 \), which indicated that the wholists and analytics performed query reformulations differently.
For a particular cognitive style group, query reformulation behaviour influenced by two factors

As illustrated in Table 4-26, a series of One-Way ANOVA statistical tests was conducted. However, the tests were not significant, that is not much difference in query reformulation behaviour among the participants of different cognitive style dimensions.

Therefore, in order to identify any complex relationships between the participants’ cognitive styles and their query reformulation behaviour, a series of exploratory factor analyses were performed with different cognitive style groups as the selection variable. Principal component analysis was adopted as the extraction method, with Eigenvalues greater than 1, and the factor loadings less than 0.1 being omitted. The sample size was 150 cases equivalent to 150 scenario-based search tasks. The factor analysis tests have extracted two factors (groups) for each of the cognitive style groups.

<table>
<thead>
<tr>
<th>Query Reformulations</th>
<th>Wholist (N = 23)</th>
<th>Analytic (N = 27)</th>
<th>One-way ANOVA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
</tr>
<tr>
<td>New</td>
<td>5.52</td>
<td>2.233</td>
<td>4.63</td>
</tr>
<tr>
<td>Add</td>
<td>3.78</td>
<td>2.575</td>
<td>4.85</td>
</tr>
<tr>
<td>Remove</td>
<td>1.57</td>
<td>1.273</td>
<td>2.44</td>
</tr>
<tr>
<td>Replace</td>
<td>3.04</td>
<td>2.820</td>
<td>3.85</td>
</tr>
<tr>
<td>Repeat</td>
<td>2.52</td>
<td>2.213</td>
<td>2.52</td>
</tr>
</tbody>
</table>

Note: * indicates p <0.05

Table 4-25: One-way ANOVA of WA with Query Reformulations

<table>
<thead>
<tr>
<th>Query Reformulations</th>
<th>Verbaliser (N = 24)</th>
<th>Imager (N = 26)</th>
<th>One-way ANOVA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
</tr>
<tr>
<td>New</td>
<td>4.79</td>
<td>1.615</td>
<td>5.27</td>
</tr>
<tr>
<td>Add</td>
<td>4.38</td>
<td>2.223</td>
<td>4.35</td>
</tr>
<tr>
<td>Remove</td>
<td>2.17</td>
<td>1.810</td>
<td>1.92</td>
</tr>
<tr>
<td>Replace</td>
<td>4.25</td>
<td>4.665</td>
<td>2.77</td>
</tr>
<tr>
<td>Repeat</td>
<td>2.42</td>
<td>1.767</td>
<td>2.62</td>
</tr>
</tbody>
</table>

Table 4-26: One-way ANOVA of VI with Query Reformulations
Chapter 4: Results

Table 4-27 show the component (factor) matrixes containing the loadings of the five query reformulation types on two factors extracted for each of the cognitive style groups. The factor loadings are the correlations between the variables (five query reformulations) and the factors. Thus, the higher the absolute value of this loading (to a maximum of 1), the greater the proportion of the total variance of the variable that is accounted for by the factor. The proportion of the variance accounted for by each factor is represented in the last row of the matrix in Table 4-27.

<table>
<thead>
<tr>
<th></th>
<th>Wholist Factor 1</th>
<th>Wholist Factor 2</th>
<th>Analytic Factor 1</th>
<th>Analytic Factor 2</th>
<th>Verbaliser Factor 1</th>
<th>Verbaliser Factor 2</th>
<th>Imager Factor 1</th>
<th>Imager Factor 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>New</td>
<td>.239</td>
<td>.929</td>
<td>.298</td>
<td>.298</td>
<td>.265</td>
<td>.877</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Add</td>
<td>.898</td>
<td>.236</td>
<td>.912</td>
<td>.163</td>
<td>.912</td>
<td>.163</td>
<td>.901</td>
<td></td>
</tr>
<tr>
<td>Remove</td>
<td>.642</td>
<td>.820</td>
<td>.820</td>
<td>.339</td>
<td>.820</td>
<td>.339</td>
<td>.678</td>
<td></td>
</tr>
<tr>
<td>Replace</td>
<td>.776</td>
<td>.787</td>
<td>.339</td>
<td>.787</td>
<td>.339</td>
<td>.749</td>
<td>.306</td>
<td></td>
</tr>
<tr>
<td>Repeat</td>
<td>.565</td>
<td>.921</td>
<td>.921</td>
<td>.583</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% of Variance</td>
<td>43.99</td>
<td>24.58</td>
<td>44.89</td>
<td>21.75</td>
<td>44.90</td>
<td>21.75</td>
<td>44.88</td>
<td>22.79</td>
</tr>
</tbody>
</table>

Table 4-27: Factor Analyses: Associations between cognitive styles and query reformulation types

We see in Table 4-27 that while one group of wholists tended to load relatively high on all the query reformulation types (factor 1), the other group tended to score high on New, and Add (factor 2). The percentages of the total variance accounted for by factor 1 and factor 2 are 44.0% and 24.6% respectively. In other words, the effect of factor 1 on wholists accounts for 44% of the total variance caused by all other factors. While one group of analytics tended to prefer New, Add, Remove and Replace, the other group preferred Add, Replace and Repeat.

The model, as illustrated in Figure 4-10, demonstrates that for a particular cognitive style group, participants’ query reformulation behaviour is influenced by the two factors (factor 1 and factor 2). The strength of the relationship between a factor and a query reformulation type varies; a particular factor influences some query reformulation behaviour more than others. Similarly, the degree of variance also differs from one factor to the other.
Based on the common and difference in search term use in two successive queries, participants’ query reformulation types were categorised into five: *New*, *Add*, *Remove*, *Replace*, and *Repeat* (see Table 4-19 for definition). A Chi-Square test of independence indicated that the query reformulation behaviours were more likely to differ across search task types (exploratory, factual and abstract). In other words, there was an effect of search task types on query reformulation behaviour; search task types influenced the way the participants reformulated *New* and *Repeat* queries.

A Pearson correlation test revealed significant associations between *Add* and *Remove*, *Remove* and *Replace*, and *Replace* and *Add* query reformulation behaviour. This indicated that particular groups of users tended to prefer certain query reformulations. We developed a path analysis model to demonstrate these inter-relationships (Figure 4-7). The one-way ANOVA test indicated that the search task types (i.e., exploratory, factual and abstract tasks), influenced the way the participants reformulated *New* and *Repeat* queries.

**4.3.5. Summary of Results of Web Search Behaviour and Cognitive styles**

Section 4.3 reported the results on the users’ Web search behaviour and their cognitive styles. The sections described findings from the qualitative and quantitative analyses of the study data on the inter-relationships between users’ Web search behaviour and their cognitive styles.
Participants’ Web search behaviour was examined through analyses of their information searching strategies, navigational styles, information processing approaches and query reformulation behaviour. While participants’ information searching strategies, navigational styles and information processing approaches were analysed qualitatively, their query reformulation behaviour was examined through quantitative analysis.

Participants’ information searching strategies were categorised as being *top-down*, *bottom-up*, or *mixed*. As previously noted, *top-down* search approach is defined as a search strategy where users searched for a general topic and then gradually searched for specific information. In contrast to that of a top-down approach, in a *bottom-up approach* users first searched for specific information and then moved to general searching. Wholists and verbalisers followed a *top-down* search approach while searching information on the Web. On the other hand, analytics and imagery users preferred a *bottom-up* approach while performing Web searches.

Based on how users view, select and process information during Web searching, three categories of information processing approaches were identified: scanning, reading and mixed. Although there was not much significant difference amongst wholists and analytics in terms of numbers for their preference of information processing approaches, wholists seemed to prefer reading, while analytics tended to process information through scanning. On the other hand, verbalisers in general preferred scanning while the majority of the imagers preferred to view or access information through reading.

Users’ navigational styles were identified as *sporadic* and *structured*. During Web navigation, while most of the users, that is wholists, analytics and imagers, tended to follow structured navigation approach, the verbalisers seemed to move in a sporadic manner while navigating on the Web. Verbalisers were found to be impatient with their search as they frequently scanned the result pages, which seemed to make them confused.

Participants’ query reformulation types were categorised into five: *New*, *Add*, *Remove*, *Replace*, and *Repeat*. While most of the participants preferred *New*, analytics preferred *Add* to any other forms of query reformulations. Verbalisers
executed a higher number of *Add*, *Remove*, and *Replace* query reformulations than their imagery peers. They tended to be good at the use of language, as opposed to imagers. On the contrary, imagers seemed to lack linguistic expression to modify their queries and use search terms. It may be due to this reason that they submitted a higher number of *New* and *Repeat* queries.

A significant difference was found among wholists and analytics in the manner they executed *Remove* query reformulations, $F(1, 48) = 4.103, p < 0.05$. Factor analyses revealed different groups within a cognitive style category in the way they performed query reformulations.

4.4. Chapter Summary

This chapter presented the results of the study on (1) user characteristics and demographic information, and (2) users’ Web search behaviour and their cognitive styles.

Section 4.2 reported on the results on the demographic information, including the study participants. This study recruited 50 study participants, 26 males and 24 females, comprising of students, and academic and professional staff from the Queensland University of Technology, Brisbane Australia. On the WA dimensions of cognitive styles, 23 of them were wholists and 27 were analytics. On the VI dimensions, 24 were classified as verbalisers, while 26 were identified as imagers.

Section 4.3 presented the results on the participants’ Web search behaviour and their cognitive styles. Web search behaviours were examined in terms of information searching strategy, information processing approaches, Web navigational styles and query reformulations. The results on the first three Web search patterns were analysed qualitatively, while the results on query reformulation behaviour were analysed using statistical analysis.

Wholists and verbalisers followed a top-down search approach while searching information on the Web. On the other hand, analytics and imagery users preferred a bottom-up approach while performing Web searches. During the Web navigation, while most of the users, that is wholists, analytics and imagers, tended to follow
structured navigation approach, the verbalisers seemed to move in a sporadic manner while navigating on the Web. Verbalisers were found to be impatient with their search as they frequently scanned the result pages, which seemed to make them confused.

Verbalisers and analytics were found scanning through the search result descriptions and result pages to see if they contained the required information or not. In comparison, wholists and imagers tended to prefer reading. They were found reading result pages in detail and spent an adequate amount of time understanding the content of the pages.

For query reformulation among the users of four cognitive style groups, analytic users were found to be more active in query reformulation, for they submitted relatively higher more queries while searching information on the Web than users of other cognitive style groups. While formulating search queries, most participants preferred New, except analytics who seemed to prefer Add to any other forms of query reformulations. Verbalisers executed a higher number of Add, Remove, and Replace query reformulations than their imagery peers. They tended to use language well opposed to imagers. On the other hand, imagers seemed to lack linguistic expression to modify their queries and use search terms. It may be due to this reason that they submitted a higher number of New and Repeat queries.

The next chapter discusses the key findings of the study in an attempt to address the three research questions framed for the study. Two models depicting the relationships between Web searching and user characteristics, such as cognitive styles, are developed and discussed. The chapter also discusses the implications of the study.
Chapter 5: Discussion, Implications and Outcomes

Discussion is an exchange of knowledge; argument is an exchange of ignorance.

Robert Quillen

5.1. Overview

This thesis examined the impact of users’ cognitive styles on their Web search behaviour. The users’ Web search behaviour was explored through analyses of their information searching strategies, Web navigational styles, query reformulation behaviour and information processing approaches. The previous chapter presented results from the analysis of both qualitative and quantitative data. The study findings provided valuable insights into Web search behaviour in general and the impact of users’ cognitive styles on their own Web search behaviour.

This chapter highlights the key findings and provides a high-level theoretical discussion of the various aspects of Web search behaviour and participants’ cognitive styles reported in Chapter 4. Two models, depicting the relationships between Web searching and user characteristics such as cognitive styles, are developed and discussed. The chapter also discusses the implications of the study. Theoretical implications of the study are also discussed and new models presented.

5.2. Key Findings

The main purpose of this study was to examine the relationships between users’ cognitive styles and their Web search behaviour. Thus, the main research question addressed in this study was:

What are the relationships between users’ cognitive styles and their Web search behaviour?

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8 Robert Quillen (1887–1948), American journalist and humourist
To address this main question, this study addressed three research questions:

RQ1: How do users perform Web searching to achieve their information needs?

RQ2: What are the effects of users’ cognitive styles on their Web search behaviour?

RQ3: How can the interrelationships between users’ cognitive styles and their Web search behaviour be effectively modelled?

The following sections focus on each of these sub-research questions and their respective findings.

