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RELATIONSHIPS AMONG WORK TASKS, SEARCH TASKS, AND INTERACTIVE INFORMATION SEARCHING BEHAVIOR

by

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ABSTRACT OF THE DISSERTATION

Relationships among Work Tasks, Search Tasks, and Interactive Information

Searching Behavior

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This dissertation explores the relationships between work tasks and search tasks, and between work tasks and interactive information searching behavior. A faceted classification of tasks served as a framework of this research. Two sequential studies, i.e., Study 1 and Study 2, were conducted. Semi-structured in-depth interviews were carried out to collect data in Study 1. The applicability of the faceted classification of tasks to a university community were examined and the classification was refined, based on which Study 1 investigated the relationships between work tasks and search tasks. The results indicated that several facets of work tasks are significantly related to search tasks, while only a few search task facets are heavily related to work task facets. The examination of the relationships provided empirical evidence to support that work tasks and search tasks are two different constructs and their effect on interactive information search behavior should be accounted for separately. This study also identified work task facets which substantially affect search tasks and interactive information searching behavior. Based on the findings in Study 1, an experiment was conducted in Study 2 to probe the relationships between work tasks and interactive information searching behavior. The results demonstrated that work tasks are important factors in shaping users' interaction with information systems. Study 2 also found that different work task facets play different roles in affecting users' interaction with information systems, and common attributes of tasks seem to be more important than the generic facets of tasks. Moreover, among common attributes objective work task complexity affects the most aspects of interactive information searching behavior. The results also indicated that knowledge of work task topic, work task difficulty, and subjective work task complexity influence different aspects of interaction in different degrees. This research demonstrates that a faceted approach to conceptualizing tasks is feasible and effective. These results and findings have theoretical, practical, and methodological implications for task-based information retrieval and personalization of information retrieval.

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DEDICATION

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Chapter 1. Introduction

Various researchers in information science have called for the merging of research in information seeking and information retrieval (Belkin, 1993; Vakkari, 1999; Järvelin & Ingwersen, 2004). One of the efforts is to take work tasks as a starting point to examine how they influence information seeking and retrieval behavior (e.g. Byström, et al., 2004; Byström & Hansen, 2002; Vakkari, Pennanen, and Serola, 2003; Wang, 1997). In addition, the effect of context on information seeking and retrieval has gained much attention in recent years, and work tasks are viewed as an important element of context (Ingwersen, 2005). Along this line, this dissertation research places work tasks in a central role of information searching in order to investigate the relationship between work tasks and information search tasks, and between work tasks and users' interactive information searching behavior.

Many studies have demonstrated that information systems are not the only channels for users to collect information. Other channels, for example, human beings, are also important ones (e.g. Blomgren, Vallo, & Byström, 2004; Freund, Toms, & Waterhouse, 2005). However, since the purpose of this study is to investigate how work tasks affect human-computer interaction, and to inform interactive information retrieval (IIR) system design and advance adaptive IR, it mostly concentrates on how work tasks are related to search tasks and interactive information searching behavior.

The following section first provides an overview of research in related areas, then defines the terminology used in this research, and finally describes how this dissertation is organized.

1.1. Overview

Work tasks as key factors affecting human information seeking have gained much attention in recent years. Several theoretical frameworks have been proposed to inform empirical studies. For example, Byström and Hansen (2002, 2005) put forward a three-level model to clarify the relationship between work tasks, information seeking tasks, and information search tasks. Leckie, Pettigrew, and Sylvain (1996) developed an information seeking model of professionals, within which work roles and associated tasks are the motivation of professionals' information seeking activities. Hansen (1999) and Kim and Soergel (2005) summarized different task characteristics and reviewed the related studies. Their studies suggest that it is still necessary to exert great effort in clarifying how task characteristics shape information seeking behavior. In order to predict search tasks and information behavior through work tasks, Li (2004) took a faceted approach to developing a classification of task. Vakkari (2003) extensively reviewed the studies in this area, aimed at informing empirical studies in task-oriented information searching. Though the aforementioned studies conceptualized tasks from different perspectives, work tasks were viewed as a starting point of information seeking and searching across these studies.

To articulate the relationships between work tasks and information seeking behavior, a myriad of studies on human information behavior have been conducted in real work task contexts. Some of these studies focus on how users seek information in a certain work task context or situation (e.g. Vakkari, Pennanen, & Serola, 2003). On the other hand, other studies directly take work tasks as independent variables to investigate their impact on human information seeking and searching behavior. This group of studies examine: (1) how task characteristics, such as task complexity (e.g. Byström & Järvelin, 1995; Byström, 2002), task stage (e.g. Wang, 1997), task interdependence (e.g. Cross, Rice, & Parker, 2001) and so forth, impact information seeking or searching behavior; (2) how work task shapes users' information seeking behavior (e.g. Algon, 1999; Solomon,1997); (3) how work task affects users' interaction with specific document genre (Freund, Toms, & Waterhouse, 2005; Freund, Toms, & Clark, 2005). This group of studies specifically examines the relationships between work tasks and behavior, and thus has a promising future to inform IIR system design.

In addition, search tasks as an influential factor of user information searching behavior have been investigated for a long time (e.g. Marchionini, 1989). These studies usually categorize information search tasks as known item search and subject search (e.g. Kim & Allen, 2002) or as more specific search task types (e.g. Kim, 2006a). However, most such investigations usually do not take work tasks into account when probing the relationship between search tasks and users' searching behavior (e.g. Marchionini, 1989; 1992; Qiu, 1993; Vakkari, 2003). Therefore, this dissertation research focuses on investigating the relationships between work tasks and search tasks.

Apart from work tasks, user's individual differences also influence information seeking behavior (Hert & Marchionini, 1998). Algon (1999) investigated how work tasks influence information-related behavior in a corporate setting, given that personal and/or situational factors are taken into account. However, for most studies in which researchers examine the impact of individual differences or system features on information searching behavior, work tasks are excluded (e.g. Allen, 1991; Wildemuth, 2004; Zhang, Anghelescu, & Yuan, 2005). Since work tasks have been recognized as a motivation of information seeking and searching (Belkin, 1996; Byström & Hansen, 2002; Ingwersen, 1992, 1996; Vakkari, 2001; Vakkari, 2003), the exclusion of work tasks prevents people from a comprehensive understanding of human information behavior. Therefore, the dissertation research attempts to reasonably incorporate these factors into a framework, and explore how they influence users' information searching behavior.

Information retrieval is an inherently interactive process (Savage-Knepshield & Belkin, 1999). According to Saracevic (1996a), interactive information retrieval (IIR) describes a more realistic picture of users' information searching. Interactive information searching behavior has drawn much attention in recent years, especially in the TREC Interactive Track. From TREC-5 to TREC-12, Rutgers TREC group at the School of Communication, Information and Library Studies conducted a series of experiments. These studies inform that it is valuable to examine interactive information searching behavior for understanding interactive information searching behavior as well as enhancing IR systems design. Along this line, this dissertation research is concerned with the relationships between work tasks and interactive information searching behavior for providing insight into task-oriented information searching and adaptive IR systems design.

Similarly to other studies on work tasks, which usually start from identifying task types, this dissertation research took Li's (2004) faceted classification of task as the departure point to classify work tasks. This classification was developed from a comprehensive survey of the literature related to work tasks and behavior in organizational management, social psychology and information science. Its ultimate purpose is to predict information behavior. The facets in this classification are categorized into two groups: Generic facets of tasks and Common attributes of tasks. Six generic facets are recognized: 'Source of task', 'Task doer', 'Time', 'Product', 'Process', and 'Goal'. Common attributes include two facets, namely, 'Task characteristics' and 'Users' perception of tasks'. These facets involve one or several sub-facets; all sub-facets have different values.

In sum, this dissertation research intended to investigate the relationships between work tasks and search tasks and the relationships between work tasks and interactive information searching behavior on the basis of Li's faceted classification of task, given that individual differences are taken into account. A preliminary research model is presented as Figure 1.1.

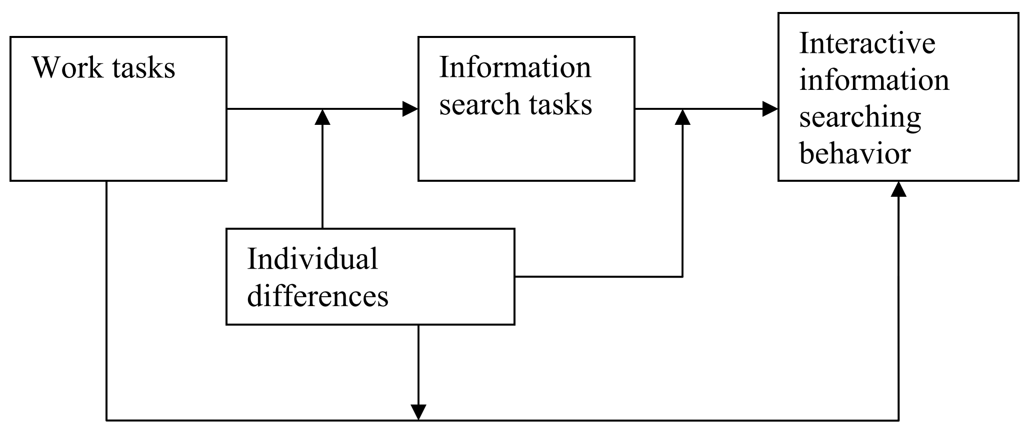

Figure 1.1. A preliminary research model

1.2. Terminology and Definitions

1.2.1. Information Seeking, Information Searching, and Information Retrieval

This dissertation research differentiates information seeking from information searching/retrieval, as Wilson (1999a, 1999b) proposed. He presented a nested model of information behavior in order to depict information seeking and information searching research areas. This model includes three levels: information behavior, information seeking behavior, and information searching behavior. He suggested that information behavior should be defined as a general area and information seeking behavior should be its sub-set with the focus on “the variety of methods people employ to discover, and gain access to information resources” (1999a, p.263), whereas information searching behavior should be defined as a sub-set of information seeking behavior and it is concerned with the interactions between users and information systems. Therefore, the difference between information seeking and information search/retrieval lies in that users conduct information search only through information systems, but they may seek information from other sources, for example, people or printed documents.

1.2.2. Work Tasks, Seeking Tasks, and Search Tasks

Tasks are activities people attempt to accomplish in order to keep their work or life moving on. The dissertation focuses on work tasks and search tasks, though information seeking tasks will be also touched upon. Work tasks have been defined from different perspectives. For instance, Ingwersen defined it as an underlying problem of a person’s actual work from cognitive perspective (Hansen, 1999); Byström and Hansen (2002) viewed work tasks as “separable parts of a person’s duties towards his/her employer” (p.242). In addition, Vakkari (2003) defined a task as an activity that the task doer performed in order to accomplish a goal. He pointed out that a task involved the description of a task and a series of actions performed during the process of completing the task. For the purpose of this research, work tasks refer to an activity people perform to fulfill their responsibility for their work, i.e., work-related tasks; moreover, it is a motivation of information searching. Obviously, it is distinct from tasks in everyday life, for example, shopping for the family. Seeking tasks refer to the activities that users engage in for gathering information for their work or life, which are associated with a variety of information sources such as people, paper-based documents, information systems, and so on. Search tasks are defined as users' activity to search for information from their interaction with information systems. This is slightly different from Byström and Hansen's (2005) perspective. From their point of view, information search tasks concentrate on interacting with an individual information source or channel, including not only IR systems but also other sources, such as a printed journal or an expert in a specific domain. Work tasks, seeking tasks, and search tasks may be the same tasks under certain circumstances, for example, librarians' work tasks are usually also seeking tasks or search tasks. Once they seek information from information systems, their seeking tasks are equal to search tasks. Since such work tasks have been widely investigated, this dissertation research focuses on work tasks which are not equal to the search tasks and have at least one associated search task.

Here, information systems refer to online information resources, for example, information retrieval (IR) systems, search engines, digital libraries, and so on.

1.2.3. Task Doers and Users

Task doers refer to the people who engage in a task. Users refer to people who engage in interaction with information systems. Sometimes task doers are not the same people as users. For example, a task doer can assign the search task to his/her colleague, and his/her colleague will be a user to search information systems. If a task doer himself/herself conducts information seeking or searching, s/he is also called "a user". This dissertation research takes the latter into consideration rather than the former.

1.2.4. Interactive Information Searching Behavior (sometimes using "interactive behavior" for short)

Interactive information searching behavior is a subset of information behavior. It refers to users' behaviors taking place during their interaction with information systems. Many researchers discuss interactive information searching behavior, which includes query formulation and reformulation, iteration, scanning, selecting, evaluating, learning, and so forth. This dissertation research is concerned with all these sorts of behavior. Furthermore, interactive information searching behavior also refers to how users interact with different features embedded in the systems, for example, search and browse features, relevance feedback, hyperlinks, and so forth. However, such behavior is not the focus of this research.

1.3. Organization of the Dissertation

This dissertation first discusses the background of this research: context and situation in information seeking and retrieval. Then, the problems and significance of task-based information searching are addressed. In the following chapter related studies are reviewed, grouped into work tasks and information seeking, work tasks and information searching, search tasks and information searching, interactive information retrieval, and individual differences and IR. The dissertation then raises the research questions, based on which two sequential studies and the results and findings are then described. The following chapter further discusses these results and findings. This dissertation ends with a conclusion chapter, which addresses the major findings, limitations, and implications of this dissertation research, as well as future studies.

Chapter 2. Context and Situation in Information Seeking and Retrieval

Context and situation have been recognized as crucial factors influencing information seeking and retrieval in recent years. This chapter presents how people in information science conceptualize context and situation.

2.1. Context in IR and Information Seeking

Context is an ill-defined term. It could be defined from a broad or narrow perspective. For example, Taylor (1991) defined American culture or Chinese culture as a context in which people seek information; however, He, Goker, and Harper (2002) addressed query context and tried to incorporate the contextual information based on log analysis into systems design. Dewey (1960) defined context as "…a spatial and temporal background which affects all thinking and a selective interest or bias which conditions the subject matter of thinking" (p.90). Since information seeking and retrieval cannot take place in a vacuum (Case, 2002), context as "a spatial and temporal background" has been an influential factor discussed in information science.

Cool and Spink (2002) categorized context in information seeking and retrieval into four levels: (1) Information environment level, such as institutional, organizational, or work task settings. (2) Information seeking level, including the goals, problem resolution task, and so on. This level is more specific compared to the first one. (3) IR interaction level. IR interaction could be a kind of context in which users engage in information searching. (4) Query level. In this level context is a linguistic environment to explain different meanings of a search term. For instance, people sometimes get the documents with the right terms, but in the wrong context (Cool & Spink, 2002). Accordingly, people's understanding of context in IR and IIR is various. He et al. (2002) claimed that contextual information was embedded in users' search topics and search sessions. Ng (2002) understood context as a search environment. Specifically, in his study it referred to Research Libraries Information Network (RLIN). In Choi and Rasmussen's (2002) study, image retrieval was treated as a context. They pointed out that it was a different context from traditional IR (text), so users may use different relevance criteria. Bilal and Kirby (2002) and Wolfram and Xie (2002) also viewed context as a search environment; for example, the traditional IR and web search engine provide different search contexts for users.

In contrast to context in IR and IIR, in information seeking area context is usually a broader concept. Researchers focus on the first two levels of context summarized by Cool and Spink (2002). Taylor (1991) defined "information use environment" (IUE) as "the set of those elements that (a) affect the flow and use of information messages into, within, and out of any definable entity, and (b) determine the criteria by which the value of information messages will be judged" (p.218). Moreover, he specifically discussed a few IUEs, and categorized people who use information as

- the professions: engineers, lawyers, social workers, scientists, teachers, managers, physicians, etc.
- the entrepreneur: farmers, small business men, etc.
- special interest groups: consumers, citizen groups, hobbyists, political action groups, ethnic cultural groups, etc.

- special socioeconomic groups: information-poor, the disabled, minorities, the elderly, etc.

(Taylor, 1991, p.222)

This classification is useful to understand the meaning of context. People play different roles in their life depending on the context. A person is called an engineer because she/he works in an engineering context and conducts tasks related to engineering. If this engineer goes shopping for his/her family, she/he will be a consumer. Therefore, to some extent, context and tasks shape or reflect the different roles of people living in this world. Further, Taylor addressed how different people who worked in different settings, such as engineers, legislators, and practicing physicians, differed in information needs (information types), use, storage, and transfer. He gave an example: For engineers reading journal articles was regarded as "wasted time" whereas academic researchers heavily depended on research articles. Therefore, it is necessary to explore characteristics of human information behavior in different contexts. Solomon (1997) focused on a public agency to examine how a work planning task was associated with the worker's information seeking behavior. He proposed "information mosaic" based on the study on work planning tasks, course-related tasks, and travel planning tasks within three contexts, i.e., public agency staff, college students, and professionals, respectively (Solomon, 1999). Limberg (1997) investigated information use for learning purpose in educational settings. Kuhlthau (1997) explored the influence of uncertainty on information seeking via a longitudinal case study. Her subject changed his/her role, from a student, to a career-entry position, and then to an industry expert. S/he engaged in information seeking across different contexts, and therefore her/his seeking behavior was diverse. As a pioneer encouraging research in information seeking in context, Dervin (1997) provided an extensive discussion of context. She pointed out that context was a multidimensional concept with various attributes. Sonnenwald (1999) listed some examples of contexts, for example, academia, family life, citizenship, and clubs. She emphasized that each context had boundaries, constraints and privileges as perceived by participants and outsiders. In order to organize the papers for the proceedings of the Conference on Information Seeking in Context 1999 (ISIC 2), Wilson and Allen (1999) grouped some papers into the health services context, everyday life, and the work environment. Obviously, these categories reflect different information seeking contexts.

2.2. Situation in Information Seeking and IIR

Case (2002) quoted several definitions for situation. For example, according to Savolainen, "the term situation refers to the time-space context in which sense is constructed" (1993, p.17). Donohew and Tipton pointed out that "Definition of situation as being composed of such things as immediate goals, priorities, and availability of information in the immediate situation" (1973, p.248). On the other hand, Vakkari (1997) put forward that situation and context could be looked at as primitive concepts, like information. Thus, it seems not necessary to define them. This point of view releases people from the dilemma in defining situation and context.

Concerned with situation and information seeking and IIR, Cool (2001) provided an extensive review on the concept of situation. She discussed the situation-related theories in different areas and how they were applied to research in information science. These theories include problematic situation, situation in cognitive sociology and social interaction, situated action theory, the theory of situation awareness, person-in-situation model, and situation environments.

Some people use context and situation interchangeably. However, others treat them differently. Sonnenwald (1999) argued that a context should be larger and may be composed of a series of situations. Allen (1991) and Case (2002) took this stance as well. In addition, in Ingwersen's IIR model (1992, 1996), work task/interest was listed under individual user's cognitive space, and social/organizational environment obviously referred to a broader concept. Additionally, Saracevic (1996a) explicitly distinguished environment from situation in his stratified model of IR interaction, and treated tasks as situation. It is noticed that environment was equal to context. Particularly, Cool (2001) differentiated situation from context and pointed out that situation was the dynamic aspect of context. She critiqued the ambiguity of context and situation in information science, and stated, "the use of situation and context interchangeably dilutes the explanatory power of each. Further, the conceptual murkiness surrounding these concepts has made it difficult to pursue methodologically rigorous investigation of either one" (p. 7). From her point of view, it is necessary to treat context and situation as different constructs.

2.3. Work Tasks as Context or Situation

With respect to work tasks, some researchers take them as contextual or situational factors. Freund, Tomes, and Clarke (2005) identified work tasks as one of the contextual factors impacting information seeking and retrieval. In order to establish a task-oriented information retrieval evaluation framework, Reid (1999, 2000) criticized the system- and user-oriented paradigms which neglected the influence of some contextual and situational factors, including tasks, on information retrieval. Chang and Lee (2000) defined a context as composed of several situations, each of which was defined by a set of related contextual factors, including tasks at hand, the type of problem encountered, and the accessibility of specific information. However, according to Saracevic (1996a), tasks at hand were situation facing the users. Therefore, there is still no consensus on whether work tasks are context or situation, or are contextual factors or situational factors.

A work task usually occurs in organizations or institutions, and is more dynamic and narrower compared to an organizational environment. For example, in an organization a manager needs to perform different tasks, and thereby faces various situations. In contrast, the organizational context is more stable than work tasks. In this example, work tasks represent specific situation embedded in a relatively bigger context. With respect to information seeking and searching, a work task's goal, performance process, outcomes, and so forth directly shape users' behavior (e.g. Algon, 1999; Byström, 1999; Pharo, 2002), while as a context, an organizational environment may indirectly impact their behavior. Ellis and his colleagues have demonstrated this point by conducting a series of studies, which showed that the information seeking pattern he proposed was robust regardless of various contexts (Ellis, 1989; Ellis, 1993; Ellis, Cox, & Hall, 1993: Ellis & Haugan, 1997). Hence, in the proposed study, situation is looked at as an aspect of context, and work tasks are part of the situation confronting task doers. Consequently, what we should bear in mind is that compared to context, work task may be more dynamic in virtue of task doers' perception and cognition during task performance, although Ingwersen (1996, 1999) claims that work tasks are more stable than information need.

Based on the understanding of work tasks as an element of context or situation, the following chapters describe a study aimed at investigating how work tasks affect search tasks and users' interactive information searching behavior.

Chapter 3. Problem Statement and Significance

In recent years work tasks have been viewed as a starting point to merge information seeking and retrieval (Byström et al., 2004). Vakkari (2003) proposed that task-oriented information searching should be a central issue to explore in information science, in that such research might be easy to implement in systems design. Several information scientists pointed out that work tasks should be a unit to investigate human information behavior (Byström & Hansen, 2002; Järvelin & Ingwersen, 2004; Vakkari, 2003). Making a further step, Järvelin and Ingwersen (2004) stated that both information seeking and information retrieval needed to extend their research towards the other by taking account of tasks as key factors. Researchers have conducted some studies at the information seeking level (Algon, 1999; Byström, 1999, 2002; Byström & Järvelin, 1995). However, although a progress has been made in incorporating real or simulated work tasks into system evaluation in recent years, by which how work tasks influence information search has been indirectly addressed (e.g Borlund & Ingwersen, 1997; Borlund, 2000; Blomgren, Vallo, & Byström, 2004; Reid, 1999; 2000), research into work tasks and information searching behavior, especially interaction, is much less established. The exploration of how work tasks affect and shape users' behavior is still lacking, though there have been some empirical studies touching upon this issue (e.g. Blomgren et al., 2004; Freund, Toms, & Waterhouse, 2005; Freund, Toms, & Clarke, 2005). Furthermore, a recent study done by Järvelin and Ingwersen (2004) showed that the work task dimension was excluded from traditional online IIR research. Specifically, the current problems of research on this issue include:

- Few studies investigate the relationship between work task and search task in depth.

  As mentioned above, work tasks are usually excluded from the studies on the relationships between search tasks and users' behavior (Vakkari, 2003). Though some researchers have realized that work tasks are motivation of search tasks and based on this assumption they conducted empirical studies (Kuhlthau, 1991; Vakkari et al., 2003), they did not examine the relationship between work tasks and search tasks. On the other hand, Byström's studies (1999; Byström & Järvelin, 1995) indicated that people needed to seek information only for some work tasks. For automatic information processing tasks in her studies, the subjects did not conduct information seeking activities. However, since her focus was on information seeking, she did not touch upon how work tasks affected search tasks. The relationship between work tasks and search tasks is ignored in her studies.

- Few studies except Pharo (2002) directly examine the relationship between work tasks and information searching behavior, especially interactive information searching behavior.

  So far, there have been some studies investigating how work tasks influence information seeking and use behavior. For example, Byström conducted a series of studies to examine how work task complexity affected information seeking behavior (Byström & Järvelin,1995; Byström, 1996, 1999, 2002); Algon (1997, 1999) categorized work tasks based on the jobs of a drug development project team and probed how work tasks influence information seeking, providing, and use behavior. These studies did not touch upon how users searched specific information systems for given work tasks. Moreover, Järvelin and Ingwersen (2004) pointed out that work tasks and information systems have received less theoretical attention as foci of modeling and theorizing. Vakkari et al. (2003) claimed that work tasks were critical factors influencing search behavior. However, they merely focused on users' behavior when searching on an IR system (PsychINFO), and ignored the role of work tasks during this process. Pharo (2002, 2004) aimed to propose the Search Situation Transition (SST) schema for the exploration of work tasks and interaction in Web information searching. Though he has realized the influence of work tasks on information searching behavior, due to the limitation of his purpose, he did not probe this influence in depth. Pharo and Järvelin (2006) further investigated the information seeking behavior of "irrational searchers". They found that information search was a dynamic process with the variation in source selection, goals, and objectives. The searchers in this study also reconsidered the usefulness of the source at different stages of their work tasks as well as their search tasks. However, how work tasks affect users' interactive information searching behavior still remains an open issue.

- Few studies take into account the influence of individual differences on the relationship between work tasks and information behavior.

People have arrived at a general consensus on influential factors of information seeking and searching behavior (Hert & Marchionini, 1998). These factors contain:

- individual characteristics, such as domain knowledge, previous experience, preferred cognitive style, etc.;
- the user's task, goal, or information need;
- characteristics of the user's organizational role and typical problems encountered within the environment;
- the retrieval system.

(Hert & Marchionini, 1998, p.305)

Except that Algon's study (1999) took account of some personal and/or situational factors, such as perceived risk, leadership, organizational structure, team colleagues, an outside agency, and so on, few studies investigate the relationship among these influential factors.

Accordingly, this dissertation focuses on how work tasks are related to search task and how work tasks influence users' interactive information searching behavior, given that individual differences are taken into account.

Chapter 4. Literature Review

This chapter reviews related studies and displays the theoretical bases and empirical evidence for this dissertation research. First, it presents the studies on work tasks and information seeking, and then work tasks and information searching, search tasks and information searching, followed by related studies on IIR. Studies on individual differences and IR are also reviewed.

4.1. Work Tasks and Information Seeking

In recent years Byström and her colleagues (Byström, 1996, 1999, 2002, 2005; Byström and Järvelin, 1995; Blomgren, Vallo, & Byström, 2004) conducted a series of studies on work tasks and information seeking behavior. They investigated the relationships between task complexity, information types, and information sources with regard to municipal administrators and newspaper journalists. Task complexity as an important characteristic was defined in terms of "*a priori* determinability of, or uncertainty about, task outcomes, process, and information requirements" (Byström and Järvelin, 1995, p. 194). Starting from this point, they first categorized tasks as automatic information processing tasks, normal information processing tasks, normal decision tasks, known, genuine decision tasks, and genuine decision tasks. The findings indicate that task complexity is related to information types and information sources selection. With the increase of the task complexity, people need more types of information, are less likely to predict the types of information they need, and are more dependent on experts to provide useful information. In general, Byström was concerned with information-seeking level and limited her studies to organizational context. Due to the influence of task complexity on seeking behavior, she inferred that it may also impact users' behavior on information-search level (Byström, 2005), although she did not explore this influence.

In addition, Byström and Hansen (2005) attempted to integrate information seeking and retrieval into a framework, i.e., a three-level task model including information–intensive work task, information seeking task, and information search task. Information–intensive work task involves information-related activities to a considerable degree. Information seeking task is a sub-task of information work task, and information search task is a sub-task of information seeking task. Information seeking task is concerned with the satisfaction of entire information need, whereas information search task concentrates on interacting with individual information source or channel, for example, an IR system, a printed journal, an expert in a specific domain, and so on. Information retrieval task is treated as a specific case of information search task. Byström and Hansen (2005) further identified three dimensions for each level of task, such as task construction, task performance, and task completion. Moreover, some of related factors to the three levels of tasks which may influence their dimensions are also recognized. As the author stated, the purpose of this model is to provide a framework for task-related empirical studies in information science. They argued that only after taking into account both work context and situation, can information seeking and retrieval be completely studied or understood. However, in this paper they only provided a theoretical framework on the relationships between work tasks, information seeking tasks, and search tasks. Empirical evidence is necessary to verify it.

Leckie, Pettigrew, and Sylvain (1996) intended to propose an original model of information seeking of professionals such as doctors, lawyers, teachers, clergy, nurses, librarians, and so on. Leckie et al. criticized that many studies addressing information seeking behavior of professionals merely focused on a specific profession and failed to provide a general model applicable to all professionals. Hence, after reviewing the related literatures, they proposed a model that involves six factors:

- Work roles: determining associated tasks.
- Associated tasks: driving information seeking behavior.
- Characteristics of information needs: playing a crucial role in the course of seeking information; relevant factors including individual demographics, context, frequency, predictability, degree of urgency, and complexity.
- Sources of information: seeking information from various information sources, for example, colleagues, librarians, handbooks, journal articles and their own personal knowledge and experience.
- Awareness of information: People prefer to gather information from familiar sources which lead to successful search before. Additionally, trustworthiness, packaging, timeliness, cost, quality, and accessibility also shape users' information seeking behavior.
- Outcomes: the results of information seeking process.

This model depicts professionals' information seeking process and takes into account different factors influencing their behavior. However, although people's role is a key component in this model, work tasks are the real motivation of information seeking behavior. Moreover, even if Lekie et al. stressed the importance of work tasks, how work tasks relate to certain information seeking behavior is not addressed. Since some studies indicate that professionals are usually not interested in consulting information systems, this study does not touch upon their searching behavior.

Algon (1999) explored individual's information-related behaviors (IRB) in the context of a project team. Her study investigated the regular relationships between the information-related behaviors (IRBs) of individuals in a work-group environment and the tasks assigned, given that major personal and/or situational factors (PSFs) were taken into consideration. Tasks in her study were defined as "the work that an individual must do to accomplish a larger goal" (p.5). They were assignments from a team leader to a team member. A preliminary research model was proposed in which tasks, situational factors, and personal factors were regarded equally balanced in their relationships to IRBs. However, the results indicate that the relationships are much more complex and IRBs are driven by tasks. Verbalizing as an IRB occurs most often. IRBs and tasks are associated with each other either positively or negatively. Algon interpreted that PSFs served as a filter between tasks and IRBs. Though this is a comprehensive investigation on the relationships between tasks, IRBs, and PSFs under the context of work teams, like Byström's studies, it concentrates on information-seeking, providing and using information, and does not touch upon the characteristics of users' search behavior.

In order to verify Ellis's information seeking pattern, which includes eight generic characteristics: starting, chaining, browsing, differentiating, monitoring, extracting, verifying and ending, Ellis and Haugan (1997) examined the information seeking pattern of R& D projects in an international oil company in Norway. They assumed that information seeking behavior to some degree was dependent on types of project. Therefore, a fixed structure of the life of R&D served as the framework for their examination of the relationship between work tasks and information seeking. This structure involved the project phases (evaluation of alternative solutions; development and testing; implementation; commercialization; summary of experience) and project types (incremental; radical; fundamental). They found that both project phases and types resulted in different seeking behavior. For incremental projects, unstructured, informal and oral communication was the major way to share information between employees; personal contacts, personal knowledge and experience, and the library were the first three most often used information channels. For radical projects, information sharing relied on the collaboration among core teams, meetings or electronic exchange. Personal knowledge and experience were the first information channel people chose. Retrospective searching in online databases was often conducted, and published literature was also popular as an information source. For fundamental project, computerized information search was crucial and taken as the departure point, followed by personal contacts. The library became the primary information channel, meetings were the most frequent method for information sharing, and people preferred face-to-face communication in order to exchange information. In effect, Ellis's studies touch upon both information seeking and searching level. Particularly, from his studies, information systems are information sources for some tasks. However, it remains an open question how people's search behavior is related to their work tasks or situations.

Based on Hackman (1969), Kim and Soergel (2005) categorized a list of task characteristics or variables which may impact information behavior into intrinsic task characteristics, extrinsic task characteristics, task performer, and relationship between tasks and performer, respectively. They addressed the issues related to operationalization and measure of task, though they did not provide an extensive examination. A research design model involving task characteristics, information seeking, and task performance is proposed. Task characteristics are supposed to impact task performance directly or through information seeking activities. They further reviewed the findings of the empirical studies which investigated the relationships between task characteristics and information seeking and searching. The most examined task characteristics so far include task stages, task complexity, task analyzability and task determinacy, task interdependence, and task scope. These task-related variables were found closely related to the types of sources used, the number of sources used, relevance judgment, information search strategies and vocabulary used, information type, search performance, and so forth. This review suggests that only a small set of task characteristics has been investigated, and thus more studies on task and information seeking behavior are called for.

To identify the contextual factors which influence information seeking behavior of a group of software engineers in the workplace, Freund, Toms, and Waterhouse (2005) conducted a two-phase study. They first recognized the contextual parameters of information behavior through interviewing the software engineers, including:

- Consultant: expertise; role; knowledge and skills
- Engagement: length, stage; system parameters; client characteristics
- Work task: consulting task; software engineering task
- Problem: information goal

They then examined the relationship of these factors and information seeking behavior in terms of information channels, information sources, and document genres. Two constraints, i.e., time and accessibility, were identified as important factors impacting the software engineers' seeking behavior, as well as information characteristics, including subject category, level of detail, formal/informal, generic/context specific, experience/knowledge, and purpose. They claimed that the findings in this study were generally consistent with previous studies. This study also provided empirical evidence to support Byström and Järvelin's (1995) model of task complexity, and also built a sound foundation for their future studies focusing on the relationship between tasks and document genre (Freund, Toms, & Clarke, 2005). However, since they are concerned with the relationships between different factors and information seeking behavior, it seems hard to see how these factors as a whole affect seeking behavior from their study. Moreover, it is very possible these factors may interact with each other and determine different behavior characteristics.

4.2. Work Tasks and Information Searching/Retrieval

Based upon five studies on students' (from universities, colleges, and secondary schools) information searching behavior after they were assigned term papers, Kuhlthau (1991, 1993) proposed a six-stage information search process model (ISP), including initiation, selection, exploration, formulation, collection, and presentation. Different from Ellis's information seeking pattern that emphasizes users' actions during information seeking, Kuhlthau probed information search process from the affective and cognitive perspectives. More important, in her study, the subjects' assignments were an implicit original motivation of information searching, and Kuhlthau focused on how they engaged in information searching for the sake of accomplishing their assignments. However, the direct influence of the assignments on their searching behavior is ignored in her study.

Wang (1997) investigated the change of knowledge structure of the researchers before, during, and after doing their research projects, based on the examination of the terms used to describe their projects. According to the author, "[a] term is a verbal representation of a concept" (p. 309). Therefore, terms used should reflect users' knowledge state. The results suggest that users usually select basic-level terms at the beginning, and subsequently broader and narrower terms are introduced. Overall, at the beginning the distribution of vocabulary is comparatively smaller than the two subsequent stages. Therefore, work task stage impacts users' term selection.

In a similar vein, Vakkari (2000) and Vakkari et al. (2003) examined the changes in search tactics and term selection when users experienced different search stages under a real task--writing a research proposal for their Master's thesis. Taking Kuhlthau's six-stage ISP as the framework, Vakkari attempted to answer "how users' conceptual structure representing information needs was related to actual search activities" (Vakkari, 2000, p.2). The findings indicate that the problem stages of the students from information science are associated with their search tactics and term selection. During the search process, due to the changes of the conceptual representation of the task, more and more specified terms were used as well as operators. Particularly, parallel tactics were used increasingly while the search process was moving forward. This study shows that the students from information science preferred to use varied search tactics during the process of preparing the proposals for their Master's thesis.

Hansen (1999) reviewed task concepts from both information science and human-computer interaction (HCI) perspectives. He intended to propose a task-oriented approach to user interface design. According to him, task types discussed in information science and HCI include the user's work tasks, search tasks, system task design, and interaction tasks. He further singled out a group of task characteristics encountered in the literature, including simple-complex tasks, structured-unstructured tasks, user-computer controlled task performance, active-passive tasks, routine tasks, single-multiple tasks, task continuity-discontinuity, task uncertainty, perceived tasks, defined-muddled work task, and stimulated work tasks. This study suggests that there exist a variety of tasks and a bunch of task characteristics which may impact information seeking, information search and retrieval. However, these task types and characteristics still need to be investigated in empirical studies.

Pharo (2002, 2004) aimed to put forward a new method schema composed of domain, procedure, and justification. He named it Search Situation Transition (SST) Method Schema, which may benefit research on work tasks and Web information searching process. This schema includes five categories which influence people's information searching behavior, i.e., work tasks, search tasks, searcher, social/organizational environment, and search process (search transition and search situation). He argued that work tasks should be a departure point for information searching, even though in some situations work tasks are equal to search tasks, for example, intermediaries who work in the library. The findings show that work task directly as well as indirectly impacts search process, especially, the relevance level (Saracevic, 1996b). He also identified several dimensions of work tasks, including goal, complexity, resource, size, and stage. The effects of work task goal and stage on search process were specifically examined. The results illustrate that work tasks and search tasks play different roles to shape users' information behavior. Based on the findings and for further study, he proposed several hypotheses: (1) search task goal can be used to perform relevance judgments on the topical level; (2) work task goal can be used to perform relevance judgments on the cognitive level; (3) work task goal can be used to perform relevance judgments on the situational level. His study reveals that work tasks could be investigated from various dimensions. These dimensions may play different roles during the course of information searching. It also shows that there are still many issues need to be further examined. For example, how many dimensions does a work task have? how do other dimensions besides work task goal impact information searching process? and so forth.

Pharo's studies provide insight into work tasks and information searching behavior, and identify a series of factors impacting their relationship. However, the aspects related to the perception of task doers are neglected, whereas these aspects may play a role in shaping users' searching behavior. As stated above, limited dimensions recognized in his study cannot lead to a comprehensive investigation of work tasks and searching behavior. Moreover, from his SST schema, searchers' individual differences appear not to impact the relationships between work tasks, search tasks, and search process. This is inconsistent with Algon's (1999) findings. That is, personal factors may mediate their relationships. Therefore, this issue deserves further investigation.