5.2.1. RQ1: How do Users perform Web Searching

The empirical study results revealed that users display high-level Web search behaviour while searching information on the Web. Users’ Web search behaviours are of four main types: *information searching strategies, query reformulation behaviour, navigational styles, and information processing approaches*. As illustrated in Figure 5-1, the four aspects of Web search behaviour are interconnected.
Users in this study go through each of these aspects while searching information on the Web. It is likely that most users initiate their Web searching with a query; however, the order of the components in the figure does not matter much because different participants seemed to follow each of these stages in different orders. In other words, a user may initiate any one of these key stages during the Web searching process. For an example, in this study one participant (e.g., Participant ID 13) formulated a query, scanned through the search result descriptions and reformulated the query without opening or navigating the search result pages, while other participants followed query reformulations, navigation and information processing.

5.2.1.1. Information Searching Strategies

During Web searching, participants were found to display one of the three information searching strategies (ISS): top-down, bottom-up and mixed. These searching behaviours were inductively derived from the users’ Web search experiment.

The majority of the participants (42%) seemed to prefer a top-down approach in which they first searched for a general topic by using fewer search terms and then gradually searched for a specific information by adding more search terms; these search terms were used to filter out the search results. Of the 50 participants, 36% of them searched in a bottom-up approach, where they first searched on a specific subject and later on more generic topics, while 22% of them adopted both top-down and bottom-up approaches.

5.2.1.2. Query Reformulation Behaviour

Participants’ query reformulations were classified into five categories: New, Add, Replace, Remove and Repeat. Chi-square test showed a significant difference in participants’ query reformulation behaviour. Further, a Pearson correlation analysis indicated a significant association between Add, Remove and Replace query reformulations at a significance level of \( p<0.01 \). It indicated that if participants added some search terms (Add), they also tended to remove (Remove) and replace (Replace) some search terms in their queries, and vice versa.
A one-way MANOVA test results showed that participants’ New and Repeat query reformulations differed across three search tasks. The search task types, that is, exploratory, factual and abstract tasks, influenced the manner in which the participants reformulated New queries and Repeat queries. This would have some implications for the design of query suggestions that are offered to users by search engines during Web searching. Search engines can identify the type of information the user is looking for by capturing the trend of the query reformulations, and can then provide effective query suggestions accordingly.

5.2.1.3. Web Navigation Styles

Participants’ Web navigational styles were categorized into sporadic and structured. Participants who followed sporadic navigations tended to formulate their query, scan the first few search result descriptions, click the ‘next’ button of the search engine, then navigate back and reformulate their query. As illustrated in Table 5-1, in general they visited relatively more Web pages than structured navigators.

On the other hand, some users navigated in a structured manner while locating information on the Web. They seemed to formulate their query carefully, opened fewer pages and read the pages in detail. They often opened the search result page in the same windows to focus on a single task/topic, and navigated back to the search result page to either reformulate their queries or open another search result page. This could be the main reason why, as illustrated in Table 5-1, on average the structured navigators clicked a relatively higher number of navigation buttons than their sporadic peers. This indicates that future Web search engines need more navigational buttons.

<table>
<thead>
<tr>
<th>Navigation Styles</th>
<th>PAGEVISITS</th>
<th>BUTTONCLICKS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Sporadic</td>
<td>33.64</td>
<td>17.906</td>
</tr>
<tr>
<td>Structured</td>
<td>30.86</td>
<td>9.717</td>
</tr>
</tbody>
</table>

Table 5-1: Mean and Standard Deviation (SD) of PAGEVISITS and BUTTONCLICKS by Sporadic and Structured navigators
5.2.1.4. Information Processing Approaches

Participants’ information processing approaches can be categorized into three: scanning, reading or mixed. While performing Web searching, some participants were found processing search results by scanning. They scanned the search result descriptions and then reformulated their queries. They seldom opened search result pages and when they did they opened them in separate browser tabs or windows and scanned them.

On the other hand, some users were found to process information by reading. They took a relatively longer time to read a search result page and thus visited a smaller number of search result pages compared to those who processed information by scanning. These users often opened search result links and pages in the same window.

There were also a few users who viewed search result pages by both scanning and reading. They flipped from one page to another but sometimes read the result page in detail. They would scan the search result pages until they found something interesting or eye catching and would then read that in detail.

In general, users have a tendency to either scan the result pages or read them in detail. These types of browsing behaviours potentially have some implications for Web site design. The study’s results shed some light for the future of Web information systems developments. Such findings may help information system developers and designers provide adaptive support to information users. Search engines can provide a series of keyword recommendations with a very brief description for each search result so that searchers who prefer scanning can scan them quickly and open only the relevant result page. On the other hand, a longer result description with more information can be provided to searchers who prefer reading.

5.2.2. RQ2: The Effects of Users’ Cognitive Styles on their Web search behaviour

The main aim of this study was to examine the relationships between users’ cognitive styles and their Web search behaviour. Based on Riding’s (1991) CSA test,
participants were classified as wholists and analytics on the WA dimension of cognitive styles, and verbalisers and imagers on the VI dimension. Participants’ Web search behaviours were investigated through their information searching strategies, query reformulation behaviour, Web navigational styles and information processing approaches.

Both the qualitative analysis and statistical quantitative analyses showed effects of participants’ cognitive styles on their Web search behaviour; these are briefly described below.

5.2.2.1. Effects of Cognitive Style on Information Searching Strategies

Participants’ information searching strategies were categorised as being top-down, bottom-up, or mixed. From the analysis of qualitative data, the participants’ cognitive style was found to have a greater impact on their information searching strategies. Figure 5-2 illustrates an overview of the associations between participants’ cognitive styles and their Web search strategies.

As illustrated by the red arrow in Figure 5-2, wholists and verbalisers in general tended to display a top-down searching behaviour. While formulating queries, the wholists and verbalisers were found to submit a relatively longer succeeding query than the preceding query. The additional search terms in the succeeding query narrowed down the search results. This finding supported previous studies (Ford & Chen, 2001; Pask, 1976), which reported that holists (i.e., wholists) tended to adopt a top-down approach to learning, while serialists (i.e., analytics) tended to adopt a bottom-up approach.

On the other hand, analytics and imagers, in general, tended to utilise a bottom-up approach while searching information on the Web. In Figure 5-2, the blue arrow illustrates the paths followed by analytics and imagers. They tended to use a longer query in the beginning and then gradually reduced the search terms in order to retrieve relevant information from the Web.

In general, the study finding suggests users’ cognitive styles influence their information searching strategies. The manner in which users displayed in information searching varied among users of certain cognitive styles. This finding
has some implications for future search engine developments and system usability research in the provision of assistance with users’ search strategies.

![Diagram of Associations between User Cognitive Styles and Search Strategies]

Figure 5-2: Associations between User Cognitive Styles and Search Strategies

5.2.2.2. **Effects of Cognitive Style on Query Reformulation Behaviour**

Query reformulation behaviour was one of the important aspects of Web search behaviour considered in this study. Based on the commonality and difference in search terms used in two successive queries, participants’ query reformulations were categorised into five types: *New, Add, Replace, Remove* and *Repeat*. The effects of users’ cognitive styles on their query reformulations were then investigated statistically.

Wholists were found to utilise *New* and *Repeat* queries: they seemed to lack query reformulation skills because new and repeated queries may not have retrieved more relevant information than would have occurred if they had used other queries, such as *Add, Remove* and *Replace*. On the other hand, analytics tended to prefer *Add, Remove* and *Replace*: they modified the existing queries by adding, removing or replacing some search terms.

On the VI dimension of cognitive styles, verbalisers were found to utilise *Add, Remove* and *Replace* queries more than their imager peers. *Add, Remove* and *Replace* queries demand higher levels of keyword searching than *New or Repeat*. And
verbalisers tended to use *Add, Remove* and *Replace* query reformulations as they think in terms of words and consider the information they read, see or listen in terms of words (Riding & Cheema, 1991). On the other hand, imagers preferred *New* and *Repeat* queries. Imagers think in terms of “mental pictures” (Riding, 1997). Therefore, they seemed to search with the same query (*Repeat*) on different search engines, such as Google Web, Google images and Google videos.

To find whether the participants with different cognitive styles differed in their query reformulations, a series of one-way ANOVA tests was conducted. The results indicated that wholists and analytics differed in *Remove* reformulations.

Factor analyses revealed that for a particular cognitive style group, the participants’ query reformulation behaviours were partially influenced by two main factors. A particular factor (say Factor 1) influences some query reformulation behaviour more than another factor (say Factor 2). Figure 5-3 is an example of how one type of cognitive style with two factors influenced query reformulations. In this case (Figure 5-3), there were two factors for wholists. While factor 1 influenced all five types of query reformulations, it influenced *Add* and *Replace* query reformulations more than *New, Remove* and *Repeat*. On the other hand, factor 2 influenced only *New* and *Add* query reformulations. Factor 1 accounted for 43.99 % of the total variations in query reformulation, while factor 2 accounted for 32%. Factor analysis indicated that patterns of relationships exist within query reformulation types for particular cognitive styles.

![Diagram of Cognitive Style and Factors](image)

**Note**: Principal Component extraction with Eigenvalues greater than 1 and the factor loadings less than 0.1 being omitted.

**Figure 5-3**: Examples of Factors affecting query reformulations
5.2.2.3. Effects of Cognitive Style on Web Navigational Styles

The effects of participants’ cognitive styles on their Web navigational behaviour were determined by analyses of *qualitative* and *quantitative* measures. The participants were categorised as having either *sporadic* or *structured* navigations.

On the WA dimensions of cognitive styles, both wholists and analytics in general tended to prefer structured navigations. However, analytics tended to visit more Web pages and clicked more navigation buttons (back button, next button, forward button, home button) than their wholist peers. One of the reasons for analytics using links and buttons more frequently seemed to be that they feel comfortable when “jumping from one point to another” (Chen & Macredie, 2002).

On the VI dimension of cognitive style, verbalisers in general preferred *sporadic* navigations: 54% of them navigated in a sporadic manner. They tended to open many links and pages, and used ‘back’ and ‘homepage’ buttons more frequently. They were also found to be impatient with their searches as they frequently scanned the result pages, which seemed to make them confused. They reported disappointment and frustration with their search results.

On the other hand, imagers followed *structured* navigational styles while searching information on the Web: 69% of them adopted a structured navigation, in which they visited relatively fewer links but to read them in detail. They seemed to be more organized with their Web searching than their verbaliser peers were.

The variation in Web navigation behaviour among the information searchers with different cognitive styles has some implications. Website designers and developers can use the findings from this study to provide effective Web page design and navigation menu systems for users.

5.2.2.4. Effects of Cognitive Style on Information Processing Approaches

This study has demonstrated that Web searchers employ different approaches in order to process and access information. Based on the qualitative analyses of Web search session logs and think-aloud protocols, this study broadly identified three categories of information processing approaches: *scanning*, *reading* and *mixed*. 
Chapter 5: Discussion and Implications

Figure 5-4 summarises the overview of the participants’ information processing approaches. In the figure, the blue arrow illustrates the path followed by verbalisers and analytics; the red, the path followed by wholists and imagers.

On the WA dimension of cognitive styles, a majority of the wholists preferred reading: 43% of them preferred reading, 22% adopted scanning, and 35% of them employed both reading and scanning. On the other hand, 37% of the analytics preferred scanning, while 33% of them preferred reading. In general, analytics seemed to prefer scanning. Similar results were found in a previous work; Wood, et al. (1996) reported analytics accessing more screens, spending less time per screen and using a greater number of new terms.

On the VI dimension of cognitive styles, verbalisers in general preferred scanning (46%) than reading (25%). They scanned through the search result descriptions and result pages to find relevant information. On the contrary, imagers seemed to prefer reading: 50% of the imagers adopted reading while only 15% of them were found adopting scanning as their means to process information. It is believed that imagers, who think in terms of “mental pictures” (Riding, 1997), preferred reading because they required more information in order to construct the “mental pictures” to make sense of the information retrieved. This may be compared to building a model; the developer needs to know the attributes and the elements that constitute it.
5.2.3. RQ3: Modelling the Interrelationships between Users’ Cognitive Styles and their Web Search Behaviour

The main goal of this study was to enhance Web search models with a greater understanding of how users’ cognitive styles affect their Web search behaviour. The previous sections demonstrated users’ Web search behaviour (RQ1), and the effects of users’ cognitive styles on their Web searching (RQ2), and they revealed that there is a close relationship between users’ cognitive styles and their Web search.

With close associations between the users’ cognitive styles and their Web search experience, the next research question (RQ3) this study addressed was how the interrelationships between users’ cognitive styles and their Web search behaviour could be effectively modelled. Two models of Web searching and user characteristics were developed based on the empirical findings of the study. Figure 5-5 illustrates a multi-stage model of user–search interaction, while Figure 5-6 shows a model of associations between users’ cognitive styles and their Web search behaviour. Both are discussed in the following sections.

5.2.3.1. Multi-stage Model of User-Search Interaction

A multi-stage model of user-search interaction was developed from the empirical results of the study. The model (see Figure 5-5) not only presents the overall relationships between different components of Web search behaviour and user characteristics, such as cognitive styles, but also includes three stages of Web search. Stages imply progression and include identifying information need, information searching, and retrieving information. Therefore, the model indicates that the whole process between the user and the Web system takes place through three stages:

- **Pre-processing Stage**: Identifying information need;
- **User–Interaction Stage**: Searching for needed information; and
- **Information Retrieval Stage**: Retrieving needed information.
Chapter 5: Discussion and Implications

User Characteristics play a vital role during Web searching. This study has demonstrated that users’ information need, information searching, and information retrieving behaviours are affected by their characteristics, such as gender, age, prior search experience and cognitive styles. Therefore, user characteristics apply to all three stages.

Each of the contextual factors played an important role during Web searching. Section 4.2 provided results on demographic information about the participants and general observations. The most important user characteristic that influenced user Web search behaviour was that of the user’s cognitive styles. A model of
associations between users’ cognitive styles and their Web search behaviour was developed (presented separately in Figure 5-6).

The following sections discuss the three stages of the multi-stage model of user–search interaction.

5.2.3.1.1. **Pre-processing Stage**

In the pre-processing stage, the user identifies their information need. A Web user performs information searching with the intention to access relevant information to satisfy their information need. Users’ interactions with the Web are greatly influenced by their information needs.

*Information Need* of a user may arise because of two reasons: one may be generated by their task-oriented objective, and another by their short-term personal user goals as a result of encounters with a new situation or searching, not necessarily related to their search topic. For an example, while the *task-oriented objective* for Participant ID 39 for the factual task was to find relevant information on laws passed by the Texas State government regarding child safety while travelling in vehicles, the *personal user goal* was to find how to search information on a specific website. This was indicated while performing the factual task:

*As this search task is a big task, I am going to find out how I am going to do that (search the task). ..The thing I am interested is how to search information on a specific site.* Participant ID 39.

The early research studies and traditional IR models were more focused on IR system needs and text representation during information retrieval, rather than studying user information needs (Robins, 2000; Zhang, et al., 2009b). Information need is an important research area because it identifies a gap in the knowledge available to a user and leads to information seeking and formulation of requests for information (Ingwersen & Järvelin, 2005, p. 20).

For the study participants, the information need to retrieve relevant information was the primary driver for all Web searching activities. The main information needs for the participants were to find relevant information for the three search tasks (task-oriented). Understanding and modelling user information need may provide avenues
to translate this understanding into a practical design for information systems and information retrieval.

5.2.3.1.2. **User–Search Interaction Stage**

The next stage of the model is that of the physical interactions between the information user and the search engines. The cognitive ability and strategy, prior knowledge of the topic, and perceptions of search task difficulty are executed through repetitive mental and physical activities during the user–search engine interactions. A series of Web search actions takes place in this level: information searching, query reformulations, Web navigations and information processing.

With their information need, and their specific user characteristics, cognitive styles and background knowledge, the users formulate queries, execute searches, navigate and examine query results. The searchers use query results to make regular judgements regarding the system and the relevance of the content to meet their information needs. The Web searching process may occur more than once and the query reformulation and system feedback may loop in a cycle. The interactions may occur in any order, as indicated by the double-headed arrows in Figure 5-5.

5.2.3.1.3. **Information Retrieval Stage**

Users search the Web to retrieve information in order to accomplish their search tasks and meet their information needs. As a user performs a Web search, both the information sought and the user’s choice regarding the relevance of the result evolve and change (Bates, 1989). The user gathers information in bits and pieces at each loop and the result of each action provokes a cognitive response that can initiate a new search query, reformulate the previous query, and cause a complete restart or even abandonment of the search.

In principle, for a specific task, the instant search interaction results can be either a failure or a perceived success. If the user is unable to retrieve the information needed, he or she may initiate a complete searching process again, terminate the search process or even revisit the information need and the search tasks. In other words, three stages are interconnected to each other as illustrated by an arrow in the model. For example after completing task 3, Participant ID 32 started working on task 2, which she had already completed.
5.2.3.1.4. **Summary of the Multi-stage Model**

The multi-stage and integrated model of Web search interactions (see Figure 5-5) provides valuable insights into user-Web interactions.

This model addresses the gap in the existing user models of Web-based information behaviour, discussed in Chapter 2. Saracevic’s (1997) stratified model of Interactive IR (Figure 2-6) includes three levels of interaction: surface, cognitive and situational. The model indicated that each component within the three levels of interaction, such as users’ physical interaction with a system, does change during the IR process. However, how these changes occur was not discussed. The multi-stage model developed in this study (Figure 5-5) addresses this gap by including three stages of Web search: pre-processing, user-search interaction and information retrieval stages. Each component of interaction takes place at a particular stage. For example, query reformulation takes place in the user–search interaction stage.

The researcher contends that the model presented here is better than the user models presented in Chapter 2 of this thesis, mainly through two broad aspects of user-Web interactions:

i. The model includes three stages of user-Web search interactions – pre-processing stage, user–search interaction stage and information retrieval stage.

ii. The model presents the overall associations between different components of user–Web search interactions. Each of these components has a vital role to play during user–Web search interactions.

A model extending this Figure 5-5 model is shown in Figure 5-6. This new model, which demonstrates the inter-relationships between users’ cognitive styles and their Web search behaviour, is discussed in the following section.

5.2.3.2. **A Model of Associations between Cognitive Styles and Web Search Behaviour**

As noted, the study findings revealed associations between users’ cognitive styles and their Web search behaviour. A model of associations between cognitive styles and Web search behaviour was developed from the empirical study findings.
Figure 5-6 illustrates a 3-dimensional cuboid model depicting possible associations between users’ cognitive styles and their Web search behaviour, examined through information searching strategies, query reformulations, Web navigations and information processing behaviour. The model was developed from Figure 5-5, study’s results from the analyses of qualitative and quantitative data gathered through the CSA test and Web search session logs, questionnaires and think-aloud. The model presents the overall themes that emerged from the study as discussed in the previous sections.
This new model consists of two major components: users’ cognitive styles and Web search behaviour. These are based on the key findings discussed in the previous sections of this chapter and in Chapter 4.

### 5.2.3.2.1. Users’ Cognitive Styles

Users’ cognitive style was found to affect their Web search behaviour. Users with a certain cognitive style group followed a particular Web search behaviour, while other types of cognitive styles displayed different search behaviour. Figure 5-6 illustrates the inter-relationship between users’ cognitive styles and their Web searching.

In the model, the four coloured pillars represent users’ cognitive styles as assessed by using Riding’s (1991) CSA test. Users’ scoring below 1.20 on the WA scale were classified as *Wholist* and those scoring 1.20 or above as *Analytic*. Users scoring below 1.03 on the VI scale were classified as *Verbaliser* and those scoring 1.03 or above as *Imager*. These two dimensions of cognitive styles are independent of each other.

The red pillar represents *Analytics*; the blue line, represents *Wholists* on the WA dimensions of cognitive style. The brown pillar represents *Verbalisers*; the orange, represents *Imagers* on the VI dimensions of cognitive styles.

While the first component of the model shows both how users’ cognitive styles are measured and derived, and their position within the model, the actual influence of users’ cognitive styles is illustrated in the second part of the model. This second part illustrates users’ Web search behaviours, which are discussed in the next section.

### 5.2.3.2.2. Web Search Behaviour

Users perform information searches to retrieve relevant information, driven by their personal and task oriented information needs. During user–Web search interactions, users utilise different searching skills, queries, navigation styles and information processing approaches in order to find relevant information. Users’ Web search behaviours are displayed through information searching strategies, query reformulation behaviour, Web navigational styles and information processing approaches. These components form layers in the model. Each component of the model is further grouped into different sub-categories: for example, users’ queries
are categorised into five types. As a result, the model represents a larger and holistic view of users’ Web search behaviours. This aspect of the model makes it different from the user models presented in Chapter 2 (e.g., Ford, 2004; Ford, et al., 2009; Knight & Spink, 2008).

As illustrated in the model, users’ Web search behaviours are significantly influenced by their cognitive styles. Users with a particular cognitive style group tend to display or follow certain Web search patterns. For example, verbalisers tend to follow a sporadic navigational style while imagers show structured navigational behaviour. Similarly, verbalisers and analytics process information by scanning, while wholists and imagers preferred reading.

5.2.3.2.3. **Summary of the Model of Associations between Cognitive Styles and Web Search Behaviour**

The findings of this study in general, and the model in particular, extend previous studies (e.g., Ford, 2004; Knight & Spink, 2008; Wilson, 1981), and particularly Ford, et al. (2009), by empirically investigating the relationships between users’ Web search behaviour and their cognitive styles.

As noted earlier, Ford, et al. (2009) proposed a model of relationships between individual differences, search characteristics, search strategies and experience of search difficulty and success (Figure 2-14). The model had two limitations: (1) the model did not indicate clearly how different components of the model, such as cognitive styles and search strategies, are linked; and (2) the model included only a small portion of Web search behaviour, such as word-oriented and phrase-oriented query transformations and browsing. The model failed to include high-level components of Web search behaviour, such as query reformulation and navigational styles. The model developed in this research, illustrated in Figure 5-6, addressed these two limitations of the Ford, et al. model (2009) by including high-level components of Web searching, such as query reformulation behaviour, and by establishing strong inter-relationships between users’ cognitive styles and their Web search behaviour.

In Knight and Spink’s (2008) model (Figure 2-10), users’ cognitive style was shown to have effects on the judgement that the user makes during information seeking and
information searching. However, how searchers’ cognitive styles influence their information seeking and their searching behaviour was neither explained clearly nor based on empirical findings. The new model, illustrated in Figure 5-6, addresses this gap by illustrating the inter-relationship between users’ cognitive styles and their web search behaviour, based on empirical findings through analyses of rich qualitative and quantitative data.

Ford’s (2004) model of learning-related information behaviour indicated that learning takes place through various information processing approaches and strategies that are harmonised with the learners’ cognitive styles, such as holist or serialist, divergent or convergent, and verbal or imager. However, it is not clearly illustrated in that model how such cognitive styles influenced users’ learning and information behaviour. Although the model presented in Figure 5-6 is not specifically for learning, it establishes a strong relationship between users’ cognitive styles and their Web search behaviour through rigours analyses of qualitative and quantitative data collected from 50 study participants.

To our knowledge, this study, and particularly the model illustrated in Figure 5-6, are the first of their kind. Users’ Web search behaviours were explored through information search strategies, query reformulation behaviour, Web navigational behaviour and information processing approaches. The results from the analyses of users’ Web search behaviour and their characteristics, particularly their cognitive styles, provided valuable information and knowledge on how users with different cognitive styles searched information on the Web.

The model illustrated in Figure 5-6 provides valuable insights into the relationship between users’ Web search behaviour and their cognitive styles. This model has several implications, both for existing theories and for practice, such as suggesting some elements of dependencies within the Web searching, which may help to provide clues for enhanced user-interface development and user study research.

The implications of the study’s finding and the models built in this study are discussed in the following section.
Chapter 5: Discussion and Implications

5.3. Implications of the Study

The study has demonstrated the inter-relationships between users’ Web search behaviour and their contextual factors, particularly their cognitive styles.

This study provides a framework for researchers, information system designers, academics, educators and trainers, and librarians who want to better understand how users perform information searching, in order to help and support their retrieval of required information. The study’s key findings have implications for extending existing information behaviour theories.

5.3.1. Implications for Existing Information Behaviour Theory

The study extends information behaviour theory through extensive exploration of the various aspects of Web searching, through examination of users’ information searching strategies, query reformulations, web navigations and information processing approaches. Several data collection instruments were utilised to capture maximum possible data, and several data analysis techniques were utilised to make sense of the data and subsequently report the findings of the study.

The key findings of the study led to the development of two models, a multi-stage model of user-search interaction (Figure 5-5) and the model of associations between users cognitive styles and their Web search behaviour (Figure 5-6). The theory and models developed in this study can be used as a theoretical framework for future work that appears to extend information behaviour theory.

5.3.2. Implications for Practice

The study results revealed several significant practical implications for research, academics, educators and librarians, and information systems developers; these implications are discussed in the following sections.