Järvelin and Ingwersen (2004) discussed the direction of information seeking research. Considering IIR as a special case of information seeking, they attempted to propose a model to incorporate information seeking and IIR into a framework. This model involves different levels, including socio-organizational and cultural context, work task context, seeking context, and IR context. The evaluation criteria corresponding to different contexts are also developed. Seeking context involving seeking tasks, seeking process, and seeking results is embedded in work task context, which involves work tasks, work process, and task results. The traditional IR process, including request, representation, query, match, and so on, is also nested in seeking context and work context, both of which are embedded in socio-organizational and cultural context. The strength of this model is that it clearly presents the relationship between the different levels of context. It also implies that information seeking and retrieval should communicate with each other. However, it still uses the traditional IR process to represent IR, which seems unreasonable. Furthermore, from this model, the direct influence of work tasks on IR is ignored; instead, it seems that only seeking process can directly affect IR and the influence of work tasks on IR is indirect. However, some researchers (e.g. Vakkari, 2003) argued that work tasks may directly impact IR. Therefore, on the basis of this model, it is hard to uncover the relationship between works task and interactive information searching behavior.

Rasmussen, Pejtersen, and Goodstein (1994) developed a framework, i.e., Cognitive Work Analysis (CWA), which could be used to analyze complex socio-technical systems. CWA can be further transformed to design requirements of information systems (Fidel & Pejtersen, 2004). This work-centered rather than user-centered framework includes seven nested dimensions, such as work environment, work-domain analysis, task analysis, organizational analysis, decision analysis, strategies analysis, and user's resources and values analysis. From the information seeking perspective, Fidel and Pejtersen (2004) regarded that these dimensions were constraints on information seeking. That is, the work environment influences "how a work place is operating, and this mode of operation shapes the task that an actor performs. The task, in turn, affects the decisions that an actor makes, and these decisions influence seeking behavior" (p.7). This framework emphasizes the factors affecting work and information behavior yet ignores their relationship. It is indeed that work tasks affect decision-making, but it is obvious that these decisions are not the only factors influencing seeking behavior. Instead, other factors related to work tasks impact seeking and searching behavior as well, for example, work task goal and stage (Pharo, 1999; 2002).

Contextual information retrieval gains much attention in recent years. Grounded on the context sphere model (Freund, Toms, & Waterhouse, 2005), Freund, Toms, and Clarke (2005) examined the relationship between work tasks and document genre in a software engineering workplace setting. They first hypothesized that work tasks are related to document genre, and then further analyzed their relationships through correspondence analysis. The results demonstrated a strong association between tasks and document genre. Tasks and corresponding document genres were identified. Different work tasks (software engineering, consulting, sales) as well as information tasks (doing, learning, fact finding, and demonstrating) seemed the major reason resulting in the variation among tasks and genres. The findings of this study suggest that tasks could predict document genres in information retrieval. However, this study is not concerned with the relation of work tasks and information search tasks.

It is noted that the studies on tasks and human information behavior usually start from the discussion of conceptualization of tasks. People attempt to classify tasks based on a certain criterion (e.g. Algon (1999) uses "interaction"; Byström & Järvelin (1995) take "task complexity") or the requirements of the specific studies (e.g. Whitley & Frost 1973). However, this kind of classification can only help understand how the specified aspect of task influences human information behavior, for example, task complexity, while tasks have been demonstrated to be multi-faceted (Pharo, 2002). As a result, this approach makes it difficult to uncover the relationship between tasks and information behavior from a comprehensive view.

In order to provide an effective tool for research into tasks and human information behavior, and also enhance the understanding of tasks, Li (2004) developed a faceted classification based on an extensive review of literature discussing task type or classification in organizational management, social psychology and information science. This classification is composed of categories, facets, sub-facets, and values (see Table 4.1_1 and Table 4.1_2).

Table 4.1_1. A faceted classification of tasks (Generic facets of tasks)

Categories	Facet of task	Sub-facets	Values	Explanation
Generic facets of tasks	Source of tasks	Organization-based	Internal imposed	Internal imposed tasks are caused by dysfunctions in operation.
			External imposed	External tasks come from the environment of an organization.
		Individual-based	Internal-generated	Tasks motivated by task doers
			External-assigned	Tasks assigned by task setters
	Task doer		Individual	Tasks conducted by only one task doer
			Individual in a group	Even though in a group, but the tasks are assigned to and completed by different members.
			Group	Tasks conducted by a group
	Time	Frequency	Unique	A task is finished at a time

			Periodical	A task is frequently done with a new assignment every time.
			Routine	A task is frequently done with the same assignment.
		Length	Short-term	A task can be finished in a short time
			Long-term	A task has to be finished in a period of time.
		Stage	Beginning	A task which just launched.
			Middle	A task which has been running for a while.
			Final	A task which is almost done
	Product		Physical	A task produces a physical product
			Intellectual	A task which produces ideas or findings
			Decision (Solution)	A task which makes a decision or finds a solution for a problem
	Process		Creating	A task to generate new ideas, designs, and so on
			Evaluating	A task to evaluate and discuss the issue
			Choosing	A task requires making a decision
			Negotiating	A task requires negotiation in order to arrive at a consensus
			Executing	A task to be performed
	Goal	Quality	Specific goal	A task with a goal that is explicit and measurable
			Amorphous goal	A task with a goal that cannot be measurable
		Quantity	Multi-goal	A task with several goals
			Single-goal	A task with only one goal

Table 4.1_2. A faceted classification of tasks (Common attributes of tasks)

Categories	Facets of task	Sub-facets	Explanation	Values
Common attributes of tasks	Task character-istics	Objective task complexity	Objective task complexity is related to the attributes such as multiple paths to a task, multiple outcomes of task, conflicting interdependence among paths and desired outcomes, and uncertain or probabilistic links among paths and desired outcomes (Campbell, 1988)	Simple tasks
				Decision tasks
				Judgment tasks
				Problem tasks
				Fuzzy tasks
		Interdepen-dence	It refers to to what extent the task demands on collective actions between task performers (Zeffane & Gul, 1993) or on work with other areas (Tushman, 1978).	High interdepend ence
				Neutral
				Low interdepend ence
		Degree of structure	Structure means logical or algorithmic processes. Different degrees of structure of a task require different logical or algorithmic processes (MacMullin & Taylor, 1984).	Well-structured
				Semi-structured
				Ill-structured
	Users' perception of tasks	Salience of a task	It is defined as the significance of a task to the task doer.	High salience
				Low salience
		Degree of urgency	It is defined in terms of whether the task is urgent or not to the task doer.	Immediate (urgent)
				Delayed (not urgent)
		Difficulty	Task doers' subjective feelings about the degree of difficulty for them to deal	Difficult to do
				Neutral

			with a task.	Easy to do
		Subjective task complexity	A task doer's perception of task complexity	Simple
				Neutral
				Complex
		Knowledge of task	To what extent a task doer know about how to finish a task-at-hand	Low knowledge
				High knowledge

It is expected that this classification could provide a helpful tool to classify work tasks and search tasks, and to investigate the relationships between tasks and human information behavior.

4.3. Search Tasks and Information Searching/Retrieval

Search tasks have drawn much attention in information science area. Marchionini (1989) conducted an exploratory study aimed at examining information-seeking strategies of novices in electronic searching environment. Two tasks as treatments were assigned to the subjects in the experiment. One was termed closed task; the other was labeled open-ended task. The former required students to locate a fact--the first year skating was introduced into the Olympic game. The subjects were required to combine three facets, i.e., place, activity, and time. For this kind of task, there was only one correct answer. The latter required the subjects to find information about women who had traveled in space. The subjects were also asked to locate facts, but many related facts may exist. These facts should combine three facets as well, i.e., person, place, and activity. The results indicate that though the subjects were equally successful in both kinds of tasks, they took more time and performed more moves for the open-ended task.

Qiu (1993a) attempted to discover users' search state patterns in a hypertext system. As a critical factor investigated in this study, two types of tasks were assigned to the subjects, i.e., a general task and a specific task. For the general task, the subjects were required to find general information about hypertext systems, including definition, history, and so forth, in order to finish a one-page encyclopedia entry. The specific task asked the subjects to locate the answers for a specific question about hypertext systems, for example, “What size should a node be?” and “What types of links should there be?” (p. 418). She found that users tended to adopt more structured search pattern when engaging in specific tasks than in general tasks. Moreover, users preferred to use browsing features for completing general tasks, but to specific tasks, analytical searching was more preferred.

Kim and Allen (2002) and Kim (2001) examined the influence of cognitive style, online database search experience, and task type on user’s search behavior on the Web. Task type referred to known item search and subject search task. Known item search task means that users need to locate and obtain a particular document for which the author or title is known, while subject search task refers to that users need to locate material dealing with a particular subject or to answer a particular question (Walker & Janes, 1999). Their investigation indicates that task type significantly affected precision and recall, search time, the number of Web pages viewed by searchers, the number of embedded links used, the use of jump tools, and the number of keyword searches completed. This illustrates that search tasks merit special attention as influential factors to shape user’s search behavior.

Hsieh-Yee (1998) conducted a study to examine users’ search tactics when they searched for known items, subject information, texts, and graphics. The results indicate that when users search for known items, whether the desired information objects are image or text does not lead to the difference of search tactics, and successful subject search greatly depends on keywords. Hsieh-Yee, Davidson, and Ozgar (1998) investigated search behavior when users engaged in a known-item search and a subject search. They found that users went through more cycles, followed more links, and used back button, history list, and stop button more frequently when performing subject searches. This indicates that a subject search task requires users to exert more effort to interact with the systems.

Toms, Freund, Kopal, and Bartlett (2002) investigated how to personalize user interface with respect to different domain-specific tasks. They specifically examined search tasks from four domains, i.e., consumer health, general research, shopping, and travel. They found that there were significant differences between users' behaviors when they conducted tasks in different domains. For example, users who were engaging in shopping or travel tasks spent more time within a site, whereas they spent more time in examining hitlists when they conducted research or consumer health tasks; users preferred to search for consumer health or research tasks but to browse when performing shopping or travel tasks. The findings suggest that for different search tasks, personalized interface is needed. Toms et al. thus put forward a list of requirements for designing the interface which deals with the four domain-specific search tasks respectively.

Based upon cognitive work analysis (CWA), Xie (2006) investigated human-work domain interaction in a corporate setting to inform corporate digital library design. Three dimensions of each of the four interactive activities (i.e. task activities, decision activities, strategy activities, and collaborative activities) and their relationships were identified. For one type of interactions, i.e., task activities (Task in this study means "information search tasks."), Xie identified three dimensions: nature of tasks, type of tasks, and time frame. By nature of tasks, she referred to whether the task was routine, typical, or new. Type of tasks includes updating information, looking for specific information, looking for items with common characteristics, and looking for known items. Time frame referred to whether the task was extremely urgent (the task should be completed within half an hour), urgent (within 24 hours) or nonurgent (more than 24 hours). This study indicates for a search task, all three dimensions are necessary to take into account. These dimensions greatly affect the decision, collaboration, and strategy activities during interaction with IR systems. The study also identified different dimensions of strategy activities, such as types of behaviors, types of resources, and types of shifts. Types of behaviors involve scanning, searching, selecting, acquiring, comparing, consulting, linking, learning, and reading. Types of resources include human, electronic and printed. Types of shifts encompass changing resources, reformulating queries, and changing behavior. This study provides empirical evidence for the three dimensions of task activities as well as for strategy activities.

In her dissertation research, Kim (2006a) focused on how search tasks could be classified and how they affected information searching interaction and information searching strategies. Grounded on literature review, various task attributes were identified, including information need, goal, topic structure, expression type, type of information needed, content, and difficulty/complexity. After perusing these attributes, Kim recognized three types of tasks: factual tasks, interpretive tasks, and exploratory tasks. Thirty subjects were recruited and experiments were conducted. The results demonstrate that task types significantly influence information searching interaction in terms of pages saved and the ratio of pages viewed to pages saved, as well as information search strategies with respect to Method, Object, and Mode (Belkin, Marchetti, & Cool, 1993). Kim further examined how different factors related to tasks, such as topic knowledge, pre-task difficulty, post-task difficulty, and so on, were correlated with various search strategies and information searching interaction. The study concludes that tasks are predictable indicators for information seeking strategies in the Web.

Gwizdka and Spence (2006) focused on factual information-seeking tasks and examined how users' behavior could indicate the difficulty of a task. Specifically, they investigated the relationship between perceived post-task difficulty, objective task complexity and measures of information search behavior. The results indicate that higher search effort, lower navigational speed and lower search efficiency were good predictors of subjective post-task difficulty. Task complexity affects subjective judgment of task difficulty and the relative importance of the predictors of subjective task difficulty. Moreover, their study illustrates other variables, such as individual differences, mediate the relationship between objective task complexity and subjective task difficulty. Their study also informs that it is necessary to take into account task characteristics, system features, and individual differences when investigating searchers' performance on tasks, search strategies, etc.

Though aforementioned studies reveal users' characteristics when they perform search tasks and illuminate that personalized interface with respect to different search tasks is necessary to be implemented in information systems, the role of work tasks playing between users, search tasks, and interfaces is neglected.

4.4. Interactive Information Retrieval

Due to the interactive nature of IR, it is hard for a user, even an expert searcher, to finish a search task only issuing one query. As a result, an iterative process is unavoidable during information search. In order to obtain useful information, users interact with various system features embedded in the systems and information returned. This section first discusses general models of IIR, and then reviews studies on users' interaction with information and interaction with system features, respectively.

4.4.1. General Models

Several models were developed to depict the process of IIR (Saracevic, 1996a). Ingwersen's model (1992, 1996) emphasizes that interaction occurs between all components involved in IR. For example, between individual user's cognitive space (including work task/interest) and information objects, between information objects and IR system setting, between individual user's cognitive space and IR system setting, and so on. Belkin's episode model (Belkin, Cool, Stein, & Thiel, 1995; Belkin, 1996) suggests that information retrieval is an iterative process that consists of a series of episodes. In each episode, different kinds of interactions happen according to user's overall and specific goals, problems, experience, and what has happened during the process of IR. The stratified interaction model proposed by Saracevic (1996a) is composed of three levels, such as surface level, cognitive level, and situational level. Interaction occurs in each level in different manners. In the surface level, users communicate with the system by querying or browsing, navigating, making relevance judgments, and so on. Users interact with the "text" or other information objects in the cognitive level. That is, they learn and assimilate the information obtained from the system and simultaneously change their knowledge state. In the situational level users interact with their tasks, and apply the retrieved information to completing tasks. Therefore, Saracevic's model involves interactions taking place during information searching, absorption, and application.

These models describe IIR in different ways. Tasks are always viewed as crucial factors involved in the process of interaction. They motivate IR process, shape users' cognitive space, influence their judgment, and determine how to apply retrieved information. However, these models only show their influence from the theoretical level, and empirical evidence is needed to justify them.

4.4.2. Interaction with Information Systems

As stated above, few studies focus on examining how work tasks influence interactive information searching behavior, whereas a series of IIR experiments were conducted to investigate interactive behavior under the administration of TREC Interactive Track. Among these experiments, Belkin et al. (2001a, 2001b, 2002, 2003a, and 2003b) designed an experimental interactive system each year in a progressive investigation of techniques supporting interactive query reformulation. They explored a number of variables related to interactive behavior, such as pages seen, unique pages seen, pages viewed, unique page viewed, number of documents saved, number of final saved documents, number of iterations, and so on. However, they have not touched upon how tasks impact these variables.

Classifying interactive behavior is also important for research into IIR. Belkin, Marchetti, and Cool (1993) proposed a four-dimensional model to classify users' interactive behavior, which was named multiple information seeking strategies (ISSs).

This model includes four facets and each facet has two sub-facets (Mode (recognition-specification); Method (scanning-searching); Goal (learning-selecting); Resource (information-meta-information)). Based on this classification, 16 strategies were identified. They designed an interactive interface, BRowsing And QUEry formulation (BRAQUE), to support ISSs, based on which they developed a prototype system MERIT (Belkin, et al., 1995).

Also based on it, Cool and Belkin (2002) further explored the issues on the classification of interactions with information. Through an empirical study, they put forth a faceted classification as follows:

- Communication behaviors

  Medium (speech, text, video…); Mode (face-to-face, mediated…); Mapping (one-to-one, one-to-many, many-to-many)

- Information behaviors

  Create; Disseminate; Organize; Preserve; Access (Method (scanning….searching); Mode (recognization….specification)); Evaluate; Comprehend (e.g. read, listen); Modify; Use (e.g. interpret)

- Objects interacted with

  Level (information, meta-information); Medium (image, written text, speech,…); Quantity (one object, set of objects, database of objects)

- Common dimensions of interaction

  Information object (part—whole); Systematicity (random—systematic); Degree (selective--exhaustive)

- Interaction criteria

(e.g. accuracy, alphabet, authority, date, importance, person, time, topic…)

Besides, four prototypical interactions with information were recognized, that is, finding a (partially) known information object, recognizing useful information objects by scanning through an information resource, evaluating the usefulness of information objects, and determining the content/structure of a set or collection of information objects. This classification is one of the most comprehensive classifications about interaction with information.

Allen (1996) was also concerned with interactive behavior. He started from answering "what happens when an individual interacts with an information system" (p.188), and identified five indispensable actions (Table 4.2) during the process of interaction.

Allen pointed out that these actions could be a sequence, and any interaction with the system requires users to scan the response, evaluate the response, learn from the response, and plan additional actions. It is worthy to note that scanning, reviewing and evaluating, learning are also recognized as interactive behaviors in Cool and Belkin's classification (2002). Hence, to some extent researchers can arrive at an agreement with respect to users' interactive behavior.

In recent years since the Web has become a popular information source, how end-users interact with the Web has drawn attention. Starting from Belkin et al.'s model, Pharo (1999) attempted to classify users' web interaction and proposed an improved model, which includes three dimensions: Method, Goal, and Resources. For Method, "scanning", "searching", and "linking" are identified as three sub-dimensions. "Learn", "select", and "illustrate" or "verify" knowledge are three sub-dimensions under Goal. He

Table 4.2. Allen's interactive behavior

Interactive behavior	Explanation
Scanning	It deals with the response from the system. By scanning, the user may "select vocabulary, identify likely texts or text representations, or find an appropriate direction in which to navigate" (p.190).
Reviewing and evaluating	It is concurrent with scanning. The user must make some judgments on what the system presents; for example, is the information useful or useless? is it satisfactory or unsatisfactory? etc. Also, this task is viewed as the first step of learning process.
Learning	The purpose of learning is to satisfy the user's information need. It involves a few sequential steps, such as comprehension, elaboration, and creation.
Planning	It means that a user may need to adjust his/her approach to the information need after s/he has dealt with informative response from the system. In other words, the user needs to "plan the development of a course of additional actions" (p.188) in order to meet information need.

removed "mode" dimension due to its confusion. Pharo also suggested using "documents" and "surrogates" to replace "information" and "meta-information" for Resources. Thus, based on this model, 18 ISSs were generated. Compared to Belkin et al.'s and Cool and Belkin's classification of interaction, Pharo's ISSs added new interactive behavior occurring in Web searching, for example, following links. However, using "surrogate" and "documents" to take the place of "meta-information" and "information" is still confusing, since "surrogate" is regarded as a type of "document."