5.3.2.1. Implications for Researchers

Understanding the cognitive aspects of information searching to improve user interface, and the performance of the information system, are important directions for research and development (Belkin, 2008). As reviewed and discussed in Chapter 2,
several studies have explored IB and Web search behaviour, and several models were proposed to understand human–computer interactions (HCI) (examples: Belkin, 1996; Ellis, 1989; Ellis, 1993; Ford, 2004; Ingwersen, 1996; Knight & Spink, 2008; Kuhlthau, 1991; Saracevic, 1997; Spink, 1997; Wilson, 1997). However, few examples of empirical research exist that show inter-relationships between user characteristics, such as cognitive styles, and their Web search behaviour.

This study contributes to IB research by investigating user–Web search interactions through analysis of users’ information searching strategies, query reformulation behaviour, Web navigational styles and information processing approaches. The empirical findings revealed significant associations between these aspects of Web search behaviours and the users’ cognitive styles. Users’ Web search interactions were greatly influenced by their cognitive styles, driven by information needs, user goals and search task types. To our knowledge, this study and the models developed are the first of their kind. It is believed that the theory and the models developed in this study may provide important insights for future related research.

This study also makes a significant contribution to the research design of user studies, by using a mixed method approach involving both qualitative and quantitative techniques. A series of data collection instruments and data analysis techniques were developed and utilised to assure what Ingwersen and Jarvelin called “statistical validation of results” (2005, p. 247). Combining both qualitative and quantitative research methods in a single study can expand its scope and provide insights into different levels or units of analysis (Tashakkori & Teddlie, 1998).

A model of study process was designed for the study (see Figure 3-4). The study process as illustrated in Figure 3-4 includes three phases: planning, data collection and data analysis. Future studies can utilize and adopt the models and framework developed in this study to conduct similar research.

5.3.2.2. Implications for Educators

Searching on the Web through search engines has become a popular way for students, academics, and educators to acquire information and learning (Gerjets,
Kammerer, & Werner, 2011). Users main perform information searching to find a solution to their problem or to acquire new knowledge.

This study sheds insights on how learners and information seekers perform information searching. Academics, educators, and trainers can utilise the findings to better understand how their clients, such as students, perform their daily information searching. Such people would be able to understand the influence of user characteristics, particularly cognitive styles, on the users’ information searching experience and would be in a better position to support students’ learning about effective information retrieval. Information managers and librarians can also utilise the study’s findings to guide and support clients’ online information searching.

5.3.2.3. Implications for Information System Designers

Understanding the cognitive aspects of information searching can assist systems designers to improve user interface efficiency and the effectiveness of the information systems’ performance. One of the goals for developing Web search models is to help Web search engine and information system designers to provide adaptive support to their users.

This study investigated how 50 users, comprising academics, students, and professionals, perform their Web searches, formulate queries, navigate, and access information on the Web. Search terms and queries transform a user’s information need into machine language that is understandable by an information system. Users’ query reformulation behaviour and how they perform queries are the essential core of user–Web search interactions. Therefore, understanding how a user with a particular cognitive style performs query reformulations can help IS designers provide assistance to the user in finding the information.

Once the information system has retrieved search results for the user, the search summary results are scanned and evaluated with regard to the users’ information need and search goal. The probability of locating the relevant information from the retrieved search results depends on how the user navigates thereafter. Some users utilise sporadic navigations, while others resort to structured navigations; the ways they navigate differ from each other. Thus, understanding how users with a particular
cognitive style navigate on the Web can help navigation systems designers to provide an adaptive navigation interface that can facilitate efficient retrieval of the relevant search results.

5.4. Chapter Summary

This chapter presented key findings of the study through discussions of the three research questions and the implications of the study. Section 5.2.1 (RQ1) has demonstrated that participants performed Web search using different strategies and approaches. Participants also differ in the manner they search information on the Web. Some participants searched in a top-down order, while others followed a bottom-up approach. While formulating queries to retrieve information from the search engine, participants utilized five types of queries: New, Add, Replace, Remove, and Repeat.

Section 5.2.2 (RQ2) summarised the influence of participants’ cognitive styles on their Web search behaviour, one of the main aims of the study. Wholists adopted a top-down approach to information searching, preferred structured navigations. They utilised New and Repeat queries more than Add, Remove or Replace queries, which indicated that they lack query reformulation skills. On the other hand, analytics tended to prefer bottom-up information searching strategy and navigated in a structured manner; they clicked more navigational buttons (back button, next button, forward button, home button) than their wholist peers. Verbalisers adopted a top-down approach to information searching. They tended to utilize Add, Remove, and Replace queries more than imagers. Verbalisers navigated in a sporadic manner and tended to prefer scanning. In contrast, imagers tended to prefer bottom-up information searching. They formulated higher numbers of New and Repeat queries during Web searching. Unlike verbalisers, imagers navigated in a structured manner.

In Section 5.2.3 (RQ3), based on the key findings of the study, two models were developed and proposed, a multi-stage model of user–search interaction (Figure 5-5) and a model of associations between Web search behaviour and users’ cognitive styles (Figure 5-6). The models provide valuable insights into the relationship between users’ characteristics, particularly cognitive styles and their Web search behaviour.
Chapter 5: Discussion and Implications

This chapter also highlighted the implications of the study for future development. Researchers, information system designers and developers, and academics, educators and trainers may utilise the findings from this study to provide effective support to users. The significant contributions and limitations of the study, as well as potential future work, are discussed in Chapter 6.
Chapter 6:  Conclusion and Future Works

Happiness does not come from doing easy work but from the afterglow of satisfaction that comes after the achievement of a difficult task that demanded our best.

T. I. Rubin 9

6.1.  Overview of the Study

This study examined the inter-relationships between user characteristics, particularly cognitive styles, and Web search behaviour. Current studies, key theoretical models and theories in the field of information behaviour, Web searching and user cognitive styles were reviewed in Chapter 2. These previous studies provided foundation, motivation and directions for the study.

Chapter 3 described research methodology for the study. A Web search experiment was set up for the study and the entire user–Web search interactions for each participant were logged by using a monitoring program. Besides content analyses of questionnaires and the CSA test, over twenty-six (26) hours of video recording of the user–Web search interactions were captured and analysed. This study utilised a mixed method research approach. The qualitative data gathered through Web search session logs and think-aloud were analysed using content analysis. The quantitative data collected through questionnaires and Web search session logs were analysed using statistical methods.

The findings from the study were presented in Chapter 4 and key findings further discussed in Chapter 5, including the implications of the study. The study findings provide valuable insights into users’ Web search behaviour from the point of view of users’ cognitive aspects. Based on the study’s key findings, two models depicting associations between various aspects of Web search behaviour and user characteristics, particularly cognitive styles, were developed.

9 Theodore Isaac Rubin (born 1923), American writer and psychiatrist
Chapter 6: Conclusion and Future Works

This chapter provides a summary of the research findings, key significance and contributions of the study. The chapter also discusses the limitations and challenges faced in the study, and presents ideas and directions for future developments.

6.2. Summary of the Study Findings

The study of information behaviour is becoming increasingly of interest including Web search behaviour. The investigation of users’ cognitive styles and their Web search behaviour has helped to better understand how users perform Web search interactions. This study investigated various aspects of Web searching and the influence of users’ cognitive styles on their Web search behaviour. Participants’ Web search behaviours were explored through information searching strategies, Web navigational styles, query reformulation behaviour and information processing approaches. Participants’ cognitive styles were assessed by using Riding’s (1991) CSA test.

The study results provide valuable insights into Web search interactions of different cognitive style users. During Web searching, the users demonstrated various techniques of information searching, Web navigations, query reformulations and information processing; the manner in which they utilised these techniques varied among users of different cognitive style groups.

Participants’ cognitive styles influenced the manner they searched for information on the Web. Based on the implicit observations during the Web searching experiment, three types of information searching strategies were identified: top-down, bottom-up, and mixed. Wholists and verbalisers followed a top-down search approach while searching information on the Web. They searched for general information and then gradually searched for specific information. On the other hand, analytics and imagers preferred a bottom-up approach while performing Web searches, searching for specific information by using a relatively higher number of search terms in their succeeding query, compared to their previous preceding query.

The participants’ cognitive styles influenced their query reformulation behaviour. A series of statistical analysis tests was performed on the data set to establish the relationships between participants’ query reformulation behaviour and their cognitive
styles, and between query reformulation types and search task types. Statistical analysis tests showed that the participants who added more search terms (Add) also tended to remove (Remove) and replace (Replace) some search terms in their queries. While most of the participants (i.e., wholists, verbalisers and imagers) preferred New to any other forms of query reformulations, analytics preferred Add.

A significant difference was found among wholists and analytics in the manner they executed Remove query reformulations. Verbalisers executed a higher number of Add, Remove, and Replace query reformulations than their imagery peers. They tended to use language better than imagers used it. On the contrary, imagery participants seemed to lack linguistic expression to modify their queries and use of search terms. It may be due to this reason that they submitted a higher number of New and Repeat queries to complete three search tasks.

In order to find any difference in participants’ query reformulation behaviour across three search task types (exploratory, factual and abstract), a one-way multivariate ANOVA (MANOVA) was performed. The test indicated that significant difference in query reformulation behaviour exists across search task types. In particular, the search task types influenced the way the participants reformulated New and Repeat queries. During Web navigation, two types of navigational styles were identified, sporadic and structured. While most of the users, that is, the wholists, analytics and imagers, tended to follow a structured navigation approach, the verbalisers seemed to move in a sporadic manner while navigating on the Web. Verbalisers were found to be impatient with their search as they frequently scanned the result pages, which seemed to make them confused.

With regard to the information processing approach, wholists in general seemed to prefer reading, while analytics tended to process information through scanning. Verbalisers in general preferred scanning. They scanned through the search result descriptions and result pages to see if these contained the relevant information or not. On the other hand, the majority of imagers preferred to view or access information through reading. They were found reading result pages in detail, spending enough time to understand the content of the pages.
Chapter 6: Conclusion and Future Works

Two models depicting the associations between Web search interactions, user characteristics and users’ cognitive styles, were developed based on the empirical results that emerged from the analyses of qualitative and quantitative data. These models provide insights for information science researchers, information system designers, academics, educators, trainers, and librarians who want to better understand how users perform information searching on the Web so that they can continue to help these users.

In general, three key study findings emerged:

- While performing Web searches, users’ Web search behaviours were demonstrated through information searching strategies, Web navigation styles, query reformulation behaviour and information processing approaches. The manner in which these Web search patterns were demonstrated varied among the users.
- Users’ cognitive styles influenced their information searching strategies, query reformulation behaviour, Web navigational styles and information processing approaches. Wholists and verbalisers adopted a top-down approach to information searching, while analytics and imagers preferred a bottom-up approach. Analytics and verbalisers in general preferred to process information by scanning. On the contrary, wholists and imagers preferred reading in order to access and process information on the Web.
- Fundamental relationships were evident between users’ cognitive styles and their Web search behaviours, and these relationships can be illustrated through modelling Web search behaviour. Two models that depict the associations between Web search interactions, user characteristics and users’ cognitive styles were developed.

6.3. Significance and Contributions of the Study

This study has extended our understanding of information behaviour and how users search information on the Web. It has provided valuable insights from the empirical analyses of user–Web search interactions and factors that affect the interactions. As discussed in the preceding sections, this study offers implications and significance.
The major outcomes of this study are 1) a comprehensive analysis of how users search the Web, 2) extensive discussion on the implications of the models developed in this study for future works, and 3) a theoretical framework to bridge high-level search models and cognitive models.

- **Comprehensive analysis of user–Web search interactions**

This study provides a comprehensive discussion and analysis of user–Web search interactions. A detailed report on how users with different cognitive styles search information on the Web has been presented. Increased understanding of users’ Web search behaviour will have implications for development of Web search models and design of IS technologies.

- **Models of Web search behaviour and user characteristics (cognitive styles)**

This research provides valuable insights on how users with different cognitive styles search information on the Web. Examination of Web search behaviour from a point of greater understanding of users’ cognitive styles extends the current studies and models to include cognitive styles in modelling Web search behaviour.

Based on the key findings of the study, two models that depict the relationships between different aspects of Web search behaviour and user characteristics were developed. The multi-stage model of user–search interaction (Figure 5-5) demonstrated the associations between information need, user characteristics, various aspects of physical Web search space and information retrieval. The second model (Figure 5-6), an extension of the general user–Web search interactions (Figure 5-5), illustrated the inter-relationships between users’ cognitive styles and their Web search behaviours, as examined through their information searching strategies, query reformulations, Web navigational styles, and information processing approaches.

- **A theoretical framework to bridge high-level search models and cognitive models**

This study provides a theoretical framework to bridge high-level search models and cognitive models. The outcome of this study benefits search engine designers and developers, towards developing user-oriented search engines that provide adaptive search interface to the users. This study also makes significant practical contributions.
for academics, educators, trainers, librarians and information managers who want to better understand how their clients (e.g., students) search information on the Web. They will benefit from understanding the influence of user characteristics, particularly cognitive styles, on the users' information searching experience.

In addition to the practical and theoretical contributions of the study, it also makes a significant contribution in the research design of a user study. This study utilised a mixed method research design, involving both qualitative and quantitative research design. Several data collection instruments and data analysis techniques were utilised to inform the empirical results of the study. Future user study researchers can utilise the methodology implemented in this study to conduct similar studies.

6.4. Limitations of the Study

The study results provided significant results on Web searching behaviour among Web searchers with different cognitive styles with several theoretical implications. However, there were some shortcomings in the overall conduct of the study. These issues are briefly outlined below.

- Cognitive Styles Analysis (CSA) test – Its reliability: Participants’ cognitive style was assessed by Riding’s (1991) CSA test. Based on the CSA ratios, participants were identified as wholists and analytics on the WA dimension, and verbalisers and imagers on the VI dimensions of cognitive styles. Despite its popular use in research, a few studies have questioned CSA’s reliability and validity (Parkinson, et al., 2004; Peterson, Deary, & Austin, 2007).

- Pre-designed search tasks – Researcher-centred: Participants were assigned three pre-designed search tasks. Although the assigned search tasks were designed as close as possible to real-world situations (Borlund & Ingwersen, 1997), and with a diverse area of topics, the subject motivation was a key issue. Some participants were familiar with certain topics, while others were not. These differences in prior knowledge about the subject might have inferred the study’s findings.

- Information needs and search time – limited. The researcher is concerned about participants’ information needs due to the fact that the search tasks
were pre-designed, as these search tasks might have limited the participant’s information need. Their information need was limited to what was required to perform the assigned search tasks, rather than being given a choice to search their own personal information need. The time limit for performing the search tasks was also limited. Although the participants were never stopped while performing their search tasks, it was recommended that they spend between 10 and 15 minutes on each search task.

• **50 participants from QUT – Representative of general searchers?** 50 participants comprising students, academic and professional staff from QUT participated in this study. Although the participants represented target sample distribution of gender, age, and occupations (i.e., staff or students), the researcher is concerned about whether this could be considered to be representative of general searchers.

• **Sample size for Factor Analysis – Minimum:** Sample size for conducting a factor analysis could have a greater impact on the outcome of the result. Several studies suggested minimums for sample size from 3 to 20 times the number of variables and absolute ranges from 100 to over 1000 (Comrey & Lee, 1992; Mundfrom, Shaw, & Ke, 2005). In this study, a factor analysis was applied to test whether participants’ cognitive styles influenced a group of query reformulation types. The number of variables was 5, equivalent to five types of query reformulations. The number of cases was 150, for 150 search tasks completed by 50 participants (i.e., each participant completed a set of three search tasks). The sample size for factor analysis might have influenced the outcome of the analysis. However, the factor analysis would have a minimal impact on the overall outcome of the study.

### 6.5. Challenges faced in the study

Due to the exploratory nature and vastness of the study area for investigation, there were some challenges faced during the course of the study.

• **A mixed methods research – More complicated:** This study adopted a mixed methods research approach, involving both qualitative and quantitative data analyses. The study utilised several data collection instruments and data
analysis techniques. While the mixed method provided rich data and results on users’ Web search behaviour and their cognitive styles, the research design was complicated, especially for a novice researcher.

- **Web search task – Time consuming:** The study recruited 50 participants for the Web search experiments. Each participant was required to run the CSA test, fill up questionnaires, and then perform Web search experiments, which took between 30 minutes to 60 minutes for each participant. The whole participation took an average of one hour for each participant. A monitoring program captured participants’ think-aloud and search sessions. The recorded desktop screenshots of the Web search experiment in a video format was replayed several times to manually create participant observation transcripts. (See examples of transcripts in Appendix E.) The total duration of the recorded Web search session video for the entire search tasks was approximately 27 hours (1,576 minutes). Therefore, for the researcher the total time spent on web search task was approximately 77 hours for the Web search task (27 hours plus 50 hours for 50 participants), a large amount of work.

### 6.6. Future Work

After consideration of the study findings as well as the limitations of the study, this work offers several directions for future research. These are outlined below.

- The study recruited 50 participants comprising academics and professional staff, and students from the QUT. Future study may involve a larger participant sample size to improve the reliability of the study findings; and may also involve general users rather than just those associated with an education institution.

- In the current study, the participants’ cognitive styles were measured by Riding’s (1991) CSA test. Some authors (Parkinson, et al., 2004; Peterson, et al., 2007) raised some issues with regard to the CSA test’s reliability and validity. Future research may utilise other instruments to assess users’ cognitive styles, such as the *Group Embedded Figure Test* (GEGT), developed by Witkin and his team (1971).
During the searching experiment, participants were assigned three pre-designed search tasks to complete. The participants’ searching experiment and user goals might have been limited due to the nature of the search task. Future research can explore user search behaviour by asking participants to find solutions to their own identified information problems.

During the search task, the study participants were also recommended to spend between 10 and 15 minutes to perform each search task. This might have affected the achievement of task objective goals and their information needs. In future, during such an experiment, the time for performing search tasks can be left up to the participants to complete in their own phase.

Web search behaviour is a large-scale study field. This study is a small part of the bigger domain of that study field. While this study attempted to include all the attributes of Web search behaviours, such as information searching strategies, query reformulation behaviour, Web navigational styles and information processing approaches, there may be still some aspects of Web search behaviours to be explored in future.

6.7. Chapter Summary

This chapter presented a summary of the research findings, and of the significance and contributions of the study. The chapter also outlined some of the limitations and challenges faced during the course of the study. Future work in the related area of studies was also discussed.

The study examined intensively the inter-relationships between users’ cognitive styles and their Web search behaviour. Users’ cognitive style was measured using Riding’s (1991) CSA test. Web search behaviours were explored through users’ information searching strategies, query reformulation behaviour, Web navigational styles and information processing approaches. The study results provided valuable insights into Web search interactions among users with different cognitive styles. The findings of the study extend our understanding of Web search behaviour and of how users’ cognitive styles influence their Web search behaviour.
Appendices

A. User Study Experiment

A.1. Participation Invitation Letter (email)

Dear FAST Staff and Students,

Your participation in the following PhD Research Project is requested. This study is part of a PhD project for Kinley Kinley. The purpose of this research is to investigate relationships between users’ Web searching behaviour and their cognitive style. The research team is looking for students and staff across faculties at QUT who has basic Web searching skills.

It is expected that this research may help you understand yourself better as a Web user and individual. You will be able to understand your Web searching behaviour, cognitive style and recognize your strengths and limitations in the context of Web searching. There are no risks in participation beyond daily Web searching activities and your personal identify will remain anonymous at all times.

As a participant you will be asked to:

• Complete the pre-Web search questionnaire;
• Complete a cognitive styles analysis (CSA) test to determine your cognitive style;
• Complete three Web search tasks;
• Think aloud (i.e. verbalize or speak out) any thoughts and reasons for changing your queries during the search activity; and
• Complete the post-search questionnaire.

To recognize your contribution, should you choose to participate, an honorarium in the form of QUT bookshop gift voucher worth AUD $30 will be given to you upon completion of your participation.

Should you wish to participate, please see the flyer attached and contact Kinley (email: k.kinley@student.qut.edu.au, phone: 0432 693 849) for details of the next steps.
Appendices

A.2. User Participation Information Sheet

Your participation in this project is voluntary. Your decisions to participate will in no form impact your current or future relationship with QUT.

What is the purpose of the research?

The purpose of this research is to investigate relationships between users’ Web searching behaviour and their cognitive style. Users’ cognitive thinking plays a vital role in their behaviour and performance. The study will explore the effects of user’s cognitive styles and other factors (such as demographic information, level of domain knowledge and level of perceptions and satisfaction) on their Web searching behaviour and develop a user-Web interaction model. Modelling users’ Web searching with a greater understanding of their cognitive styles could lead to an enhanced Web search model.

Are you looking for people like me?

The research team is looking for students and staff across QUT who has basic Web searching skills.

What will you ask me to do?

As a participant you need to complete the following events.

<table>
<thead>
<tr>
<th>Event</th>
<th>Details</th>
<th>Estimated Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Web Search Questionnaire</td>
<td>Participant completes a questionnaire including demographic information, Web search experiences, and consent form</td>
<td>5 minutes</td>
</tr>
<tr>
<td>Cognitive Styles Analysis (CSA) test</td>
<td>Participant completes a computer presented test to determine their cognitive style.</td>
<td>8 minutes</td>
</tr>
<tr>
<td>Three Web</td>
<td>Participant conducts a Web searching on</td>
<td>35 minutes at their</td>
</tr>
<tr>
<td>Search Tasks</td>
<td>three assigned search tasks</td>
<td>own phase.</td>
</tr>
<tr>
<td>-----------------------------</td>
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<td>------------</td>
</tr>
<tr>
<td>Think aloud</td>
<td>Participant verbalise orally their thoughts including the reasons for their actions while performing the Web searching. The think aloud data and Web search logs will be recorded using Camtasia program only to help the researcher in the transcripts.</td>
<td>On going.</td>
</tr>
<tr>
<td>Post-Web search questionnaire</td>
<td>Participant completes a post-Web search questionnaire to assess their satisfaction, perceptions, and information relevancy.</td>
<td>4 minutes</td>
</tr>
</tbody>
</table>

Your think-aloud and screen video stream such as URLs visited, and search terms submitted to search engines will be recorded using a desktop monitoring program. The study will be conducted in a quiet environment setting (computer laboratory or meeting room) at QUT.

**Are there any risks for me in taking part?**

The research team does not believe that there are any risks if you choose to participate in this research. It should be noted that if you do agree to participate, you can withdraw from participation at any time during the project without comment or penalty.

**How long the study will take?**

The study is expected to take one hour.

**Will my identity and privacy be protected?**

All comments and responses are anonymous and you will be referred to by a pseudonym to protect your identity and privacy. All data will be stored securely and any details that identify you will be removed from the documents/material you provide.
Appendices

Are there any benefits for me in taking part?

It is expected that this research may help you understand yourself better as a Web user and individual. You will be able to understand your Web searching behaviour, cognitive style and recognise your strengths and limitations in the context of Web searching.

Will I be compensated for my time?

To recognise your contribution, should you choose to participate, an honorarium in the form of QUT bookshop gift voucher worth AUD $30 will be given to you upon completion of your participation.

I am interested – what should I do next?

If you would like to participate in this study, please contact Kinley (email: k.kinley@student.qut.edu.au, phone: 0432 693 849) for details of the next step. You will be provided with further information to ensure that your decision and consent to participate is fully informed.

Thank You!
A.3. Instructions for Participants

PARTICIPANT INFORMATION for QUT RESEARCH PROJECT

Modelling Web Search Behaviour: Understanding Users’ Cognitive Style

<table>
<thead>
<tr>
<th>Research Team Contacts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mr. Kinley Kinley (Project Student)</td>
</tr>
<tr>
<td>0432 693 849</td>
</tr>
<tr>
<td><a href="mailto:k.kinley@student.qut.edu.au">k.kinley@student.qut.edu.au</a></td>
</tr>
</tbody>
</table>

Description

This project is being undertaken as part of PhD for Mr. Kinley Kinley. The purpose of this project is to investigate relationships between users’ Web searching behaviour and their cognitive style. Users’ cognitive thinking plays a vital role in their behaviour and performance. The study will explore the effects of users’ cognitive styles and other factors (such as demographic information, level of domain knowledge, and level of perceptions and satisfaction on their Web searching behaviour) and develop a user-Web interaction model. Modelling user’s Web searching with a greater understanding of their cognitive styles could lead to an enhanced Web search model.

The research team is looking for students and staff across faculties at QUT who has basic Web searching skills. The research team requests your assistance because we believe you, as a Web user, can provide valuable insights into Web searching behaviour.

If you would like to participate in this study, please contact Kinley (email: k.kinley@student.qut.edu.au, phone: 0432 693 849) for details of the next step. You will be provided with further information to ensure that your decision and consent to participate is fully informed. All comments and responses are anonymous and you will be referred to by a pseudonym to protect your identity and privacy. All data will be stored securely and any details that identify you will be removed from the documents/material you provide.

Participation

Your participation in this project is voluntary. If you do agree to participate, you can withdraw from participation at any time during the project without comment or penalty. Your decision to participate will in no way impact upon your current or future relationship with QUT (for example your grades). As a participant you need to complete:

1. A pre-Web search questionnaire to assess your level of domain knowledge, search experience, and demographic variables.
2. A cognitive styles analysis (CSA) test to determine your cognitive style.
3. Three Web search tasks.
4. A post-Web search questionnaire to indicate your satisfaction, perceptions, and information relevancy.