4.4.3. Interaction with System Features

Koenemann and Belkin (1996) compared the search effectiveness of an advanced IR system (INQUERY) and one of three experimental versions, each providing a different level of interaction with a relevance feedback facility. The results indicate that the users preferred the one they can control best.

Since it is well documented that increased query length leads to improved search performance in best-match IR systems, in order to investigate the methods to elicit longer query in the Web searching, Belkin et al. (2002) conducted an experiment to see whether a query-entry line or a scrollable query-entry box was more effective in eliciting longer query. The results illuminate that the box mode led to somewhat longer queries. However, no statistically significant difference was detected. Another technique (Belkin et al., 2003a) they used was to ask searchers to describe their information problems at length, and they found that the users input significantly longer queries. Nevertheless, the difference in the length of queries did not lead to significant search performance and users' satisfaction. These two studies suggest that it could inform system design to explore how users interact with different system features though work task is not taken into account.

According to Lazonder (2000), system features which ask for interactive activities with the system, such as clicking hyperlinks, entering keywords, scrolling a page and so on, are always associated with successful strategy execution. Moreover, experienced searchers usually expended less time and more efficiently than novices because novices had to spend more time to get familiar with system functions and features, and during this process, incorrect actions usually occur (Watson, 1998; Fidel et al., 1999; Lazonder, 2000). However, what roles work tasks play within users' interaction with these features has been ignored.

Building on the naturally-collected verbal protocol data, Byrne, Jon, Wehrle, and Crow (1999) presented a taxonomy of tasks users engage in during browsing the Web (see Table 4.3). In this dissertation, what 'task' they refer to is called 'behavior'. In fact,

Table 4.3. A taxonomy of WWW use

Top-level tasks	Explanation	Subtasks
Use information task	any activities (or series of activities) in which the user was attempting to use a piece of information from the WWW	read/view/listen, save to disk, display for others, duplicate, print
Locate on page	finding the information or link on a Web page	something "interesting", related concept, tagged information, specific string, image
Go to page	The activities that bring users to a particular URL, such as back/forward button, bookmarks, hyperlinks, typing in a URL, and so on.	hyperlink, back/forward, bookmark, history list, provide URL, etc.
Provide information	Users provide information about production selection, shipping address, search criteria, and so on in order to obtain useful information from the WWW.	search string, shipping address, survey response, etc.
Configure browser	Users change the state of the browser, for example, the state of the window or windows (they may change their size, location, and so on.)	add bookmark, set helpers, change cache size, and window management (subtasks: scroll, resize window, etc.)
React to environment	The situation that the browser demands something of the user, for example, responding to a dialog box. The other typical React task is use of the reload button.	respond to dialog, respond to display change, reload, etc.

this taxonomy involves various interactive information searching behavior, for example, 'Use information task' and 'Go to page'. However, since most of actions described in the taxonomy are related to interaction with system features, this study is grouped into this category.

The taxonomy reflects users' interactive behavior when searching the Web. It informs that users' behaviors are different when interacting with IR systems and the Web. Some interactive behaviors missing from Cool and Belkin's (2002) classification are recognized in this taxonomy, for example, "configure the browser", "add bookmark", "hyperlink", "history list", and so on. Therefore, with the increased use of the Web to gather information for work tasks, interaction with information systems proves to be more complicated.

4.5. Individual Differences and IR

Individual differences have long been taken as critical factors influencing human beings' information behavior. Hackman (1969) put forward a framework for analyzing the effects of work tasks on human behavior. He listed the personal factors mediating the relationship between work tasks and outcomes, including: (1) understanding of task, (2) acceptance of task, (3) idiosyncratic needs, values, etc., (4) previous experience with similar tasks, (5) ability, (6) performance motivation, and (7) level of arousal.

Egan (1988) reviewed the individual differences which influence human-computer interaction. Based on empirical studies in text editing, information search, and programming, Egan identified several important individual differences, such as experience, technical aptitude, other aptitudes (verbal aptitude, motor aptitude, etc.), age, domain specific knowledge, personality and affect. Among these differences experience, technical aptitudes, age, and domain specific knowledge were found consistently to impact the effectiveness of computer use in many empirical studies while others did not. Nielsen (1989) compared 92 benchmark measures for hypertext usability from 30 different papers in the scientific literature. He found that individual differences among users and the effect of different tasks were two most important issues to affect usability of a system.

In the IR area Saracevic (1991) synthesized the effects of individual differences on IR tasks (indexing consistency and relevance judgment) via literature review. He addressed the influence of subject knowledge, subject expertise, and personality on relevance judgment. According to him, some agreements have been reached on this issue. For example, the greater the assessors' subject knowledge, the higher the agreement in relevance judgment. In addition, he addressed the impact of individual differences on performance, such as experience with computers, search tasks, technical aptitude, age, personality, and education background.

In addition, some individual differences have been widely investigated in information science, such as search experience, search knowledge, and domain or subject knowledge. Both Penniman (1981) and Tolle (1983) found that frequent searchers used more search commands, conducted more extensive searches, and made fewer errors when searching in MEDLINE and CATLINE respectively (Borgman, 1989). Similarly, Fenichel (1981) revealed that the novices searched more slowly, made more errors, and used less thesaurus terms than the experienced subjects. Hsieh-Yee's study (1993) indicated that search experience affected the use of many search tactics; subject knowledge became a factor to influence users' searching behavior only after they have a certain amount of search experience. Yuan (1997) pointed out that search experience impinged on several aspects of users' behavior, including commands and features used during the search, search speeds, learning approaches, and so on. With respect to search performance, many studies (e.g. Elkerton & Williges, 1984; Howard, 1983; Marchionini, Lin, & Dwiggins,

1990) showed that expert users outperformed the novices. Even though people believe that search experience greatly impacts users' behavior, once the novices are trained before searching, that is, they have necessary search knowledge, their performance will be improved (Fenichel, 1981; Meadow, Wang, & Yuan, 1995; Vakkari et al., 2003).

How domain knowledge impacts information searching draws much attention in information science. Some studies (Allen, 1991; Marchionini, Dwiggins, Katz, & Lin, 1993; Hsieh-Yee, 1993; Kiestra, Stokmans, & Kamphuis, 1994; Vakkari, et al., 2003; Wildemuth, 2004; Zhang, Anghelescu, & Yuan, 2005; Hembrooke, Granka, Gay, & Liddy, 2005) found that domain knowledge influenced users' source selection, term selection, search pattern, and other behaviors, even though there has been no consensus on its effects on search performance. However, high domain knowledge is helpful for a searcher to make relevance judgments, regardless that this searcher is an adult or a child (Marchionini, et al., 1993; Hirsh, 1997).

Ford, Miller, and Moss (2005a, 2005b) investigated how individual differences influenced web search strategies, i.e. Boolean searching or best-match searching. Individual differences in their study included study approaches, cognitive and demographic features, and perceptions of and preferred approaches to Web-based information seeking. Sixty-eight subjects were recruited to search three tasks with different levels of complexity on AltaVista. The results demonstrated that individual differences affected users' selection of Boolean or best-match searching. Specifically, the selection of Boolean searching strategy was associated with younger individuals in the more complex tasks, graphic orientation (as opposed to verbal orientation) in the most complex task, and high Boolean experience in the least complex task. The use of the best-match searching strategy was related to older individuals in the more complex tasks, low Boolean experience in the least and the most complex tasks, and high cognitive complexity in the most complex task. This study illustrates that both individual differences and task complexity are influential factors for users' selection of different web search strategies, and therefore should be taken into account when probing users' information searching behavior.

In sum, individual differences are important factors to impact IR. However, as mentioned before, the exclusion of work tasks in these studies obstacles the further understanding of this issue.

4.6. Summary of the Literature

The literature review chapter categorizes the related literature into work tasks and information seeking, work tasks and information searching, search tasks and information searching, interactive information retrieval, and individual differences and IR. The review indicates that it is worthy of exerting effort to exploring the following open issues:

- Work tasks and search tasks: few studies investigate the relationship between work tasks and search tasks. However, it is valuable to do this work since work tasks are relatively static compared to information need (Ingwersen, 1996; 1999). Some studies have demonstrated that it is effective to examine dynamic behavior through invariant factors (e.g. Rasmussen, Pejtersen, & Goodstein, 1994; Xie, 2006). Therefore, the dissertation research investigated how work tasks are related to search tasks through a faceted classification of tasks (Li, 2004).
- Work tasks and interactive information searching behavior: The review illustrates that some studies have investigated this issue, but only some aspects of interactive

behavior have been examined. More studies are still called for. In addition, mostly these studies are concerned with some aspects of work tasks and information behavior. A relatively comprehensive investigation involving different facets of work tasks and different kind of interactive behavior is still lacking. Hence, the dissertation research attempted to investigate this issue based on a faceted classification of tasks (Li, 2004).

- The role of individual differences in the relationship between work tasks and interactive information searching behavior: As reviewed above, few studies take individual differences into consideration when examining the relationship between work tasks and interactive information searching behavior, even if many studies demonstrate the influence of individual differences on users' information searching behavior. Thus, the dissertation research also investigated this issue.

Chapter 5. Research Model and Research Questions

5.1. Research Model

Based on the literature review, a refined research model was developed (See Figure 5.1). The elements of this model and their relationships are explicated as follows:

1. Context: As stated before, it is a broader concept than situation, and directly influences work tasks. That is, context determines what work tasks should be performed in order to achieve the big goal of an organization or institution. In addition, it influences seeking tasks, search tasks and information seeking and searching behavior.
2. Work tasks: A work task is defined as an activity, assigned or self-generated, for fulfilling task doers' responsibility for their work. A work task is the motivation of information seeking and retrieval. It is described by the faceted classification in this dissertation research.
3. Seeking tasks: Seeking information is necessary for some work tasks. People usually seek information from different information sources, such as human, paper-based documents, information systems, and so on. A seeking task is influenced by context and work tasks. It also impacts users' information seeking behavior.
4. Seeking behavior: It is characterized as information source selection, communication channels with people who may provide useful information, and so on. Work tasks and seeking tasks influence these behaviors. The relationship between seeking tasks and behavior will inform systems design.
5. Search tasks: Once task doer decides to search for information from information systems, s/he begins to conduct a search task. A search task is a special case of a

seeking task. Work tasks and seeking tasks trigger search tasks, while search tasks directly shape users' interactive information searching behavior.

6. Interactive information searching behavior: It includes users' behavior when interacting with information systems. Based on the literature review, the specific behaviors include querying, iterating, learning, evaluating, selecting, obtaining and other interactive behavior with different system features, such as search modes, result display format, relevance feedback feature, scroll bar, zoom in and out, and so on.

7. Individual differences: In this dissertation research, individual differences include users' domain knowledge, search experience, search knowledge, educational level, gender, and age, which are demonstrated as influential factors of human information searching behavior in many studies (See "Literature review" section). In the model, these characteristics are hypothesized to moderate the relationship between work tasks and interaction.

To sum up, this model depicts various factors involved in information seeking and search. Empirical studies are needed to examine how these factors may influence the characteristics of search tasks and interactive information searching behavior.

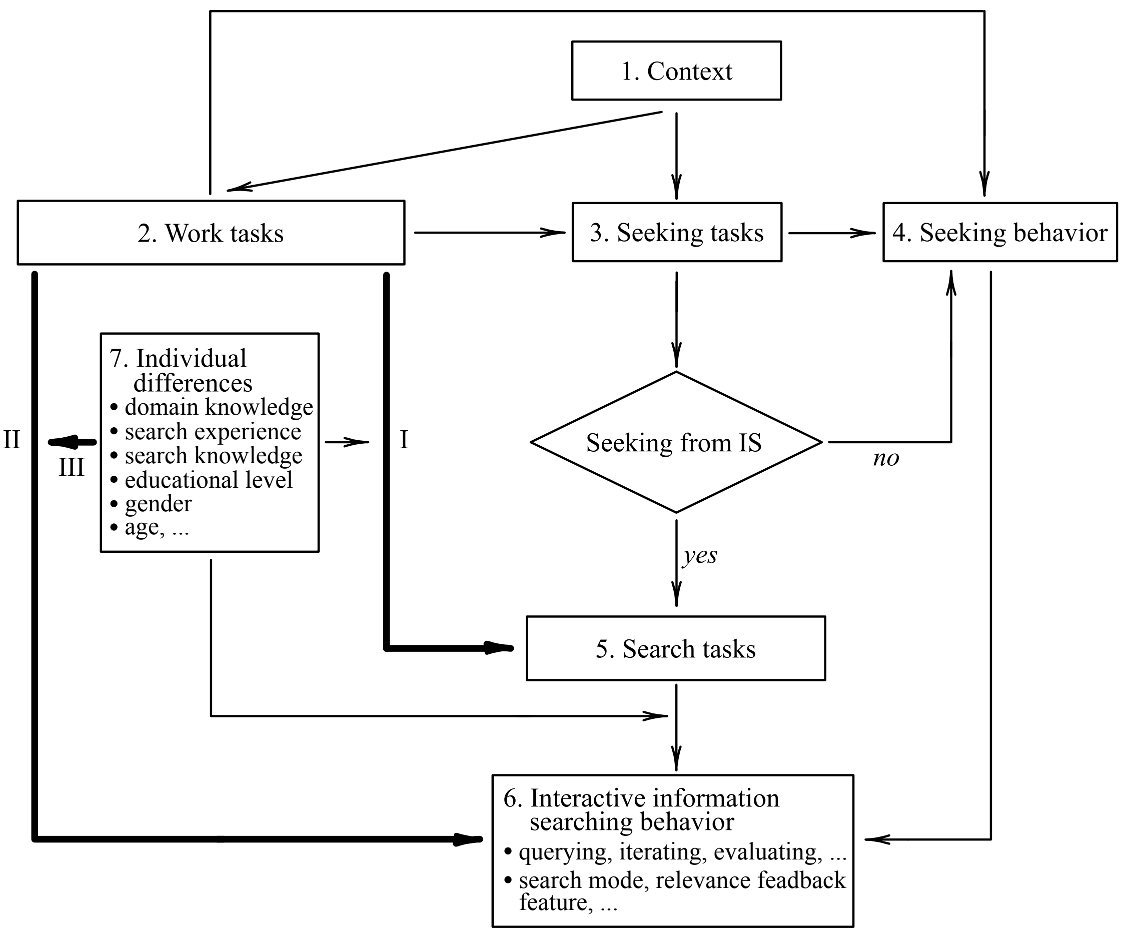

Figure 5.1. A refined research model

5.2. Research Questions

Since the research model depicts complicated relations among the elements, which are beyond the purpose of this study, this dissertation research only focuses the investigation on the highlighted relationships; that is, the relationships between work tasks and search tasks (I), and between work tasks and interactive information searching behavior (II), given that individual differences are taken into consideration (III). Also, because this research starts from a faceted classification of tasks, which was developed based on an extensive literature review, whether it is sufficient to classify the work tasks in the context investigated remains unknown. Specifically, the research questions of the proposed study include:

Q1: Are there insufficient or inappropriate facets or sub-facets or values when the faceted classification is used to classify work tasks and search tasks in a real context?

Since the faceted classification is the basis of this research, it is necessary to examine its appropriateness and sufficiency in classifying work tasks and search tasks from a real context. Through this research question, some insufficient or inappropriate facets or values will be identified. Then, the faceted classification could be refined and benefit to the following investigation.

Q2: What are the relationships between work tasks and search tasks in terms of their facets?

In this research, both work tasks and search tasks could be described using the faceted classification. Through examining the relationship between the facets of work tasks and search tasks, this study explores how work tasks are related to search tasks.

Q3: How do work tasks affect users' interactive information searching behavior, given that individual differences are taken into consideration?

Based upon the literature review, the influence of work tasks on interactive information searching behavior, especially when individual differences are taken into account, remains an open question. In this dissertation research, work tasks are described by the different facets identified in the classification, through which to examine how work tasks and different facets of work tasks affect interactive information searching behavior. Such behavior includes specific information systems they consulted, browsing web sits, iteration, query terms used, query length, and viewing and selecting search results.

Chapter 6. Methodology of Study 1

Two sequential studies, namely, Study 1 and Study 2, were designed to answer the research questions. Specifically, Study 1 targeted Q1 and Q2, and Study 2 aimed to answer Q3. This chapter describes the methods of data collection and analysis in Study 1.

The objectives of Study 1 were to:

- identify new facets, sub-facets, and values, and adjust or drop insufficient or inappropriate ones, and then refine the classification.
- examine the relationships between work tasks and search tasks in terms of their facets.
- identify the facets which substantially affect search tasks and interactive information searching behavior, based on which to identify work task types for testing in Study 2.

To limit the possible influence of context on the relationships investigated, this dissertation was conducted in a university community. Although many previous studies related to information behavior were conducted in this area, few of them investigated the relationships concerned in this research. Therefore, limiting the study to this context is still attractive.

6.1. Study 1: A Case Study through Semi-Structured in-depth Interviews

As listed above, Study 1 aimed to examine the relationships between work tasks and search tasks, and explored the key facets or sub-facets to shape users' interaction with information systems. For these purposes, it is necessary to gather typical work tasks which require searching information systems from different populations in a university community. Therefore, conducting an experiment is not appropriate for data collection because the restricted experimental design and lab settings may block in depth discussion on how work tasks motivate search tasks and affect information searching behavior. Observation is also not suitable for Study 1 since it is impossible to know how work tasks motivate information seeking only through observations. Focus group interview is an appropriate method to probe how subjects who are demographically homogenous or have certain experience in common discuss a phenomenon, a viewpoint, and an event. Its advantage lies in that researchers can observe how group interaction generates data and insights. However, this is not the focus of Study 1. Other members' comments or opinions on a member's work tasks and information seeking activities are not important here. Thus, focus group interview is not adopted for this study. Since Study 1 was based on a faceted classification of tasks, it in fact was based on a certain theoretical framework. Accordingly, a grounded theory approach which is aimed at developing theories inductively from a corpus of data is also not an appropriate approach. Since this study requires both comprehensive and deep description about work tasks and search tasks from the subjects, it is not easy to control whether the subjects provide desired data by writing journals. Therefore, writing journals seems not very helpful in terms of the purposes of Study 1.

After considering different research methods and the aims of Study 1, semi-structured in-depth interviews were taken to collect data. The semi-structured in-depth interview has turned out to be an effective method and a partially "digging tool" of social science (Lindlof, 1995). In order to answer Q1 and Q2, typical work tasks and their associated search tasks should be collected. The semi-structured in depth interview could satisfy this requirement through asking the subjects to discuss work tasks which are different from those discussed by previous subjects. This approach can also provide a chance to deeply discuss the relationships between work tasks and search tasks the subjects conducted recently. Another advantage to take semi-structured in depth interviews is that the faceted classification (Li, 2004) provides a framework to design the interview protocol.