You will be also asked to think-aloud (i.e. verbalise or speak out) your thoughts and reasons while searching on the Web. Your think-aloud and screen video stream such as URLs visited, and search terms submitted to search engines will be recorded using a desktop monitoring program. The study will be conducted in a quiet environment setting (computer laboratory or meeting room) at QUT.

The study is expected to take ONE hour.

**Expected benefits**
It is expected that this research may help you understand yourself better as a Web user and individual. You will be able to understand your Web searching behavior, cognitive style and recognize your strengths and limitations in the context of Web searching. To recognize your contribution, should you choose to participate, an honorarium in the form of QUT bookshop gift voucher worth AUD $30 will be given to you upon completion of your participation.

**Risks**
There are no risks beyond normal day-to-day living associated with your participation in this project.

**Confidentiality**
All comments and responses are anonymous and will be treated confidentially. The names of individual persons are not required in any of the responses. Your interactions with the search engines and think-aloud (audio verbal) will be recorded using a desktop monitoring program. Only the research team will have access to the data. Please note that the audio records will be destroyed after the contents have been transcribed.

**Consent to Participate**
We would like to ask you to sign a written consent form (enclosed) to confirm your agreement to participate.

**Questions / further information about the project**
Please contact the researcher team members named above to have any questions answered or if you require further information about the project.

**Concerns / complaints regarding the conduct of the project**
QUT is committed to researcher integrity and the ethical conduct of research projects. However, if you do have any concerns or complaints about the ethical conduct of the project you may contact the QUT Research Ethics Officer on +61 7 3138 5123 or ethicscontact@qut.edu.au. The Research Ethics Officer is not connected with the research project and can facilitate a resolution to your concern in an impartial manner.
CONSENT FORM for QUT RESEARCH PROJECT

Research Team Contacts

<table>
<thead>
<tr>
<th>Mr. Kinley Kinley (Project Student)</th>
<th>Dr. Dian Tjondronegoro (project supervisor)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0432 693 849</td>
<td>3138 5074</td>
</tr>
<tr>
<td><a href="mailto:k.kinley@student.qut.edu.au">k.kinley@student.qut.edu.au</a></td>
<td><a href="mailto:dian@qut.edu.au">dian@qut.edu.au</a></td>
</tr>
</tbody>
</table>

Towards Modelling Web Search Behaviour: Integrating Users’ Cognitive Styles

Statement of consent
By signing below, you are indicating that you:
• have read and understood the information document regarding this project
• have had any questions answered to your satisfaction
• understand that if you have any additional questions you can contact the research team
• understand that you are free to withdraw at any time, without comment or penalty
• understand that you can contact the Research Ethics Officer on +61 7 3138 5123 or ethicscontact@qut.edu.au if you have concerns about the ethical conduct of the project
• agree to participate in the project

Name

Signature

Date / /
I hereby wish to WITHDRAW my consent to participate in the research project named above.

I understand that this withdrawal WILL NOT jeopardise my relationship with Queensland University of Technology.

Name: ____________________________________________________________

Signature: _________________________________________________________

Date: _____ / _____ / _____
A.4. Pre-Web Search Questionnaire

Part A: Demographic Information

Please indicate your most appropriate response with tick [✓].

1. Your Gender: a) Male [ ] b) Female [ ]

2. Your Age Group:
   a) Under 20 [ ] b) 20-25 [ ] c) 26-30 [ ] d) 31-35 [ ]
   e) 36-45 [ ] f) 46-55 [ ] g) 56+ [ ]

3. Your Title
   a) Mr [ ] b) Mrs [ ] c) Ms [ ] d) Dr [ ] e) Professor [ ]

4. Your School/Disciplines

5. Your Faculty/Division

6. Your area of study /undergraduate Major (If applicable)

7. Are you a student?
   a) No [ ]► Go to Question 8
   b) Yes [ ]►
      Enrolled as: a) Full-Time [ ] b) Part-Time [ ]
      Coursed enrolled: a) Bachelor [ ] b) Graduate Cert/Diploma [ ]
      c) Master by course work [ ] d) Master by research [ ] e) Doctorate [ ]
      f) Post Doctorate [ ] g) Visiting Students [ ] h) Others [ ]

8. Are you a staff?
   a) No [ ]► Go to Question 9 (You should have completed Question 7)
   b) Yes [ ]►
      Employed as: a) Full-Time [ ] b) Part-Time [ ] c) Sessional Staff [ ]
      d) Adjunct [ ] e) Professional [ ] f) Other [ ]
Part B: Web using experience

9. How long do you usually take to search for a piece of university academic information?
   a) Less than 5 minutes  
   b) More than 5 minutes  
   c) Few hours (less than an hour)

10. How long have you been using search engine(s)?
   *Please indicate your previous search experience in number of years. Tick ONLY one box.*
   a) Less than 1 year  
   b) 1-2 years  
   c) 3-5 years  
   d) 6-10 years  
   e) More than 10 years

11. Which Web search engines do you use most frequently for information searching? *Please tick ONLY one box.*
   a) Google  
   b) Yahoo  
   c) Altavista  
   d) Excite  
   e) MSN  
   f) ASK  
   g) Bing  
   h) Others:_________

12. Which Web browser do you use most frequently for information viewing? *Please tick ONLY one box.*
   a) Internet Explorer  
   b) Netscape  
   c) FireFox  
   d) Maxthon  
   e) Chrome  
   f) Safari  
   g) Opera  
   h) Other:_________

13. Do you use any social network(s)?
   a) No  
   b) Yes *Go to Question 14*

14. Please indicate what you think your level of experience with the Web searching (Tick ONLY one box on a scale of 1-5 for each):

<table>
<thead>
<tr>
<th>In using:</th>
<th>Extensive Experience</th>
<th>Partially Experience</th>
<th>No Previous Experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) keywords only</td>
<td></td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>b) AND, +, OR (Boolean operators)</td>
<td>5</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>c) Advanced Features</td>
<td>5</td>
<td>4</td>
<td>3</td>
</tr>
</tbody>
</table>

***End of Pre Web Search Questionnaire***
A.5. Instructions for Thinking Aloud

You are required to verbalize orally your thoughts, motivations, actions, and reasons while conducting a Web search. This will enable the researcher to understand your cognitive thinking. The whole process will be audio recorded and later transcribed by the researcher.

The CSA is a computer presented test to determine individual’s cognitive style on the wholist-analytic and verbal-imagery dimensions styles. Wholist-analytic style dimension determines whether an individual tends to process information in wholes or in parts; the verbal-imager style dimension determines whether an individual tends to process information in words (verbals) or mental pictures (images). The CSA indicates the position of an individual on each of the fundamental style dimensions by means of a ratio. Please note that CSA is not a measure of intelligence or ability.

Instructions

1) Instructions about the test:
   1) Only three keys on the keyboard will be used: “B”, “N” and Enter/Return.
   2) You have to mark the key “B” with the red sticker and key “N” with the blue.
   3) To start the test, double click on the “csa.exe” file located on Desktop. The CSA file will automatically load and run.
   4) Follow the instructions displayed and work at your own pace.

2) At the end of the test, a screen (similar to the figure below) will indicate your cognitive style. Accordingly please record your cognitive style and the ratios below:

   My Cognitive Style is: 

   The WA ratio is: 

   The VI ratio is: 

   If you like to receive feedback about your cognitive style and the way you learn, and think, please provide your contact details (Optional).
Your responses indicate that your cognitive style is

WHOLIST - IMAGER

WV ratio = 0.99
VI ratio = 1.32

When you have finished press any key.
Appendices

A.7. Search Tasks

Instructions and Suggestion

• Please complete the following three search tasks.

• You may use any search engine(s) and search features you wish to.

• Please do what you normally do when searching until you are satisfied with the information retrieved.

• We recommend you spending between 10 and 12 minutes on each task.

• You are requested to save all the searched information (text, images, audios and videos) under the respective task folders in the root folder ‘user x’ on Desktop (see below), where ‘x’ is your unique user ID, or bookmark the links.

Search Tasks

Task 1: You, with your two friends, are planning a trek for one week in Solukhumbu in Nepal. The trekking will occur next month. You are told that tourists trekking in the place may get high-altitude illness. You decide that you should know more about the place, and the symptoms, seriousness and prevention of high-altitude sickness.

Task 2: You have recently moved to Austin, Texas, The U.S., and would like to know the relevant laws passed by the Texas State government regarding child safety while travelling in vehicles. Identify three such rules.

Task 3: You recently heard about the Bermuda Triangle mystery, and you are curious and want to know more about it. So you want to search any relevant information (articles, images and videos) about it and what effect it has on the travellers in the region.
### Part A: Satisfaction

15. Please indicate your satisfaction with Web search. *Tick only one box on a scale of 1-5 for each question.*

<table>
<thead>
<tr>
<th>Perceived satisfaction with search efficiency.</th>
<th>Strongly agree</th>
<th>Agree</th>
<th>Not Sure</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I am satisfied with the response time when using search engine(s) to find needed information.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>2. I am satisfied with the performance of the search engines to find needed information.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>3. I am satisfied with the retrieved information.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>4. I will use the search engine(s) to find information in future.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>5. I will use different search engine(s) to find information in future.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

### Part B: Perceptions

16. Please indicate your level of difficulty for each search task on a scale of 1-5. *Please tick one box for each task.*

<table>
<thead>
<tr>
<th></th>
<th>Most Difficult</th>
<th></th>
<th>Least Difficult</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Task 1</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Task 2</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Task 3</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
</tbody>
</table>
Appendices

17. Please indicate your level of success for each search task on a scale of 1-5.

Please tick one box for each task.

<table>
<thead>
<tr>
<th>Task</th>
<th>Most Success</th>
<th></th>
<th></th>
<th>Least Success</th>
</tr>
</thead>
<tbody>
<tr>
<td>Task 1</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Task 2</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Task 3</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
</tbody>
</table>

Part C: Relevance

18. Please indicate, on a scale of 1-5, how the search contributed to the information you need for each task.

<table>
<thead>
<tr>
<th>Task</th>
<th>Substantial Contribution</th>
<th></th>
<th>No Contribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Task 1</td>
<td>5</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Task 2</td>
<td>5</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Task 3</td>
<td>5</td>
<td>4</td>
<td>3</td>
</tr>
</tbody>
</table>

19. Please indicate, on a scale of 1-5, how much your knowledge on each of the problems you are trying to identify, has improved as the result of the search.

<table>
<thead>
<tr>
<th>Task</th>
<th>Considerable Knowledge</th>
<th></th>
<th>Little Knowledge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Task 1</td>
<td>5</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Task 2</td>
<td>5</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Task 3</td>
<td>5</td>
<td>4</td>
<td>3</td>
</tr>
</tbody>
</table>

***End of Post-Search Questionnaire***

Thank You!
A.9. Checklist (for researcher use)

Checklist

At the end of the Web search, the researcher will make sure that the following items are completed for each study participant.

<table>
<thead>
<tr>
<th>Participation Information</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Consent form</td>
<td></td>
</tr>
<tr>
<td>Pre-Web Search Questionnaire</td>
<td></td>
</tr>
<tr>
<td>Cognitive Styles Analysis Test</td>
<td></td>
</tr>
<tr>
<td>Audio-recorded Thinking aloud</td>
<td></td>
</tr>
<tr>
<td>Search Task</td>
<td></td>
</tr>
<tr>
<td>Post-Web Search Questionnaire</td>
<td></td>
</tr>
<tr>
<td>Honorarium (QUT Bookshop voucher $30)</td>
<td></td>
</tr>
</tbody>
</table>
Appendices

A.10. Participant’s Demographic Data (for researcher use)

Brief information on each study participant will provide a snapshot data about the participants. This will also act as a checklist for the study.

<table>
<thead>
<tr>
<th>User ID</th>
<th>Date</th>
<th>Gender (M/F)</th>
<th>Std Staff</th>
<th>CSA test requested (✓/X)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>User1</td>
<td>M</td>
<td>F</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>User2</td>
<td>M</td>
<td>F</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>User3</td>
<td>M</td>
<td>F</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>User4</td>
<td>M</td>
<td>F</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>User5</td>
<td>M</td>
<td>F</td>
<td></td>
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<tr>
<td>User6</td>
<td>M</td>
<td>F</td>
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<tr>
<td>User7</td>
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<td>M</td>
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<td>User12</td>
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</table>
In this study, a pilot study, with four participants, was carried out to test the research instruments and the reliability of the study. The pilot study, not only ensured the quality of the method chosen, but also helped to make necessary changes to the data collection instruments and analysis techniques. A number of observations were made during the pilot study, which are outlined below.

- The search tasks, provided during the pilot study, have been replaced by three new search tasks, developed based on the concept of “simulated work task situation” or scenario (Borlund & Ingwersen, 1997).

- It was observed during the pilot study that the participants appeared to experience fatigue towards the end of task 3. It was assumed that the reason to be that the three tasks were listed and given to the participants in ascending order of the task complexity. (Task 1 was easier and simpler than task 2 and task 3 was much complex than task 2.) It was therefore, necessary to break such a hierarchical level of task complexity, and for the main study, the exploratory task (task 2) of the second level of task complexity was assigned first, followed by the factual task of the lowest level of task complexity (task 2), and the abstract task.

- During the pilot study, participants were found to be verbalising what they were typing rather than their thoughts and actions. The researcher had to remind them from time to time of their thinking aloud. For the main study instruction on think-aloud were explained clearly; participants were checked for their understanding of the instruction. A label, ‘Think-Aloud’, was displayed below the computer monitor in order to remind the participants of their thinking aloud, without obstructing their search tasks.
## Appendices

### C. Result Data

#### C.1. Consolidated Participant Profile

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**Note:** FAST: Faculty of Science and Technology, BEE: Faculty of Built Environment and Engineering, BUS: Faculty of Business, CS: Creative Industries, SS: Staff and Student, WA: Wholist/Analytic, VI: Verbaliser/Imager, ISS: Information Searching Strategies, IPA: Information Processing Approaches, NA: Not applicable

**Table C-1: Study Participant Profile**
Appendices

C.2. Examples of results retrieved by search queries

Figure C-1: Examples of search results retrieved following a top-down search
### C.3. Descriptive of the Web search Characteristics by age group

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### Table C-2: Descriptive of Web search characteristics (dependent variables) by age group

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</table>

Table C-2: Descriptive of Web search characteristics (dependent variables) by age group
Dear Mr Kinley Kinley

Project Title: Modelling Web search Behaviour: understanding user’s cognitive style
Approval Number: 1000000100
Clearance Until: 17/02/2013
Ethics Category: Human

This email is to advise that your application has been reviewed by the Chair, University Human Research Ethics Committee, and confirmed as meeting the requirements of the National Statement on Ethical Conduct in Human Research.

Whilst the data collection of your project has received ethical clearance, the decision to commence and authority to commence may be dependent on factors beyond the remit of the ethics review process. For example, your research may need ethics clearance from other organisations or permissions from other organisations to access staff. Therefore the proposed data collection should not commence until you have satisfied these requirements.

If you require a formal approval certificate, please respond via reply email and one will be issued. Decisions related to low risk ethical review are subject to ratification at the next available Committee meeting. You will only be contacted again in relation to this matter if the Committee raises any additional questions or concerns.

This project has been awarded ethical clearance until 17/02/2013 and a progress report must be submitted for an active ethical clearance at least once every twelve months. Researchers who fail to submit an appropriate progress report may have their ethical clearance revoked and/or the ethical clearances of other projects suspended. When your project has been completed please advise us by email at your earliest convenience.

For variations, please complete and submit an online variation form:

http://www.research.qut.edu.au/ethics/forms/hum/var/variation.jsp

Please do not hesitate to contact the unit if you have any queries.

Regards

Research Ethics Unit  |  Office of Research
Level 4  |  88 Musk Avenue  |  Kelvin Grove
p: +61 7 3138 5123 e: ethicscontact@qut.edu.au
w: http://www.research.qut.edu.au/ethics/
E. Examples of Participant Observation Transcripts with Open Coding (for Participant ID 1)

Task 1

Search Session Logs

(Google Web) Solukhumbu -> Solukhumbu trek safety -> solukumbu trek high altitude illness -> (Auto-result) Solukumbu trek high altitude illness -> solukum high altitude illness -> solukumbu high altitude illness symptom

Think-aloud

Our first task is trekking to Solukhumbo in Nepal. Let’s go to Google; its my favourite search engine. To be honest I know nothing about this place. My search will start with the name of the place and I type in Solukhumbu. Currently, (there are) lots of things but in order to plan for trek, firstly I need to know my plan which means my visit, my place, and second to see if anybody has stayed there.

It [the page the user was reading] seems there is a story on people who went there. For trek, it is a good starting point. So it is necessary to save the page. Before starting. …(Reads the page).

This seems a complete story on the trek. We got the same pretty much the same time frame. We may have the same safety issue. That is another issue I need to be concerned. The word “safety” is too broad. Lets put ‘high altitude illness”’. There is a tying mistake, “does and don’t” may have a good information for us.

I need to pay more attention. It seems to me that this page belongs to a travel agent. Not a right place to find information. Not something we need.

Trek in Everest, this seems a good place. Very good plan: day 1, day 2, and day3… There is a eight-day plan. We can use this later.
This page is very good I need although this is not about something on safety. It does help. We got “about” information here.

It seems this page provides general information about everything I need. Lets save it. Say any symptoms. Yap, because the symptoms of high altitude may not be necessarily related with Solukhumbu. Actually, although there is no keywords for Solukhumbu occurred in the information there, but it is still what I am interested in.

Even though it does not descript what exactly symptoms are but it gives us general information about say high altitude illness. So, I will still keep it. I need something details. Ok. I think we got it. We got it.

That’s very good. We got the plan and something to help us to plan. We got general information about say high altitude illness, how serious they are, percentage of people who experienced there before and for the symptoms, sickness and also the ways to prevent, suggestions to prevent the high altitude sickness.

**Participant Observation**

The user prefers to use IE and Google as the search engine. The user is glancing through search results. The user is reading through the page. The user saves the page. He believes that it is a good starting point. The user could not find any relevant information on the first result page. The user meant high altitude illness although there is a spelling mistake “altitude”

The user is quick to identify the mistake. It looks to me the user is highly experienced Web user. He was reading a description of a link about “does and don’t” about altitude sickness.

The user reads carefully. He thinks that the page belongs to a travel agent and does not serve any purpose for him. So he closes the page.

He is excited about the page. The earlier search results with five search terms displayed 1,390 results. He thinks the search keywords are too much. So he reduces search terms to four. He uses bottom-up search strategies (from narrow to
**Appendices**

broad by reducing search terms). He reads the page in details. He looks very happy at the information displayed as I could make it from his expression.

The user reads very carefully.

**Task 2**

**Search Session Logs**

(Google Web) Child safety vehicle Austin texas -> (Find Tool) Child

**Think-aloud**

Lets move to task 2, Austin Texas USA. Child safety. Let’s start from the specific keywords. So what I need is child safety vehicle Austin and Texas to make it USA. I got a long list of [results] and those keywords are highlighted.

The first one should the one I need for the law and for the seat belt.

[Reads second results] The second one may also interest me but they may be the same law as the first law one.

Because I believe say even though this law is for Texas not only for Austin, state law will apply to any region under the state. So I believe this law [which] applies to Texas should also apply to Austin as well.

See what I got, Texas department of public safety. I got the laws here. Ok lots of things. I don’t want to read everything. Let’s have a search [on the page]. [Reads some paragraph with the keyword ‘child’]. There is another law.

Ok. I think I got certain information and not all. I have summary of activities. Injury Prevention Program, once again it is too long to read. I don’t want to read. No, this is not the one I want.

New Texas law begins September 1 2009 [reads the page]. Bicycle laws. I think that law is also considered as safety issues.
Ok. I think this also helps. Bike Texas. Come on. Where is the information? Let’s refresh that. Forget this one. This is not (good). Too much information (on this page).

I think it gives us enough information and how laws about child safety, while travelling on a school bus and so on. That finish tasks two and we can now go to task 3.

**Participant Observation**

The participant reads the task 2 descriptions. He reads the first result description. He believes the required information can be mostly found in the first displayed result (link) as confirm by the think-aloud. So he opens the first result page and even did not bother to read the rest of the results descriptions at this time.

Clicks on the opened tab and switch back to the search results page as the opened tab window has not completely loaded. He reads the first paragraph and highlights keywords. This type of action was observed for the first time. He is excited and happy about the information he found. The user uses ‘find’ tool for the first time to find the keyword “child’ in the page.

He read almost all the result descriptions in details and then clicks on the next button on the Google search page. Normally searcher reads only page 1 of the result page unless they find it very difficult to locate the required information. So it was a surprise to see this participant navigating to several next result pages. He saved a link directly to the folder without even opening it. It was not sure why the participant did that. Earlier, the participant said he did not want to read the page, as it was too long. However, he opened the page again and read the page for few minutes. It seemed the participant was lost or confused. The click on the a link led to a result page with lots of links
Appendices

Summary:

- The first thing Participant 1 did with the results from his first query during the factual task search was to quickly scan the search result descriptions, and then he formulated his query without opening or reading the result pages.

Task 3

Search Session Logs

(Google Web) Bermuda triangle -> (Yahoo Web) Bermuda Triangle -> Bermuda triangle mystery -> (Yahoo image) Bermuda triangle mystery -> (Google Video) Bermuda triangle mystery -> (YouTube) Bermuda triangle mystery

Think-aloud

Bermuda triangles….

First let us find information about Bermuda triangle. Wikipedia is a good information knowledge source because the entire abstract on organising information put there. So lets have a check. I am going to search about the images of the location of the Bermuda triangle. Now that we know the location, we can find out it has been there, history.

(Reads headings) For me, the literature information provided by this Wikipedia is sufficient information to me. Do they have any images about this (Bermuda triangle)? I will use Google image to search that [images].

The first one is interesting. Its painted not a… it seems to me there are lots of paintings. I mean not real images, photos about that [Bermuda Triangle]. There are many paintings because people were talking about Bermuda triangle for very long time, 3 decade. Yes, it is a painting. I have not looked at the next page. I wonder if they have real pictures about anything happened there [Bermuda Triangle]. There are many duplicate images here. Now, its not what I want. No nothing there. I will have a look at yahoo. I will have at yahoo. Yahoo image. Typing the key words. Its interesting. It seems Yahoo gives different images compared to Google. But it seems it goes too far, but not many paintings. Let’s try Bermuda triangle mystery.
Ok we got some paintings. Wreckages. Let’s have a look on this one. Paintings drawn on some accidents that happened before. It’s again, what a joke. I think I will give up for the images (Bermuda Triangle images). I don’t think I can find real images because its still mystery. So, I think I have reasons to believe [that] I can find lots of paintings but not the real photos of what happened in the accidents there.

Well, I will have a look at the videos and see any videos about this [Bermuda Triangle]. I believe those videos are also from news, captured from news, something like that.

For video Bermuda Triangle mystery, actually I will go (search) go for Google videos then YouTube. YouTube videos may provide a better resource than Google videos. But I will try with Google videos first. This open should be good. Too bad, it’s not what I want. Many videos talking about disappearing of US Nay flight 19. Let’s save this search result.

The first result page on Bermuda triangle is from youtube.com. I think it is originally from science program. Come on! Come on! This is science program. Ok let’s search you tube directly. Yes, YouTube has lots of information. It seems the information [found] here is better than those found Google because many information are here not only from say, science or national geography programs but also news about some real accidents happening there (Bermuda triangle).

We don’t have time to (watch each of these videos). I completed three tasks.

**Participant Observation**

The use asked the researcher if he is to give images or the location of the Bermuda Triangle.

I like the way he organise the search. He wants to search the location first followed by history. He was found only reading sub-headings.
Appendices

This was the first time that the researcher has seen the participant using “images” search features on Google. It seems the user has a good experience with searching particularly using Google search engines. He confirms the images found by Google image search is a painting and what he said earlier. The participant has visited result page up to page 4 of the Google search result pages, which is amazing. Usually Web users do not visit more than few result pages but they modify their search terms.

For the first time, the user switched to Yahoo search engines. It seems to me that this user likes images more than text. The user did not like the image. He is not very keen on the images found. The user is having difficult to find the relevant video on Bermuda Triangle.

The participant tends to visit many sites, opens many links. He hardly modifies search terms. I am not sure why he saved the search result page. This result page can be retrieved at any time using the search terms. I am not sure why he thinks the video is from science program and which science program.

He waits while the video loads. He saves the video page without much viewing it.

He has high expectation from you tube, no matter what kind of information he is looking for. From his conclusion remarks, I get a feeling that in general he is satisfied with the information retrieved for all three tasks. He admits that task 3 is still mystery and that images are paints rather than real images.

I need to make changes to three tasks if possible so that users are deemed to modify their search terms rather than visiting several pages. The real searching skill of the participant is not yet revealed.
F. Glossary

The key terms used in this thesis are outlined below in their respective broad topic. These are to develop an understanding of the concepts and terminology used.