However, the limitation of semi-structured interviews is also obvious. For example, subjects have to recall some instances. Though they are asked to talk about recent work tasks and associated search tasks, it is very possible that they may miss something (Bartlett & Toms, 2004). Moreover, for the issue of how they interact with information systems during searching for information, they may be only able to give very rough description. These shortcomings will be made up by the subsequent experiment in Study 2.

6.2. Data Collection

6.2.1. Subject Recruitment

According to Leckie et al. (1996), people's work roles determine their work tasks. To collect data for Study 1, people working in a university community and heavily depending on information systems were grouped into: Undergraduate students, Master's students, Ph.D. students, Faculty, and Support staff. Since people in these categories had different levels or work roles, they were further classified as different sub-categories. One subject was recruited through convenience sampling from each sub-category. In total 12 subjects were recruited. Table 6.1 shows the categories of the subjects and their majors or titles.

The subjects were volunteers with $10 as compensation. They signed the consent form before the interview and the receipt after the interview.

Table 6.1. Subjects recruited in Study 1

Interviewees' categories		Major	Title
Undergraduate students	Non-majored	No	
	Majored	Exercise Science and Sports Studies/Chinese (Minor)	
Master students	Non-thesis required	Education	
	Thesis required	Environmental Science	
Ph.D. students	Pre-qualified	Library and Information Science	
	Post-qualified	Environmental Science	
faculty	Faculty with administration	Library and Information Science	
	Faculty without administration	Statistics	
Support staff	Administrator		Career Management Specialist
	Secretary		Administrative Assistant
	IT service		IT manager
	Librarian		Reference Librarian

6.2.2. Task Form

To collect data, critical incident technique was employed. The subjects were required to discuss the work tasks and associated search tasks they conducted recently. A task form (see Appendix 1) was designed. It was sent to the subject two or three days before the interview. The subjects were required writing down at least three typical work tasks and associated search tasks, among which two were selected to discuss during the interview if the subject was interested in discussing them and they were different from the previous subjects' work tasks, especially different from the work tasks discussed by another subject from the same category. The task form could also save time since the subject had already listed their typical work tasks and no time was necessary to explore what their typical work tasks were and made decision for which work tasks should be discussed during the interview. So, more time could be used to discuss the relationships between work tasks and their associated search tasks.

6.2.3. Interviews

To investigate the relationships between work tasks and search tasks, the interview questions were developed based on the faceted classification. For example, the facet 'Source of task' in the classification means who the work task is from. During the interview, the interviewer asked the subjects "Was this work task generated by yourself or assigned to you by someone else? If someone else, who?" Other questions were developed in the similar way. The interview protocol was used in the pilot study, based on which it was revised (See Appendix 2). To identify new facets of work tasks and search tasks, the subjects were asked "What other aspects of this work task do you find important?" and "What any other aspects of this search task do you find important?"

During the conversation, two work tasks and associated search tasks were discussed. The interviewer asked the questions about the first pair of work task and its associated search task, and then the second pair of work task and associated search task. The interviewer asked the same questions for the two pairs of work and search tasks. Since work tasks and search tasks shared the same classification, the subjects were asked almost the same questions when discussing both of them.

The associated search task of each work task was discussed in general. The subjects usually did not split their search task as search task one or two. They gave a general description and assessment of their information search in different information resources. One exception was that Subject 6 (S6) discussed two associated search tasks for Work

Task 12 (WT12). She differentiated her search in New York Library web site and Google as different search tasks with different purposes. However, the two search tasks she described shared the same characteristics in most facets or sub-facets. For convenience in data analysis and consistence with other associated search tasks, the two search tasks were considered as one. Hence, twenty four pairs of work tasks and their associated search tasks were analyzed. All work tasks that were collected are listed in Table 6.2.

All interviews were conducted from December 17, 2006 to January 22, 2007. Most interviews were less than one hour long except two. The interviewees decided the place to talk. In total 12 interviews were conducted, and all conversations were recorded by using a digital recorder. Since the interviews were semi-structured, the follow-up questions, for example, 'why' or 'how' questions, were asked in case when the subjects did not discuss the issues in details.

6.3. Data Analysis

All interviews were transcribed. This section focuses on the qualitative and quantitative approaches to analyzing the data. Chapter 7 will report the results and findings.

6.3.1. Open Coding

A software tool, ATLAS, ti 5.0, helps to analyze the qualitative data. This software saves all codes and helps create a coding scheme. All transcripts were imported to the software. Figure 6.1 shows an example using this software tool to code the qualitative data.

Considering the purposes of Study 1, the transcripts were coded in several rounds. The first round of coding aimed to identify new facets, sub-facets, values and

Table 6.2. Work tasks (WT) and search tasks (ST) collected in Study 1

Work roles	S	WT/ST	Description
Ph.D student_post qualified	1	1	Work task: Conducting a scientific experiment Search task: Search for journal papers about the similar experiment in nitrogen tests
	1	2	Work task: Doing dissertation Search task: Search for journal articles and books which support the subject's arguments
Ph.D student_pre qualified	2	3	Work task: Writing an essay Search task: Search for articles about fairness judgment in cognitive science
	2	4	Work task: Doing a take-home exam Search task: Search related descriptions and articles about endowment effects
Master student_non thesis required	3	5	Work task: Preparing exams Search task: Search text books about biology
	3	6	Work task: Transferring to a new program Search task: Search for information about MBA program ranking and reputation
Master student_thesis required	4	7	Work task: Designing a device for an experiment Search task: Search for information about the parts needed to build the experimental system, including what parts are appropriate and the price
	4	8	Work task: Doing an assignment (answering questions) Search task: Search for images about land cover in New Jersey
Undergraduate_non majored	5	9	Work task: Doing an assignment (writing a resume) Search task: Search for journalist job description and sample resumes
	5	10	Work task: Doing a project for a course Search task: Search for books and facts about history of Jazz which help complete the paper
Undergraduate_majored	6	11	Work task: Writing a paper for extra credit Search task: Search for scholarly articles and any other information about the categorization of Parkinson disease
	6	12	Work task: Doing a final paper

			Search task: Search for books about modern China poetry
Professor_without administration	7	13	Work task: Teaching a course Search task: Search for data sets which are appropriate for the students' exercises
	7	14	Work task: Doing a research project Search task: Search for journal articles about some educational measurement for unbiased tests
Professor_with administration	8	15	Work task: Doing a research project Search task: Search for journal articles, news, web sites, web quality, instruments about food safety
	8	16	Work task: Developing courses for a new program Search task: Search for syllabi in related courses from other universities
Support_Adminstration	9	17	Work task: Locating internship opportunities for students Search task: Search for company contacts and internship opportunities for students
	9	18	Work task: Administrating the relationship between companies, faculty, and students through an information system Search task: Search for students resumes which match the internship requirements of companies
Support_IT services	10	19	Work task: Designing and building a web site Search task: Search for information about web site building and programming.
	10	20	Work task: Finding solutions for IT problems Search task: Search for solutions from software developers and computer manufacturers.
Support_Secretary	11	21	Work task: Preparing applicants' files for admission committee Search task: Search for application, such as recommendation letters, GRE scores, and so on
	11	22	Work task: Providing class roster for professors Search task: Search for class rosters as the students and faculty members requested
Support_Librarian	12	23	Work task: Providing "Ask a Librarian"

			services Search task: Search for information about the users' questions
	12	24	Work task: Collection management in a library Search task: Search for information about books, price, publishers, and so on

inappropriate or insufficient ones, and then the faceted classification was refined, based on which a coding book entailing facets, sub-facets, values, explanation, and examples was developed as well. Then the work tasks and associated search tasks were classified based on the coding book and their relationships were explored through different statistical tests. The second round coding intended to identify the possible relationships between facets of work tasks and information searching behavior. Figure 6.2 outlines the procedures of the data analysis for Study 1.

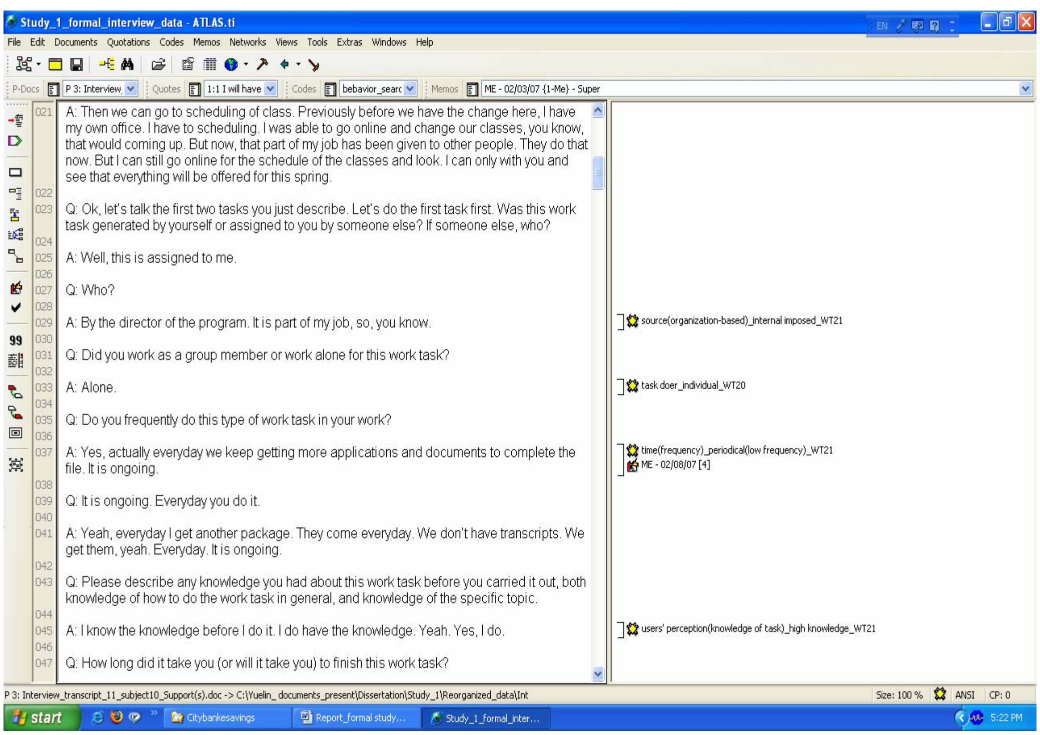

Figure 6.1. A screen shot from ATLAS, ti5.0

6.3.1.1 Recognize facets and values of work tasks and search tasks

As mentioned before, the faceted classification of tasks served as a framework of this research. The interview questions were derived from this classification. It was not hard to recognize the facets and values of work tasks and search tasks on the basis of the subjects' answers. Table 6.3 shows some examples. Through coding the data, some inappropriate sub-facets and values were identified. Then the faceted classification was refined, based on which all work tasks and search tasks were classified to explore the relationships between work tasks and search tasks. The results will be reported in Chapter 7.

Table 6.3. Examples of identifying the facet, sub-facet, and values of work tasks (WT) and search tasks (ST)

Quotations extracted from the transcripts (examples)	Facet(sub-facet)/Value
"Q: Was this work task generated by yourself or assigned to you by someone else? A: assigned by the professor." (WT5)	Source of task/External assigned
"Q: Did you work as a group member or work alone for this work task? A: Work alone, definitely." (WT2)	Task doer/individual
"Q: How long did it take you (or will it take you) to finish this work task? A: This essay? I would say five to eight hours." (WT3)	Time(length)/Short-term
"Q: What's the final results of this work task? A: It is the dissertation." (WT2)	Product/Intellectual
"Q: Can you please describe the goal of this work task? A: Help us to understand what we have learned in the class better to memorize to understand better the medical and biological issues. That is the main task." (WT5)	Goal(quality)/Amorphous
"Q: Do you frequently do this type of search task in your work? A: Yes. Q: How frequent? A: Every time when I have questions on anything, I look at Google. So I am pretty frequently." (ST9)	Time(frequency)/Routine

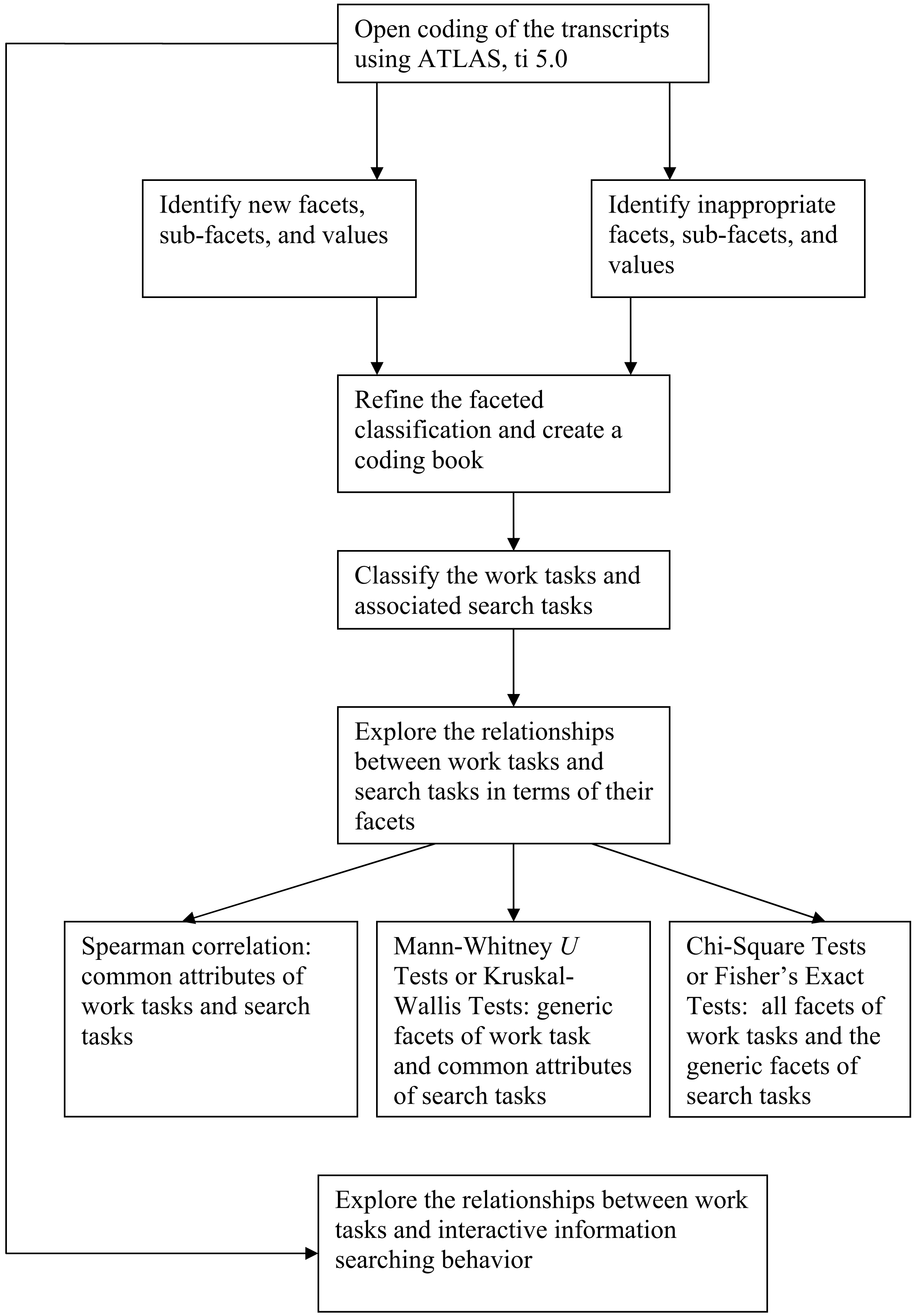

Figure 6.2. Data analysis flowchart of Study 1

Table 6.4. Examples of identifying the relationships between WT and information searching behavior

WT	Information searching behavior	Facets ----behavior
WT1	"A: I gave a combination of keywords, like "soil" and "nitrogen", usually it comes out more than I need. I narrow down the search by giving more words." "A: usually it comes out more than I need. I narrow down the search by giving more words."	KTT---query formulation
WT2	"This case mostly Web of Science, also Rutgers search engine for the books." "I usually have to go through the title first, if the title is interesting, I briefly look at the abstract. Since there is a convenient link there, I just click the link and get the full-text." "Yes, there are a good proportion of papers are not useful at all. Maybe just the title is similar, in fact, there is nothing in there and useful." "That is complex, because information like huge there. How to narrow down what you really need is not easy. For this work, I don't know, sometimes you search wrong words and get too many results. Yes, I have to say it is not easy. It takes time to try." "I will search one thing for a while, try different ways. If there is no more information, I will consider it is complete. I can never definitely say I have done it. It is always going on until I get the whole dissertation done, the whole work task done. The searching is done, just like it is goes along with work task." "You can come up good keywords from you knowledge and your experience."	Product (intellectual)---iterative search KTT---query formulation

(KTT: Knowledge of task topic)

After the classification was refined, a coding book including codes, operational definitions of the codes, and examples was established to classify the work tasks and associated search tasks (See Appendix 3).

6.3.1.2. Identify the relationships between work tasks and interactive information searching behavior

There are many work task types produced based on the faceted classification of tasks. It is impossible to test the influence of all these work task types on interactive information searching behavior in this research. Therefore, one of the purposes of Study 1 was to identify the facets which substantially affect information searching behavior. To this end, the second round coding focused on identifying the influential facets which may be related to information searching behavior. The paragraphs related to information searching behavior were extracted from the transcripts first. Then the relevant facets which were possibly related to the behavior were recognized. Table 6.4 shows some examples.

By coding the transcripts, the most influential facets which possibly affect information searching behavior surfaced. These facets were used to construct work task types for testing in Study 2. Chapter 7 will further discuss this issue.

6.3.2. Contingency Tables

After the faceted classification of task was refined, all work tasks and associated search tasks were classified based on the refined classification. SPSS produced contingency tables based on each facet of work tasks and generic facets of search tasks to examine the possible relationships between them. An example of the contingency table is shown in Table 6.5.

Through further analysis of these contingency tables, some possible relationships were recognized. For example, Table 6.5 shows that 83.3% of unique work tasks were accompanied by long-term search tasks, while 87.5% of intermittent work tasks and 70% of routine work tasks were associated with short-term search tasks. These relationships were further tested through Chi-Square Tests or Fisher's Exact Tests (if the contingency tables were 2 x 2 tables).