<table>
<thead>
<tr>
<th>Terms</th>
<th>Description</th>
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<tbody>
<tr>
<td><strong>User–Computer Interactions</strong></td>
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<tr>
<td>Information Behaviour</td>
<td>Information behaviour refers to how people seek, manage and use information and includes “activities concerned with information use, such as, information seeking behaviour and interactive IR” (Ingwersen &amp; Järvelin, 2005, p. 21).</td>
</tr>
<tr>
<td>Information Searching</td>
<td>Information searching behaviour is the action engaged by information users in interacting with information retrieval systems (Wilson, 2000), which could be either at the human computer interaction level, such as typing or at the cognitive intellectual level, which may involve mental acts such as using a Boolean search strategy or judging the relevance of the information.</td>
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<tr>
<td>Information Seeking</td>
<td>Information seeking is defined as “purposive seeking for information” in which an individual interacts with “manual information system” (such as newspaper or library) or with “computer-based systems” (such as the Internet) in order to achieve a goal (Wilson, 2000, p. 1).</td>
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<tr>
<td>Information Retrieval (IR)</td>
<td>Information retrieval (IR) is a process of finding material that satisfies information needs, initiated by presenting queries to the information processing system. IR systems started as processing systems in the 1950’s and 1960’s (Saracevic, 1997).</td>
</tr>
<tr>
<td>Interactive Information Retrieval</td>
<td>Interactive Information retrieval (IR) is viewed as “interactive communication processes” that occur between an end user and IR system during information retrieval in organized knowledge sources, such as the Internet (Ingwersen, 1992, p. 228)</td>
</tr>
</tbody>
</table>
### Appendices

<table>
<thead>
<tr>
<th><strong>Web Search Behaviour</strong></th>
<th>Web search behaviour refers to information seeking and information searching on the Web, which requires users to interact with Web search engines to retrieve the required information.</th>
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<tr>
<td><strong>Search Term</strong></td>
<td>A search term is defined as a series of characters delimited by a white space.</td>
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<tr>
<td><strong>Search Query</strong></td>
<td>A search query is defined as a string of terms submitted to a search engine per search session.</td>
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<tr>
<td><strong>Query Length</strong></td>
<td>Query length is an average number of search terms submitted per search query to search engines.</td>
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<tr>
<td><strong>Query Reformulation</strong></td>
<td>Query reformulation is a process of altering a given query in order to improve search or retrieval performance (Jansen, et al., 2009b).</td>
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<tr>
<td><strong>Information Searching Strategy (ISS)</strong></td>
<td>Information searching strategy refers to users’ behaviour while locating information on the Web, and how they approach information searching. Information searching strategies can be categorized as top-down or bottom-up.</td>
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<tr>
<td><strong>Top-down</strong></td>
<td>A top-down searching refers strategy where users search on a general area and then narrow down their search until they find the information need (Navarro-Prieto, et al., 1999).</td>
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<tr>
<td><strong>Bottom-up</strong></td>
<td>In a bottom-up search strategy, users first searched for specific information and then moved to general search. They also look for specific keywords in the search engine and then scroll down the results until they find the required information.</td>
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<td><strong>Information Processing Approach (IPA)</strong></td>
<td>Information Processing Approach (IPA) refers to strategies adopted by users to view, select and process information during Web searching. IPA can be categorized as scanning or reading.</td>
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<tr>
<td><strong>Scanning</strong></td>
<td>Scanning refers to browsing behaviour, where a user scans a result page or search result page for general information.</td>
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<tr>
<td><strong>Reading</strong></td>
<td>Reading refers to a comprehensive searching, where a user reads a result page in detail; such acts are characterized by a longer time spent on reading a page and a lesser number of pages visited in a given duration.</td>
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<td><strong>Navigation Style</strong></td>
<td>Navigation Style refers to a browsing behaviour in which the user accesses the content by following a series of links or pages. Navigational styles may be of two types: Sporadic and Structured.</td>
</tr>
<tr>
<td><strong>Sporadic</strong></td>
<td>Sporadic navigational style refers to those navigational behaviours in which users performed an irregular navigation during Web searching.</td>
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<tr>
<td><strong>Structured</strong></td>
<td>Structured navigation style is a navigational behaviour in which systematic steps are followed during the course of Web searching.</td>
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<tr>
<td><strong>Web Search Logs</strong></td>
<td>A search log (we called it “Web search sessions”), also referred as transaction log, is a record of interactions between a system, such as a search engine and the users of the search system. The process of analysing this data is referred to as search log analysis.</td>
</tr>
</tbody>
</table>

**Variables**

| **Contextual Factor** | Various attributes that govern user information searching and retrieval, such as user age, gender, prior search experience, and individual differences are known as contextual factors. |
| **Independent Variable** | Factors that affect other factors, known as ‘dependent variables’, or that influence the outcome of the experiment are known as independent variables. Independent variables are factors that affect the searcher’s Web search interactions, such as cognitive style. |
| **Dependent Variable** | Dependent variables are factors that are affected during an experiment or factors that depend on the independent variables chosen. |
### Appendices

#### Cognitive Styles

<table>
<thead>
<tr>
<th>Cognitive Style</th>
<th>Cognitive style is defined as “an individual’s preferred and habitual approach to organise and represent information” (Riding &amp; Rayner, 1998, p. 8).</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive Styles Analysis (CSA)</td>
<td>CSA is a computer-administered program to measure users’ cognitive styles. Using Riding’s (1991) CSA test, users can be classified as wholist or analytic, and verbaliser or imager.</td>
</tr>
<tr>
<td>**Wholistic-**Analytic (WA) Dimensions</td>
<td>The WA dimension of cognitive styles describes the habitual way in which people think about, view and structure information in wholes or parts (Riding &amp; Cheema, 1991).</td>
</tr>
<tr>
<td>Verbal-imagery (VI) Dimensions</td>
<td>The VI dimension of cognitive styles describes an individual’s tendency to process information either in verbal or verbal mode of representation and thinking (Riding &amp; Cheema, 1991).</td>
</tr>
<tr>
<td><strong>Wholist</strong></td>
<td>Wholists tend to see a situation as a whole ‘picture’ (Riding &amp; Pearson, 1994), retain a global or overall view of the information, and view ideas as complete wholes.</td>
</tr>
<tr>
<td><strong>Analytic</strong></td>
<td>Analytics tend to see a situation as parts; they see a situation as a collection of parts and focus on one or two aspects of the situation at a time.</td>
</tr>
<tr>
<td><strong>Verbaliser</strong></td>
<td>Verbalisers are individuals who think in terms of words, and consider the information they read, see or listen to, in words or verbal associations.</td>
</tr>
<tr>
<td><strong>Imager</strong></td>
<td>Imagers are individuals who think in terms of mental pictures. When they read or listen, they retain the information in mental pictures either of the representations of the information itself or of associations with it.</td>
</tr>
<tr>
<td><strong>Holist-Serialist</strong></td>
<td>Pask’s (1976) identified two cognitive learning styles: holist and</td>
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</tbody>
</table>
serialist.

**Holist**
A holist tends to adopt a global approach to learning, has a preference for seeing the task in a broad approach; and looks for higher order interrelationship between topics in the learning process and building a broad conceptual overview.

**Serialist**
A serialist uses a narrow step-by-step learning approach, tend to examine one thing at a time in detail, concentrating on each step and testing out simpler hypothesis for each next move.

**Field-dependent-independent**
Field-dependence-independence cognitive styles describes the degree to which the surrounding field affects an individual’s perception or comprehension of information (Witkin, et al., 1977a).

**Field-Independent**
The field-independent individuals perceive part of a field as discrete from the surrounding field as a whole and experience the components of a structured field analytically, rather than embedded in the field.

**Field-Dependent**
The field-dependent individuals tend to rely on the external environment and are less good at structuring and analytic activity. Their perception is strongly dominated by the prevailing field.

**Research Methods**

**Mixed Methods**
A mixed methods research design is defined as “the collection or analysis of both quantitative and qualitative data in a single study in which the data are collected concurrently or sequentially, are given a priority, and involve the integration of the data at one or more stages in the process of research” (Creswell, et al., p. 212).

**Qualitative Analysis**
Qualitative research refers to a systematic and detailed study of individuals in natural settings, often referred to a variety of terms, such as “field research”, “naturalistic research”, “interpretive
## Appendices

research”, “phenomenological research”, “action research”, and more (Kaplan & Maxwell, 2005, p. 32).

<table>
<thead>
<tr>
<th>Quantitative Analysis</th>
<th>Quantitative data analysis is a process of presenting and interpreting numerical data through statistical analysis.</th>
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<tbody>
<tr>
<td>Content Analysis</td>
<td>Content analysis is defined as “a research technique for making replicable and valid interferences from texts to the contexts of their use” (Krippendorff, 2004, p. 18).</td>
</tr>
<tr>
<td>Think-Aloud</td>
<td>There is arguably no other better method to read cognitive thinking than asking the subjects to verbalise what they are thinking. This method is known as think-aloud or protocol analysis.</td>
</tr>
<tr>
<td>Correlation Analysis</td>
<td>Correlation analysis in statistics measures the degree of association (variation) between two or more variables. Correlation coefficient $r$ is a measure of the linear relationship between two sets of data.</td>
</tr>
<tr>
<td>Chi-square</td>
<td>The Chi-Square test for independence is a statistical test, which compares two sets of categories to determine whether the two groups are distributed differently among the categories. It is a statistical test to check whether there is a relationship between two types of variables (Gravetter &amp; Wallnau, 2008).</td>
</tr>
<tr>
<td>ANOVA</td>
<td>Analysis of Variance (ANOVA) is a statistical method of analysing data variability between the variables or within the groups. The ANOVA method is an appropriate method when the groups of observations are created by a categorical independent and dependent variables (Iversen &amp; Norpoth, 1987, p. 8).</td>
</tr>
<tr>
<td>MANOVA</td>
<td>Multivariate analysis of variance (MANOVA) is a technique to test the effect of one or more independent variables on a set of two or more dependent variables. MONAVA is a generalized form of</td>
</tr>
</tbody>
</table>
ANOVA, used when there are two or more dependent variables.

**Factor Analysis**
Factor analysis is used to investigate whether a number of observed variables are linearly related to a smaller number of unobserved factors or not.

**Structural Equation Modelling (SEM)**
SEM is a statistical methodology used to test “the plausibility of hypothetical assertions about potential interrelationships among the constructs, as well as their relationships to the indicators or measures assessing them” (Raykov & Marcoulides, 2006, p. 1). Constructs are the observed features of the behaviour (e.g., anxiety), obtained by measuring instruments, such as questionnaires. The method is also known as path analysis.

**Normalisation**
A method of normalising two discourses to a favoured number or instances, say 100. The actual data is normalized by first calculating the ‘normalizing factor’.
References


References


References


References


Annual Conference of the Australian Computer-Human Interaction Special Interest Group, Brisbane, Australia: 340-343.


References


the the second Nordic Conference on Human-Computer Interaction, New York, NY, USA: 101-110.


References


References


Brief Curriculum Vita

Publications (selected)

Journal


International Conferences


**PC and Reviewer**

**Program Committee (PC)**

- OZCHI: Annual Conference of the Australian Computer-Human Interaction Special Interest Group, 26-30 November 2012, Melbourne, Australia
- FLAIRS-25 Special Track Cognition and Artificial Intelligence (AI), 23-25 May 2012, Florida, USA

**Invited Paper Reviewer**

- PACIS: Pacific Asia Conference on Information Systems, 9-11 July 2011, Brisbane, Australia
• OZCHI: Annual Conference of the Australian Computer-Human Interaction Special Interest Group, 22-26 November 2010, Brisbane, Australia


Professional Presentations (selected)

Invited Talks and Symposium

• Weekly Seminar at QUT Mobile Innovation Lab, 13 April 2012, Brisbane, Australia

• ISfTE2009 pre-seminar symposium (Education System in Bhutan), 3 June 2009, Utah, USA

Conference/Poster presentation

• Paper presentation at the ADCS2010, 10 December 2010, Melbourne, Australia

• Two papers presentation at the OZCHI2010, 26-30 November 2010, Brisbane, Australia

• Poster presentation at the HCSNet SummerFest09, 30 November 2009, Sydney, Australia

• Paper presentation at the ISfTE2009, 8 June 2009, Utah, USA

• Paper presentation at the ATEA2009, 30 June 2009, Albury, Australia

• Paper presentation at the ISTE2008, 23 April 2008, Armidale, Australia

Professional Memberships (Associate/Member)

• Association for Computing Machinery (ACM) – since 2011

• Australian Computer Society (ACS) – since 2009

• International Society for Teacher Education (ISfTE) – since 2008

• Australian Teacher Education Association (ATEA) – since 2009