6.3.3. Relationships and Nonparametric Tests

For the facets categorized into 'Common attributes of tasks', the values usually imply different degrees; for example, for 'Interdependence' the values include 'High', 'Moderate', and 'Low'. Therefore, nonparametric tests were employed to process these ordinal data. SPSS software was used to carry out all statistical tests. Specifically,

- Spearman correlation examined the relationships between common attributes of work task and search tasks. Since work tasks and search tasks were classified based on the same classification in terms of their common attributes, all these attributes were measured by ordinal data, i.e., 'High', 'Moderate', and 'Low'. In SPSS, they were coded as '1', '2', and '3' respectively. Spearman correlation was also used to test the correlation between the attributes of work task and between the attributes of search task to see whether there were highly correlated attributes in terms of work tasks and search tasks respectively.
- Mann-Whitney *U* Tests and Kruskal-Wallis Tests explored the possible relationships between the generic facets of work tasks and common attributes of search tasks. Mann-Whitney *U* tests here tested whether two groups of work tasks (for example, 'long-term' and 'short-term' work tasks) had significant difference

in their associated search tasks' attributes, while Kruskal-Wallis Tests examined whether three or more groups of work tasks (for example, 'unique', 'intermittent' and 'routine' work tasks) had significant difference in their associated search tasks' attributes.

Figure 6.2 shows the relationships investigated between work tasks and search tasks and the tests were applied.

Table 6.5. Values of Time (Frequency) (WT) * values of Time(Length) (ST)

			values of time(length) (st)		Total
			short-term	long-term	
values of time (frequency) (wt)	unique	Count	1	5	6
		% within values of time (frequency) (wt)	16.7%	83.3%	100.0%
	intermittent	Count	7	1	8
		% within values of time (frequency) (wt)	87.5%	12.5%	100.0%
	routine	Count	7	3	10
		% within values of time (frequency) (wt)	70.0%	30.0%	100.0%
Total		Count	15	9	24
		% within values of time (frequency) (wt)	62.5%	37.5%	100.0%

In summary, this chapter addresses how data were collected and processed in Study 1. To articulate the relationships between work tasks and search tasks, both qualitative and quantitative data analyses were employed to mine the data. The results and findings will be reported in Chapter 7.

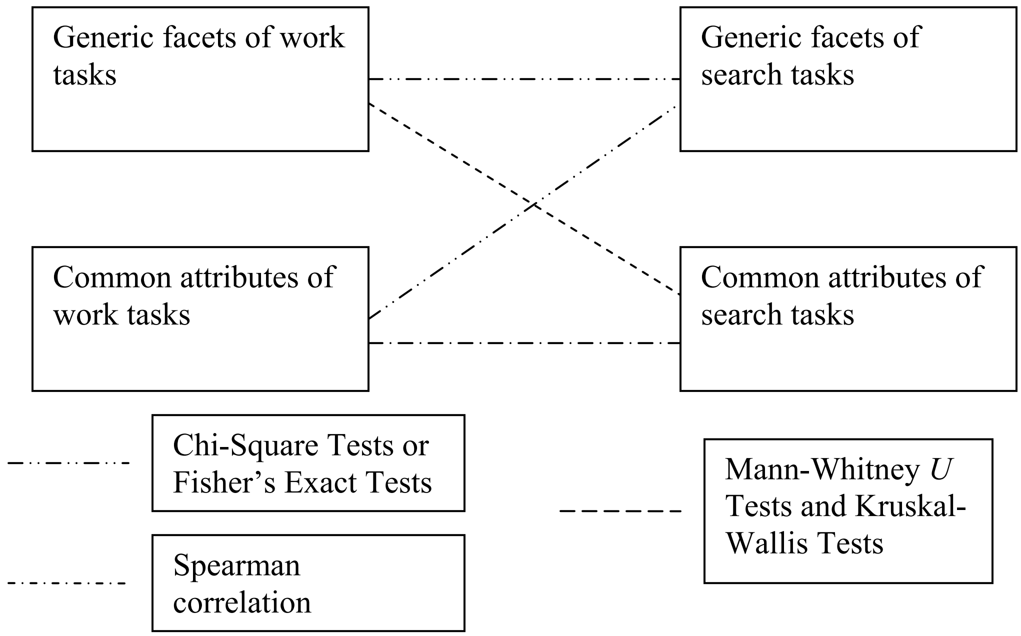

Figure 6.3. Statistical tests used for the relationships between work task and search task facets

Chapter 7. Results of Study 1

This chapter reports the results and findings of Study 1. Based on the data analysis, the faceted classification was refined in terms of real work tasks collected in a university community. Study 1 also explored the relationships between work tasks and search tasks and identified the facets or sub-facets which substantially affected information searching behavior. Moreover, the work task types which could be used in Study 2 were identified based on the consideration of the relationships between work tasks and search tasks, and work tasks and interactive information searching behavior.

7.1. A Refined Faceted Classification of Tasks

As mentioned above, the purpose of the first round coding was to recognize new facets, sub-facets, and values of work tasks and search tasks. Based on the data, there were no new facets detected. The answers of most subjects to the two questions: "What any other aspects of this work task do you find important?" and "What other aspects of this search task do you find important?" reflected the aspects which had been included in the faceted classification. Other subjects' answers were not related to facet of task at all. For example, S10 discussed the communication issues between team members. However, some new sub-facets and values emerged; some sub-facets and values were found inappropriate or insufficient and should be adjusted.

7.1.1. Sub-facets Adjusted or Dropped

Several sub-facets were found inappropriate to classify work tasks and search tasks collected in Study 1:

- Organization-based and Individual-based: These two sub-facets of the facet 'Source of task' in the original version of the faceted classification. However, during classifying the real work tasks, it was found that both 'Internal-imposed' tasks and 'External-imposed' tasks were in fact 'External-assigned'. Therefore, these two sub-facets were dropped but 'Internal-generated' and 'External-assigned' were kept as values of the facet 'Source of task'.

- Knowledge of task: The pilot study of Study 1 indicated that 'Knowledge of task' was not a sufficient sub-facet. During the interview, some subjects asked the interviewer to clarify what kind of knowledge of task they should discuss. After analyzing the data two types of knowledge of task surfaced: One is 'Knowledge of task topic' (KTT) (refers to the knowledge on the content of the task) and the other is 'Knowledge of task procedure' (KTP) (refers to the knowledge on the procedures to complete the task). Therefore, in the formal study, a question was added to ask the subjects to provide their knowledge level in KTT and KTP respectively. Some subjects gave completely opposite answers to these two aspects of knowledge of task. For example, S7 was an assistant professor in her first year. She said that she was quite knowledgeable in the course she offered, but she was not knowledgeable in how to teach and interact with her students in the classroom. She evaluated her KTT as 'High', but KTP as 'Low'. So it was necessary to divide 'Knowledge of task' into 'Knowledge of task topic' (KTT) and 'Knowledge of task procedure' (KTP).
- Objective task complexity: The sub-facet 'Objective task complexity' turned out to be problematic. This sub-facet and associated values were derived from Campbell (1988). He pointed out that objective task complexity "implies an increase in information load, information diversity, or rate of information change"

(p.43), based on which he addressed four basic complexity attributes: (1) multiple paths to tasks; (2) multiple desired outcomes of tasks; (3) conflicting interdependence among paths and desired outcomes; (4) uncertain or probabilistic links among paths and desired outcomes. On the ground of these attributes, Campbell (1988) identified 16 types of task and characterized them into simple tasks, decision tasks, judgment tasks, problem tasks, and fuzzy tasks. Different tasks involve different complexity attributes. However, Study 1 indicated that it was difficult to classify both work tasks and search tasks according to Campbell's task types, since the data collected in Study 1 did not provide detailed information related to the dimensions of task complexity. On the other hand, it was obvious that some work tasks or search tasks in Study 1 were more complex than others. These tasks involved more activities, more information sources consulted, and more comprehensive information search. Therefore, based on the data the sub-facet 'Objective task complexity' was redefined as the quantity of activities required completing a task. Although this number might be dependent to some extent on how any one individual decides to address a particular task, it can also be construed as a characteristic of the task itself. For instance, the task of completing a dissertation requires many different activities, or even, many different sub-tasks, while determining a student's registration status might require only the single activity of accessing the appropriate database. This definition of "objective task complexity" thus corresponds roughly to Campbell's "multiple paths to tasks" dimension, and stands in contrast to "subjective task complexity", which is the individual's *perception* of how complex the task is.

- Structure: 'Structure' was defined from two aspects: (1) whether the procedure to complete the task is known; (2) whether the objective of task is clearly defined. However, since a new sub-facet 'Knowledge of procedure' was added, it is not necessary to still keep 'Structure' since they overlap to some extent. Therefore, 'Structure' was dropped.

In addition, 'Degree of urgency' was changed to 'Urgency' for keeping consistent with other labels, for instance, 'Difficulty".

7.1.2. Values Added, Dropped, or Adjusted

The data analysis indicated that some of values were inappropriate. Thus, some values should be dropped or adjusted and some new values should be added.

- Source of task/Collaboration: For the facet 'Source of task', a new value 'Collaboration' was added. Some subjects felt that it was hard to answer whether the work task was generated by them or assigned by someone else since some work tasks were neither generated by the subjects themselves nor assigned by someone else, but the result of collaboration with colleagues or group members. For example, S8 said: "Well, it can be one and other. I am thinking now (it) is my interdisciplinary work. It is not the assigned. I would decide in collaboration with them what I am gonna to do." For such kind of task, the original values of the facet 'Source of task' (Internal generated, and External assigned) were not sufficient. Therefore, a new value 'Collaboration' was added.
- Time (Frequency)/Intermittent: In order to differentiate the tasks which were conducted frequently from which were not frequently conducted, the values 'Periodical' and 'Routine' in the facet 'Time' were redefined. 'Periodical' tasks

meant that the tasks which were conducted more than one time but with low frequency, while 'Routine' tasks were conducted frequently, both based on the subjects' assessment. Also, since 'Periodical' implies that something happens periodically, it is not an appropriate label here. Therefore, 'Intermittent' took its place.

- Product/Factual, Image, and Mixed (for search tasks): Though work tasks and search tasks were supposed to share the same classification scheme at the outset, for search tasks it was hard to share the same values with work tasks in terms of the facet 'Product'. No products of search tasks could be classified as 'Physical'. As a result, new values for search tasks were needed. Based on the data, 'Factual', 'Image', and 'Mixed product' emerged. For example, S5 said: "I use Google to look up like the job description and I think those are my sources" when engaging in WT9. "Job description" was looked at as a "Factual" product of the associated search task of WT9 (ST9). To WT8, S4 conducted very different information search since she searched for image. So 'Image' as a value of 'Product' was added. On the other hand, some subjects searched for different sorts of products, including journal papers, factual information, image, video, and so on, for example, ST15. For such search tasks, a value 'Mixed product' was added.
- Process/One-time and Multi-time: In the faceted classification, the facet 'Process' included five values, i.e., 'Creating', 'Evaluating', 'Choosing', 'Negotiating', and 'Executing'. However, in practice it was not easy to classify real tasks based on these values. Some tasks involved different types of process. For example, WT13 involved 'Evaluating' and 'Creating' since the subject had to compare different

existing approaches to solve their research question ('Evaluating'), and propose their own method ('Creating'). This violated the requirement of a faceted classification, since a task could only be classified into one value with respect to one facet. Therefore, it was imperative to reconsider the values of the facet 'Process'. Some subjects emphasized that their work tasks or search tasks could not be completed one time. They needed to engage in them repeatedly or multiple times. For example, S4 described the procedure to complete WT7: "…So it is kind of back and forth, and talking to them (workers) and then coming back to catalogue ordering and going back and forth for like a month and finally to start ordering, and after all the parts arrived and started building, and eventually we set up thing in the lab and we started testing run. The testing run sometimes worked; sometimes failed. When it was failed we got together to discuss what was the problem and tried to fix it. So, repeating." This was different from the process of conducting WT11, for which S6 directly searched Google and easily obtained the information needed, and then wrote the paper. Therefore, it could be seen that there were two approaches to completing tasks here: One was labeled as multi-time process and the other was named one-time process.

- Goal (Quality)/Mixed goal: For tasks with multiple goals, some goals were very specific, but some goals were amorphous. For example, S7 conducted a research project (WT14), which had two goals. One was to answer the research questions and the other was to "get (a paper) published". Obviously, the first goal is amorphous, while the second one is specific. For such tasks, a value 'Mixed goal' was added.

- Objective task complexity/High, Moderate, and Low complexity: As mentioned above, the sub-facet ‘Objective task complexity’ was redefined. Accordingly, the previous values (‘Simple tasks’, ‘Decision tasks’, ‘Judgment tasks’, ‘Problem tasks’, and ‘Fuzzy tasks’) were not appropriate and new values were necessary. ‘High complexity’, ‘Moderate complexity’, and ‘Low complexity’ were assigned as the values of the sub-facet ‘Objective task complexity’. They are defined based on how many activities are involved in a work task, and how many information sources people consulted during the search.
- Salience of task/Moderate salience: For salience of ST24, S12 said: “The search task, well, it is personal. Sometimes you can, if you forget it, you skip this one. It is fine. Still you know the book, but the thing is that if you want to make a good order, if you want to make your collection good, if like I describe healthy, the more search task, you do the better job you had.” So it is not easy to say whether this task is high salient or low salient task. For such tasks, a ‘Moderate salience’ value was added.
- Urgency/Moderate urgency: In the faceted classification, there are only two values for the sub-facet ‘Degree of urgency’. However, some tasks, especially routine tasks, the degree of urgency relied on the specific situation. For example, when S10 described the urgency of WT20, she said: “The urgency depends on how urgent it is for you (the client). For example, if they (the clients) need to make a conference call tomorrow morning, but the phone is not working now. Obviously, you know, like the priority issue. But if they find out the Internet is not working, but they are in vacation for two weeks, then we have two weeks to

fix the problem, so entirely determined by the person to bring up the problem." So, a value 'Moderate' was added for such tasks.

- Knowledge of task topic/High, Moderate, and Low knowledge and Knowledge of task procedure/High, Moderate, and Low knowledge: 'Knowledge of task topic' and 'Knowledge of task procedure' were new sub-facets. Most subjects used "a lot", "some", "a little bit", or "not at all" to describe their knowledge levels. Correspondingly, the values 'High', 'Moderate', and 'Low' knowledge were assigned to these two sub-facets.

In summary, taking into consideration the results and findings in Study 1, a refined classification is presented below (See Table 7.1). It is noted that this refined classification incorporates all new sub-facets and values and adjustments into the original version of the faceted classification of tasks. Operational definitions are also listed. This refined classification is expected to be more appropriate and sufficient to classify work tasks and their associated search tasks in a university community.

7.2. Relationships between the Facets of Work Tasks and Search Tasks

The section reports the inter-relationships between work tasks and search tasks by examining the relationships between their facets.

7.2.1. Relationships between the Facets of Work tasks and the Generic Facets of Search Tasks

As described in Chapter 6, the contingency tables were analyzed through Chi-Square Tests or Fisher's Exact Tests. Table 7.2 presents the significant associations between the facets of work tasks and the generic facets of search tasks.

Table 7.1. A refined faceted classification of tasks

	Facets	Sub-facets	Values	Operational definitions
Generic facet of task	Source of task		Internal generated	A task motivated by a task doer. It is a self-motivated task
			Collaboration	A task motivated through discussion among a group of people
			External assigned	A task assigned by task setters based on their individual purpose
	Task doer		Individual	A task conducted by one task doer
			Individual in a group	A task assigned and completed by different group members separately, though they are in a group
			Group	A task conducted by a group of people (at least two people)
	Time	Frequency	Unique	A task conducted for the first time
			Intermittent	A task conducted more than one time but assessed by task doer as not frequently conducted
			Routine	A task assessed by task doer as frequently conducted
		Length	Short-term	A task which could be finished within one month
			Long-term	A task which has to be finished for more than one month
		Stage	Beginning	A task which just launched.
			Middle	A task which has been running for a while.
			Final	A task which is almost done
	Product		Physical (for WT)	A task which produces a physical product

			Intellectual (for WT and ST)	A task which produces new ideas or findings
			Decision/Solution (for WT)	A task which involves making a decision or solves a problem
			Factual information (for ST)	A task locating facts, data, or other similar items in information systems
			Image (for ST)	A task locating image in information systems
			Mix product (for ST)	A task locating different types of items in information systems
	Process		One-time task	A task accomplished through one process without repeated procedures
			Multi-time task	A task accomplished through repeatedly engaging in the same or similar process
	Goal	Quality	Specific goal	A task with explicit or concrete goals
			Amorphous goal	A task with abstract goals
			Mixed goal	A task with both concrete and abstract goals
		Quantity	Multi-goal	A task with two or more goals
			Single-goal	A task with only one goal
Common attributes of task	Task characteristics	Objective task complexity	High complexity	A work task involved at least five activities during engaging in the task; a search task involved searching at least three information sources
			Moderate	A work task involved three or four activities during engaging in the task; a search task involved searching two information sources
			Low complexity	

A work task involved one or two activities during

				engaging in the task; a search task involved searching one information source
		Interdependence	High interdependence	A task conducted through collaboration among a group of people (at least two people)
			Moderate	A task conducted by one task doer with suggestions or help from other people or group members
			Low interdependence	A task conducted by one task doer without any help from other people
	User's percepti on of task	Salience of a task	High salience	A task assessed by the task doer as highly important
			Moderate	A task assessed by a task doer as moderate importance or the degree of salience depends on specific situations
			Low salience	A task assessed by the task doer as not important
		Urgency	Immediate (urgent)	A task assessed by a task doer as highly urgent
			Moderate	A task assessed by the task doer as moderately urgent or the degree of urgency depends on specific situations
			Delayed (not urgent)	A task assessed by the task doer as no urgency
		Difficulty	High difficulty	A task assessed by a task doer as high difficulty
			Moderate	A task assessed by a task doer as moderate difficulty or the degree of difficulty depends on specific situations
			Low difficulty	A task assessed by a task doer as no difficulty or easy to complete

		Subjective task complexity	High complexity	A task assessed by a task doer as highly complex
			Moderate	A task assessed by a task doer as moderately complex or the degree of complexity depends on specific situations
			Low complexity	A task assessed by a task doer as simple
		Knowledge of task topic	High knowledge	A task assessed by a task doer as highly knowledgeable on the task-related topic
			Moderate	A task assessed by a task doer as moderately knowledgeable on the task-related topic or the degree of knowledge on the task topic depends on specific situations
			Low knowledge	A task assessed by a task doer as not knowledgeable on the task-related topic
		Knowledge of task procedure	High knowledge	A task assessed by a task doer as highly knowledgeable on the method or procedures to completing the task
			Moderate	A task assessed by a task doer as moderately knowledgeable on the method or procedures to completing the task or the degree of knowledge on the method or procedures depends on specific situations
			Low knowledge	A task assessed by the task doer as not knowledgeable on the method or procedures to completing the task

Table 7.2 shows that in terms of the generic facets of search tasks, only 'Time(length)' and 'Product' are significantly related to different facets of work tasks.

7.2.2. Relationships between the Generic Facets of Work Tasks and Different Attributes of Search Tasks

As noted above, ordinal data (i.e., High (1), Moderate (2), and Low (3)) were collected for different search task attributes. All work tasks were classified into different values in terms of different generic facets or sub-facets. Mann-Whitney *U* Tests and Kruskal-Wallis Tests were employed to test the relationships between the generic facets of work task and search task attributes.

Table 7.2. Possible relationships between the facets of WT and the generic facets of ST

Work tasks	Search tasks	Tests
Time(frequency)	Time(length)	χ^2 (2, n=24) = 7.75, p<.05
Time(length)	Time(length)	Fisher's Exact Test, p<.01
Goal(quantity)	Time(length)	Fisher's Exact Test, p<.05
Objective task complexity	Time(length)	χ^2 (2, n=24) = 13.76, p<.01
Interdependence	Time(length)	χ^2 (2, n=24) = 6.42, p<.05
Difficulty	Time(length)	χ^2 (2, n=24) = 7.04, p<.05
Subjective task complexity	Time(length)	χ^2 (2, n=24) = 6.52, p<.05
Knowledge of task topic	Product	χ^2 (6, n=24) = 16.44, p<.05

A Kruskal-Wallis analysis of variance revealed that the degree of task interdependence of search tasks was significantly different across different values of source of work tasks (χ2 (2, n=24) = 7.53, p<.05). The effect of source of work task on the degree of search task interdependence was significant. The mean ranks of the three types of search tasks in task interdependence were 16.00 (internal-generated task), 4.33 (collaboration), and 13.42 (external-assigned task), respectively. The degree of task interdependence of search tasks motivated by the collaboration-based work tasks was higher than the degree of task interdependence of search tasks motivated by the internal-generated or external-assigned work tasks. This means that if a work task is generated through group members' collaboration, the search tasks conducted by the group members are more interdependent.

Also, a Kruskal-Wallis analysis of variance indicated that the degree of the subjects' knowledge level of search task topic was significantly different across the different values of work task product. This means that the effect of product of work tasks on the subject's knowledge level of search task topic was significant ($\chi 2$ (2, n=24) = 6.50, $p<.05$). The mean ranks of the subjects' knowledge level of search task topic were 8.83 (physical), 15.88 (intellectual), and 9.92 (decision/solution). The subjects had the least knowledge on search task topic when the subjects were engaging in the search for the intellectual work tasks.

A Mann-Whitney *U* Test indicated that the difficulty of search tasks was significantly lower when the subjects were engaging in the one-time work tasks than multi-time work tasks (n=24, z=-2.10, $p<.05$). This indicates that the one-time work tasks more possibly led to search tasks with low difficulty, whereas multi-time work tasks more probably resulted in search tasks with high difficulty.

Also, a Mann-Whitney *U* Test detected that the subjective task complexity of search tasks was significantly higher when the subjects were conducting the multi-goal work tasks than single-goal work tasks (n=24, z=-2.08, $p<.05$). Hence, it is possible that the multi-goal tasks led to highly complex search tasks, while the single-goal work tasks were associated with search tasks with low complexity.

7.2.3. Relationships between Work Task Attributes and Search Task Attributes

The relationships between work task attributes and search task attributes were examined by Spearman correlation analyses. Figure 7.1 shows the significant correlations between them.

- A significant correlation was found between objective task complexity of work tasks and objective task complexity of their associated search tasks ($r_s(24) =.616$, $p<.01$). This means that more objective complexity work tasks were associated with more objective complexity search tasks.
- Task interdependence of work tasks was significantly correlated with task interdependence of their associated search tasks ($r_s(24) =.545$, $p<.01$). This indicates that higher interdependent work tasks were associated with higher interdependent search tasks.
- A significant correlation was detected between degree of urgency of work tasks and degree of urgency of their associated search tasks ($r_s(24) =.681$, $p<.01$). More urgent work tasks were found to be associated with more urgent search tasks. In addition, urgent work tasks were significantly correlated with subjective complexity search tasks ($r_s(24) =.469$, $p<.05$) and objective complexity search tasks ($r_s(24) =.441$, $p<.05$). The urgency of work tasks may raise the complexity level of search task in both subjective and objective aspects.
- The correlation between difficulty of work tasks and objective complexity of their associated search tasks was significant ($r_s(24) =.468$, $p<.05$). This positive correlation indicates that more difficult work tasks were associated with more

objective complexity search tasks. In addition, a significant correlation was found between difficulty of work tasks and subjective complexity of their associated search tasks ($r_s(24)=.625$, $p<.01$). More difficult work tasks were associated with more subjective complexity search tasks.

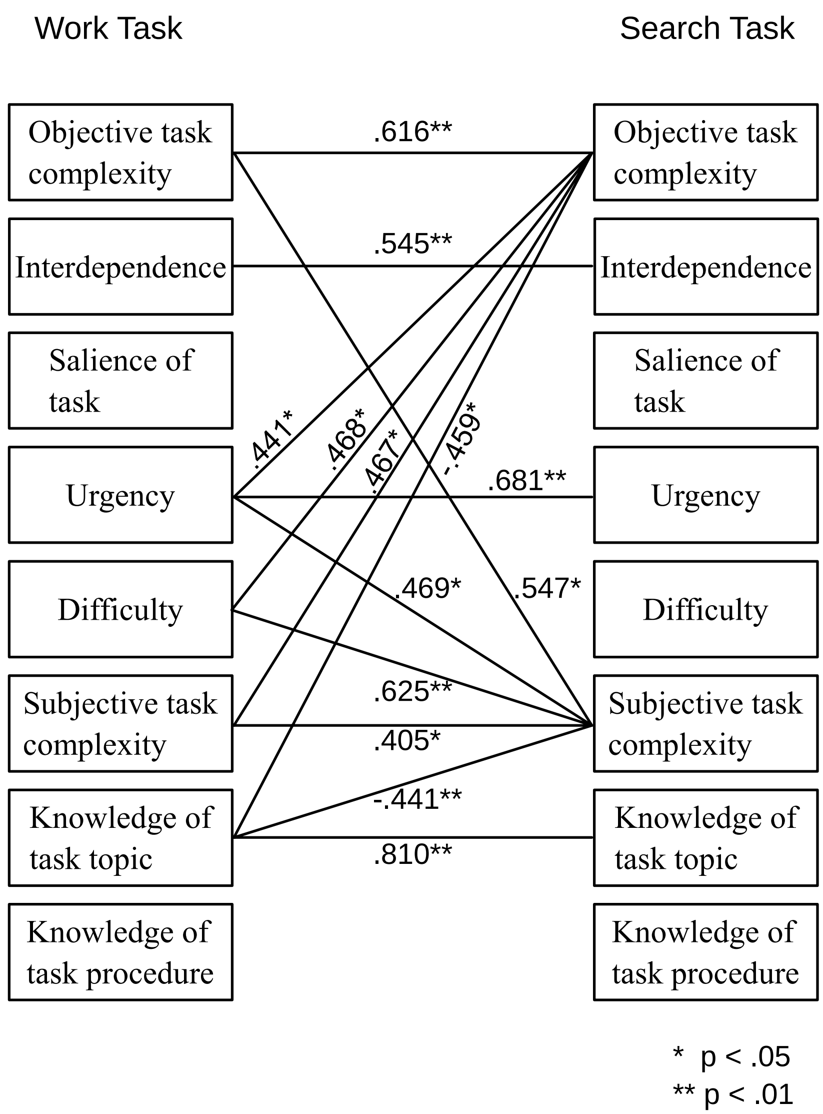

Figure 7.1. Correlations between common attributes of work tasks and search tasks

- A significant correlation was detected between subjective complexity of work tasks and their associated search tasks ($r_s(24)=.405$, $p<.05$). This means that more subjective complexity work tasks were associated with more subjective complexity search tasks. Moreover, subjective complexity work tasks were found to be significantly correlated with objective complexity search tasks ($r_s(24)=.467$, $p<.05$).

- There was a significant correlation existing between the subjects' knowledge level of work task topic and objective complexity of their associated search tasks ($r_s(24)=-.459$, $p<.05$). This negative correlation means that if the subjects were engaging in the work tasks they had higher knowledge level of task topic, the associated search tasks they conducted were in lower complexity (objective). Additionally, a highly significant correlation was found between knowledge level of work task topic and knowledge level of associated search task topic ($r_s(24)=.810$, $p<.01$). This means that if a subject was more knowledgeable in work task topics, she/he also was more knowledgeable in its associated search task topics.

However, since all work tasks collected were assessed as 'High salience' work tasks, Study 1 did not see significant relationships between salience of work tasks and different search task attributes. Also, knowledge of work task procedure had no significant correlation to any search task attributes. Figure 7.1 shows that 'Difficulty' and 'Knowledge of task procedure' are not significantly correlated with any work task attributes.

Since most work tasks collected were 'Final' work tasks, there were no enough data to examine the relationships between 'Time(Stage)' of work tasks and the facets of search tasks and interactive information searching behavior. Therefore, this study did not consider task stage issue.

To summarize, the facets and sub-facets of work tasks which substantially affect search tasks are listed in Table 7.3.

Table 7.3. Facets and sub-facets of work tasks which substantially affect search tasks

	Facets	Sub-facets
Generic facet of task	Source of task	
	Time	Length
	Time	Frequency
	Product	
	Process	
	Goal	Quantity
Common attributes of task	Task characteristics	Objective task complexity
		Interdependence
	User’s perception of task	Urgency
		Difficulty
		Subjective task complexity
		Knowledge of task topic

7.3. Facets Related to Interactive Information Searching Behavior

As explained in Chapter 6, the second round of open coding attempted to identify the possible relationships between the facets of work tasks and interactive information searching behavior. Since it was not realistic to require the subjects to recall their specific behavior when searching information systems, during the interview only some general questions about their information searching were asked, for example, what specific sources they consulted, procedure of information searching, and so on (See Appendix 2). Table 7.4 lists all codes which indicated the relationships between facets and information searching behavior.

It is noted that only some of facets or sub-facets were identified to be related to information searching behavior from the data. Based on the frequency number of the codes, the most influential facet or sub-facet seemed to be ‘Knowledge of task topic’

(18), then 'Product' (9), 'Subjective task complexity'(4), 'Urgency' (1), and 'Difficulty' (1). Among them there was one generic facet: 'Product', and others were work task attributes.

Table 7.4. Facets which possibly affect information searching behavior (highlighted parts give the reason to assign the corresponding codes)

Facets or Sub-facets	Codes	Examples (Quotations)
Knowledge of task topic	KTT---query formulation	"A: I gave a combination of keywords, like "soil" and "nitrogen", usually it comes out more than I need. I narrow down the search by giving more words." (ST1)
	KTT---go to a specific system (Google)	"Basic search, yeah, just the box, simple box, basic search, yeah, because I was thinking, I thought that I could get the whole bunch of articles, related articles to this bias, because it is very, I mean, very well-known bias in psychology area, and had been replicated by many literature. So I think there should have something in Google." (ST4)
	KTT---selecting information	"I can just read the abstract part and decide whether I need that web site or not." (ST11)
	KTT (low)---search mode (basic search) KTT (high)---search mode (advanced search)	"what kind of circumstance we do advanced search. When we found who the researchers were, we would put their name, you know, as the author in the advanced search. Once we get some terms done, then we put the terms limited to say, title or index field, you know, that is, really to narrowing down when you do the basic search, and then you just need to see what the pattern are, what the words are, so we did the basic search and then we did advanced search as we became more knowledgeable." (ST15)
Product	Product (intellectual)---iterative search	"I will search one thing for a while, try different ways. If there is no more information, I will consider it is complete. I can never

		definitely say I have done it. It is always going on until I get the whole dissertation done, the whole work task done. The searching is done, just like it is goes along with work task." (ST2)
	Product (intellectual)---go to a specific system (Gale group)	"Yeah, library has it too. I access (Gale group) from our school. If I would not write the paper, I would not do that." (ST10)
	Product (decision/solution)---go to specific systems (Google or vendors' web sites)	"The next step is where to look for IT solutions. When you check the basic, everything seems to be OK. Now you got the problem, and you don't know what the cause is. So we do research, we rely on each other. Each other is based on the experience, based on the knowledge, what the possible cause could be. Once you find the cause, in the IT profession, some causes, we know the answer to it already, because it is supposed to know for the job. Other things we don't know who is knowing. That is you thought to seek information, whether you call company, you go Google, you go Microsoft database, that is, you know the causes, you need to find the solutions now." (ST20)
Subjective task complexity	Subjective task complexity (low) ---query formulation	"Yeah, because like it is simple, so what I put in Google as simple as it is. It is not like a big paper where I have to find a little details." (ST9)
	Subjective task complexity---go to library	"This one is in the new field. I don't know where I can get most of the paper, so actually I think when sometimes it is complicated for me. I usually have to go to the library to check out the book for that, if so I can. I think there are must have some online sources for that kind of journal." (ST14)
Urgency	Urgency (immediate)---go to specific systems (web site and BBS, rather than library)	"Because this project is very urgent, I want to those sources which provide me quick reply. I don't want to do substantial very comprehensive search. For example, go to library to borrow some books. It takes too long time to read. And to update, I need more updated more fast information, so I go to web

		site. I go to BBS." (ST6)
Difficulty	Difficulty (low)---search mode (advanced)	"For this one, sometimes advanced search, because it is easy. Like, because I know specifically, like, this is what part of Jazz music. Jazz music is such a broad topic. You need like "the history of Jazz", and like I will do that. And like, in the database, there are be stuff like history, like opinion, auditoria. I will check history in advanced search, because I want to like the factual research." (ST10)

- Knowledge of task topic (KTT): Table 7.4 indicates that KTT was related to different aspects of information searching behavior. Mostly it influenced where the subjects went to for useful information, such as databases, OPAC, or search engines. It also affected the subjects' query formulation. Understanding of the topic helped the subjects to identify effective search query terms. The subjects also decided what information they selected to use based on their knowledge of task topic. Besides, low or high knowledge of work task topic seemed related to the subjects' usage of the search mode (i.e. basic search, advanced search, and so on).
- Product: 'Product' of work tasks was also an important facet which influenced information searching behavior. Compared to other aspects of information searching behavior, 'Product' seemed more important in determining what specific systems the subjects went to. Additionally, the product of a work task was possibly related to the subjects' iterative search in information systems, S1 tried different ways to do search for completing an intellectual work task (ST2, see Table 7.4).

- Subjective task complexity: It seemed that less complexity work tasks may lead to less complexity search queries which involved fewer keywords, for example, for ST9 (see Table 7.4). Besides, subjective task complexity seemed to influence the subjects' decision on where to search, for example, for ST 14 (see Table 7.4).
- Difficulty: Some empirical evidence indicated that the degree of difficulty of work tasks may affect the subjects' selection of the search mode. S5 used advanced search for WT10 since it was easy.
- Urgency: S3 discussed how degree of urgency of WT6 influenced her information search. Since WT6 was an immediate task, the subject had to gather information in a tight time. She only selected the systems which could provide quick response or reply, and she did not conduct a comprehensive information search due to the high degree of urgency of the work task.

Table 7.5 lists the facets and sub-facets which substantially affected information searching behavior.

Table 7.5. Facets and sub-facets of work tasks which substantially affect information searching behavior

	Facets	Sub-facets
Generic facet of task	Product	
Common attributes of task	User's perception of task	Urgency
		Difficulty
		Subjective task complexity
		Knowledge of task topic

Compared to Table 7.3, the facets and sub-facets which affect information searching behavior are different from those that substantially affect search tasks. Among the generic facets of work tasks, only ‘Product’ affected both search tasks and information searching behavior. In terms of common attributes of work tasks, no sub-facets of the facet ‘Task characteristics’ were found to affect information searching behavior. However, empirical evidence indicates that almost all ‘User’s perception of task’ possibly affect information searching behavior except ‘Salience of task’ and ‘Knowledge of task procedure’.

The identification of these influential facets provides insight into the relationships between work tasks, search tasks, and interactive information searching behavior. This is helpful to recognize work task types for further testing in Study 2.

7.5. Correlation among Work Task Attributes and among Search Task Attributes

Spearman correlation was used to examine the intra-relationships between work task attributes and search task attributes respectively. Figure 7.2 indicates that several work task attributes were correlated with each other.

Specifically, the following work task attributes were significantly correlated with each other:

- ‘Objective task complexity’ and ‘Interdependence’ ($r_{(s)}(24)=.461$, $p<.05$)
- ‘Objective task complexity’ and ‘Difficulty’ ($r_{(s)}(24)=.532$, $p<.01$)
- ‘Objective task complexity’ and ‘Subjective task complexity’ ($r_{(s)}(24)=.500$, $p<.01$)
- ‘Objective task complexity’ and ‘Knowledge of task topic’ ($r_{(s)}(24)=.-440$, $p<.05$)
- ‘Urgency’ and ‘Difficulty’ ($r_{(s)}(24)=.589$, $p<.01$)
- ‘Difficulty’ and ‘Subjective task complexity’ ($r_{(s)}(24)=.851$, $p<.01$)

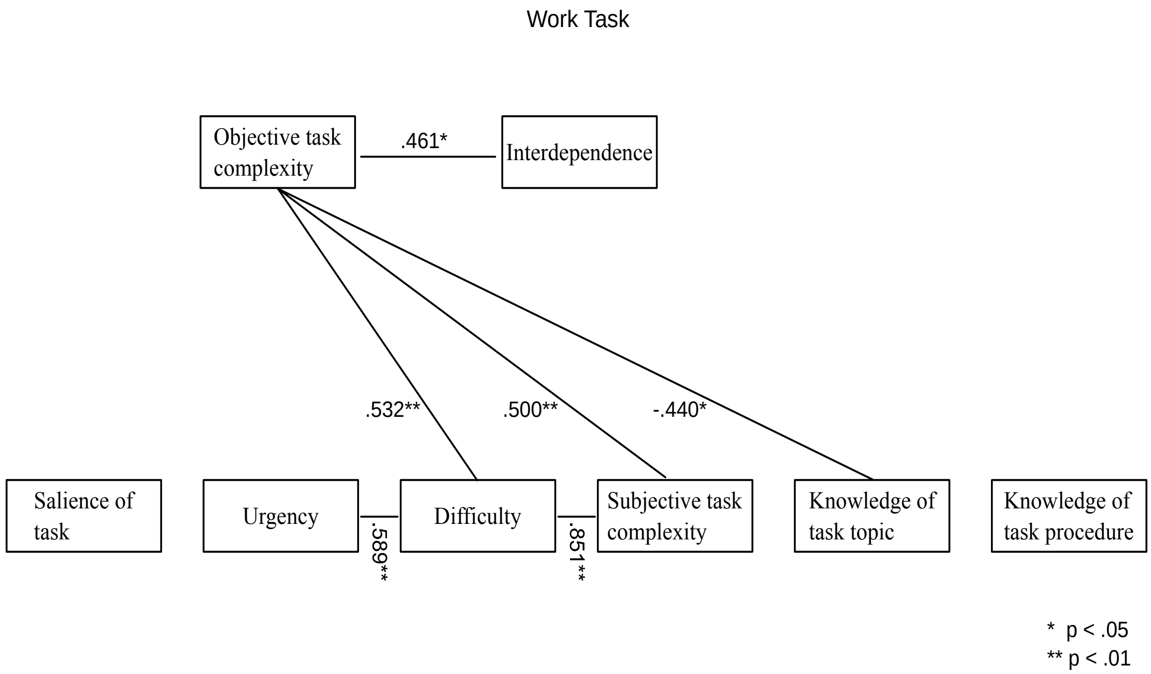

Figure 7.2. Relationships between work task attributes

It was noted that 'Objective task complexity' was correlated with several other attributes. Particularly, it was highly correlated with 'Urgency' and 'Subjective task complexity'. Additionally, 'Objective task complexity' was the only attribute which was significantly correlated with 'Knowledge of task topic'. It was interesting that 'Difficulty' and 'Subjective task complexity' were not correlated with 'Knowledge of task topic'.

Besides, the correlations between search task attributes were tested. Figure 7.3 shows the results.

In terms of search tasks,

- 'Objective task complexity' was significantly correlated with 'Difficulty' ($r_{(s)}(24)=.408$, $p<.05$)

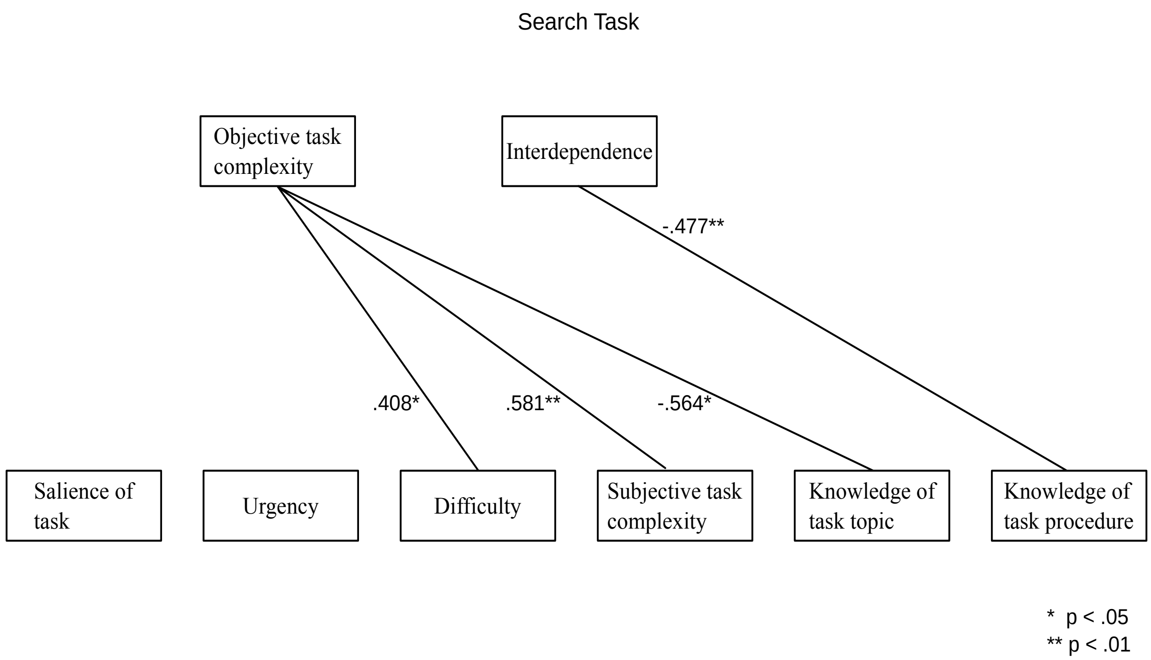

Figure 7.3. Relationships between search task attributes

- ‘Objective task complexity’ was significantly correlated with ‘Subjective task complexity’ ($r_{(s)}(24)=.581$, $p<.01$)
- ‘Objective task complexity’ was significantly correlated with ‘Knowledge of task topic’ ($r_{(s)}(24)=.-564$, $p<.05$)
- ‘Interdependence’ was significantly correlated with ‘Knowledge of task procedure’ ($r_{(s)}(24)=-.477$, $p<.01$)

It is noticed that there was no significant correlation between ‘Urgency’ and ‘Difficulty’, and between ‘Difficulty’ and ‘Subjective task complexity’, though in terms of work tasks both pairs of attributes were highly correlated with each other. This divergence may indicate that work tasks and search tasks differentiate from each other in nature.

7.6. Selection of Work Task Types Tested for Study 2

Study 2 aimed to investigate the relationships between work tasks and interactive information searching behavior. It was necessary to identify different work task types to test in the experiment. The work task types in this research were operationalized as the combinations of different values from different facets or sub-facets. However, based on the refined faceted classification of task a million work tasks types could be generated. It was not realistic to take all of these work task types to test in Study 2. For this reason, the following issues should be taken into account when considering these work task types:

- Study 1 has identified the facets or sub-facets which substantially affect search tasks and information searching behavior. Only these facets or sub-facets should be used to construct work task types for testing in Study 2. The facets or sub-facets which were not related to search tasks or interactive information searching behavior, including 'Task doer', 'Goal (Quality)', and 'Salience of task' were not be taken into account.
- For Study 2 a quasi-experiment was conducted. As a result, some values could not be used in constructing work task types, for example, 'Internal-generated', 'Middle', 'Final', 'High interdependence', and 'Delayed'.
- Due to the time limit in an experiment (around two hours), only limited work task types can be tested. Consequently, some facets or sub-facets have to keep constant and only a few most influential facets can be varied. Based on Study 1, the most influential facets or sub-facets which affect search tasks and information searching behavior are 'Objective task complexity', 'Knowledge of task topic', 'Product', and 'Subjective task complexity'. Since 'Knowledge of task topic' and

'Subjective task complexity' could only be assessed by the subjects, 'Objective task complexity' and 'Product' could be varied for developing work task types. Moreover, since no empirical evidence showed that 'Product/physical' affected search tasks and interactive information searching behavior in Study 1, this value was not be considered for constructing work task types.

- Considering some generic facets and sub-facets cannot be controlled, for example, 'Time', 'Process', and some facets of 'Users' perception of tasks', including 'Knowledge of task topic', 'Knowledge of task procedure', 'Subjective task complexity', and 'Degree of difficulty', it is reasonable not to consider these sub-facets when developing work task types for testing in Study 2, but to require the subjects to assess them during the experiment.

Taking into all issues addressed above, Table 7.6_1 and 7.6_2 show the work task types could be tested in Study 2 for examining the relationships between work tasks and interactive information searching behavior.

Table 7.6_1. Work task types for testing in Study 2

Facets	Type 1	Type 2	Type 3
Source of task	External assigned	External assigned	External assigned
Time(Stage)	Beginning	Beginning	Beginning
Goal (Quantity)	Single-goal	Single-goal	Single-goal
Product	Intellectual	Intellectual	Intellectual
Objective task complexity	High	Moderate	Low
Interdependence	Low interdependent	Low interdependent	Low interdependent
Urgency	Immediate	Immediate	Immediate

Table 7.6_2. Work task types for testing in Study 2

Facets	Type 4	Type 5	Type 6
Source of task	External assigned	External assigned	External assigned
Time(Stage)	Beginning	Beginning	Beginning
Goal (Quantity)	Single-goal	Single-goal	Single-goal
Product	Decision	Decision	Decision
Objective task complexity	High	Moderate	Low
Interdependence	Low interdependent	Low interdependent	Low interdependent
Urgency	Immediate	Immediate	Immediate

7.7. Summary of Study 1

To summarize, Study 1 collected 24 pairs of work tasks and associated search tasks through semi-structured in depth interviews. The interview transcripts were coded for different purposes: for identifying new facets, sub-facets, and values and inappropriate or insufficient ones, and for recognizing the facets which substantially affect information searching behavior. Though no new facets were identified, some sub-facets and values were necessary to adjust or drop and some new sub-facets and values emerged. The faceted classification was then refined by incorporating all adjustments into the original version of the faceted classification.

Study 1 examined the relationships between work tasks and search tasks by using different statistical tests: Spearman correlation, Chi-Square Tests or Fisher's Exact Tests, Kruskal-Wallis Tests, and Mann-Whitney *U* Tests. The facets and sub-facets of work tasks that substantially affected search tasks were recognized. Some facets, for example, 'Goal (Quality)' and 'Knowledge of task procedure', seemed unrelated to search tasks. 'Knowledge of task procedure' of search tasks seemed not related to any facets of work tasks. Study 1 also identified the most influential facets or sub-facets which affected information searching behavior, including ‘Knowledge of task topic’, ‘Product’, and ‘Subjective task complexity’.

Figure 7.4 summarizes the relationships between work tasks, search tasks, and interactive information searching behavior. In the figure, bold work task facets mean these facets substantially affect search tasks and interactive information searching behavior since they are related to at least three facets of search tasks and behavior; italic work task facets to some extent affect search tasks and behavior as these facets are related to at most two facets of search tasks and behavior; other facets have no relationships with search tasks and behavior. In terms of search tasks, light gray search task facets are substantially related to work task facets, while dark gray search task facets are to some extent related to the facets of work tasks. Other facets of search tasks have no relationships with any facets of work tasks. The dash line indicates that the relationships are identified through coding the interview transcripts, while the solid line indicates that the relationships are significant through statistical tests. It is noted that the facets of work tasks significantly affect ‘Time (Length)’, ‘Objective task complexity’, and ‘Subjective task complexity’ of search tasks and substantially relate to two types of behavior: ‘Go to a specific system’ and ‘Query formulation’.

However, as noted above, it is not easy to require the subjects to fully describe their specific interactive behavior during searching information systems in interviews. Therefore, the relationships identified between work tasks and interactive information searching behavior based on coding the transcripts could not sufficiently reflect the real relationships between them. Thus, further exploration is necessary.

Based on the facets and sub-facets that substantially influence search tasks and interactive information searching behavior, Study 1 informed the selection of the work task types for testing in Study 2. These work task types were the combinations of different values. Some values were kept constant. Only the values of the most influential facets or sub-facets were varied. The next chapter will address how the relationships between work tasks and interactive information searching behavior were examined in Study 2 through these work task types.

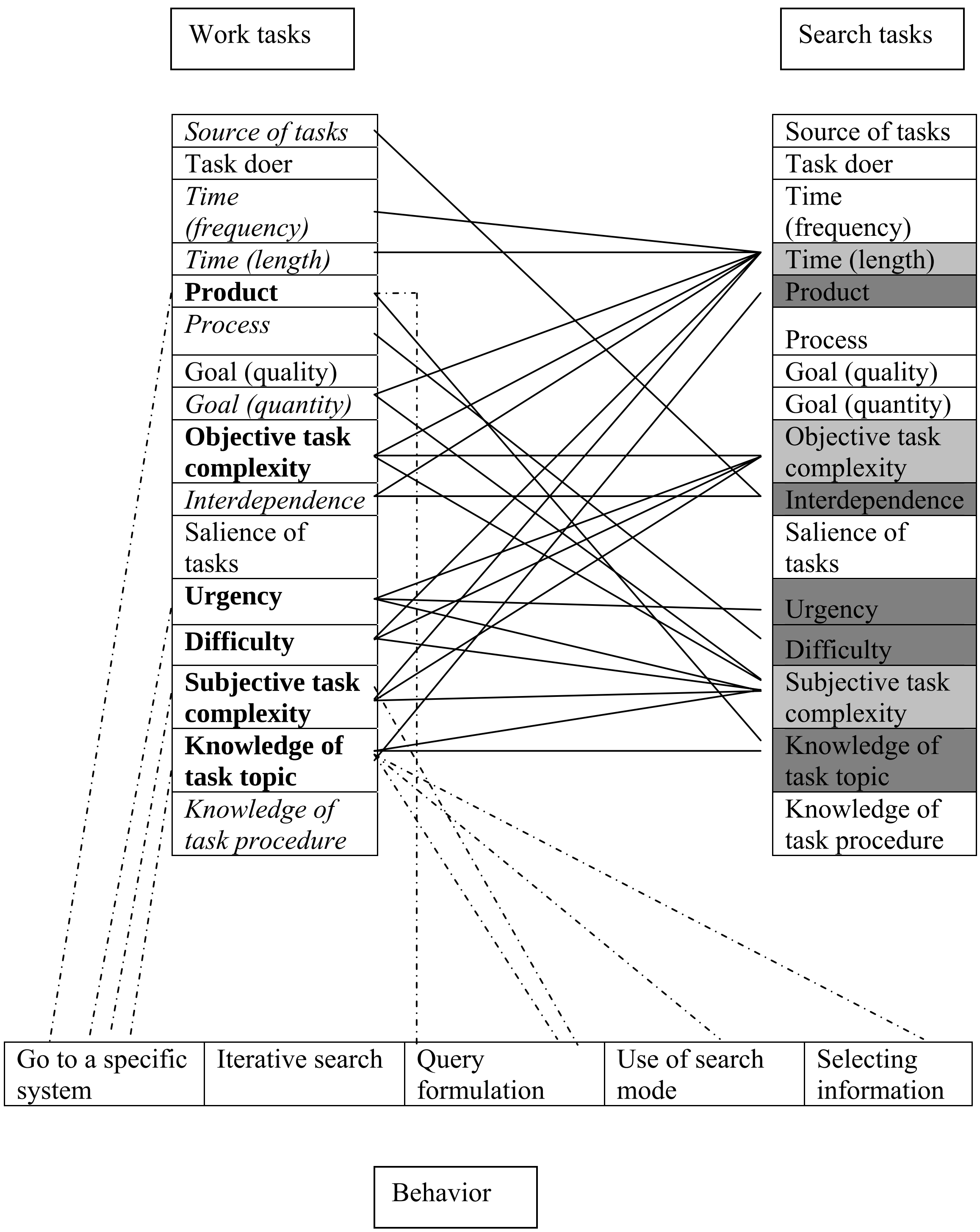

Figure 7.4. Relationships between work task, search task, and interactive information searching behavior

Chapter 8. Methodology of Study 2

The purpose of Study 2 was to investigate the relationships between work tasks and interactive information searching behavior, given that individual differences were taken into account. Therefore, it is necessary to observe users' behavior and explore why they behave in certain ways. Moreover, since individual differences were taken into consideration in Study 2, the data related to the subjects' characteristics should be gathered as well.

It could work to observe real users in their everyday work settings. However, it is time-consuming and hard to examine in depth how and why they behave in certain ways. On the other hand, conducting an experiment could be an ideal way. By designing a set of instruments and using usability test software to record the entire interaction process during the experiment, the data will be collected in around two and a half hours. The data include the participants' evaluation on different facets of work tasks and search tasks, their individual differences, their interaction with the information systems, their thinking aloud during the experiment, and their comments on the influence of work tasks on interactive information searching behavior. Accordingly, a quasi-experiment could be an effective and efficient way to collect data for this research.

8.1. Variables and Measures

Work tasks and search tasks: Since it is hard to compare the interactive information searching behavior if work tasks conducted during the experiment are different, the experiment does not use subjects' real work tasks and search tasks. Instead, several simulated work task situations were developed for Study 2 based on the work task types listed in Table 7.6_1 and Table 7.6_2.

Simulated Work Task Situation was proposed by Borlund (Borlund & Ingwersen, 1997; Borlund, 2000) as an approach to the evaluation of IIR, which proved to work as well as real information need. An empirical study (Borlund, 2000) indicated that a good simulated work task situation should reflect three main characteristics:

- The situation has to be one to which the test persons can relate and with which they can identify;
- The topic of the situation has to be of interest to the group of test persons; and
- The situation has to provide enough imaginative context in order for the test persons to be able to apply the situation.

(Borlund, 2000, p.86)

Therefore, the simulated work task situations should be carefully designed based on the consideration of the subjects' background.

Since this research was conducted in a university community, the simulated work task situations should be related to work tasks people conduct in a university community. All scenarios were developed based on the real work tasks collected in Study 1. Table 8.1_1 to Table 8.1_6 lists the work task types and the scenarios which imply the values of different facets involved in each work task type. The Intellectual/High complexity task is denoted as task IH. Following the same rule, other task types include IM, IL, DH, DM, and DL.

As the work task types only imply part of facets and sub-facets, the participants of the experiment were asked to assess the values of other facets and sub-facets which significantly or substantially affect search tasks and interactive information searching behavior in the questionnaires. For the generic facets of work tasks and search tasks,

Table 8.1_1. Work task type 1, simulated work task situations, and search task

Type 1_IH	Scenario
External assigned	Work task: Imagine you are a graduate student working on a research project entitled “Global warming and human life”. You would like to investigate how global warming would affect people’s every day life. For doing this project, you need to review previous studies, design your research, collect data, analyze the data, write a research report. You are now just starting on this project. Instruction: You need to search for any information which could help you to understand the general research topic, and the different ways in which the project would be designed.
Single-goal	
Beginning	
Intellectual	
High objective task complexity	
Low interdependent	
Immediate	

Table 8.1_2. Work task type 2, simulated work task situations, and search task

Type 2_IM	Scenario
External assigned	Work task: Imagine you are taking a course and your final project is to write a research paper about “history of Jazz”. You should give a comprehensive introduction about the history of Jazz in this paper. You need to read the relevant documents, write the paper, and present it to the class. Instruction: You need to search for any information which could help you to start your work task.
Single-goal	
Beginning	
Intellectual	
Moderate objective task complexity	
Low interdependent	
Immediate	

Table 8.1_3. Work task type 3, simulated work task situations, and search task

Type 3_IL	Scenario
External assigned	Work task: You are taking a course about preparing for job hunting. One of your assignments is to write a resume. You decide to write a resume which is appropriate and strong for applying for jobs in journalism, but you have no ideas about what should be included in such kind of resume. You should read the relevant materials and write down the resume. Instruction: You need to search for any information which could help you to complete your work task.
Single-goal	
Beginning	
Intellectual	
Low objective task complexity	
Low interdependent	
Immediate	

Table 8.1_4. Work task type 4, simulated work task situations, and search task

Type 4_DH	Scenario
External assigned	Work task: Imagine you are planning to apply for MBA program in USA. You need to decide the appropriate programs to apply for. So you need to consider the location of these programs, compare their tuition, investigate their reputation, consider your GMAT score (imagine you got 700 points, a good score), then make the decision and prepare your application package (including writing personal statement, cover letter, asking for references, and so on).
Single-goal	
Beginning	
Decision/Solution	
High objective task complexity	
Low interdependent	
Immediate	Instruction: You need to search for any information which could help you to complete your work task.

Table 8.1_5. Work task type 5, simulated work task situations, and search task

Type 5_DM	Scenario
External assigned	Work task: You are doing a take-home exam and need to answer several questions related to a cognitive bias "endowment effect": (1) What is "endowment effect"? (2) List at least three experiments done by researchers about this bias; (3) List at least one researcher who disagrees with this bias and his views. You need get and read the related stuff, and write down the answers.
Single-goal	
Beginning	
Decision/Solution	
Moderate objective task complexity	
Low interdependent	Instruction: You need to search for any information which could help you to complete your work task.
Immediate	

Table 8.1_6. Work task type 6, simulated work task situations, and search task

Type 6_DL	Scenario
External assigned	Work task: You need to take at least three courses next semester and your advisor ask you to check the classes offered next semester in your program before you make decision.
Single-goal	
Beginning	
Decision/Solution	
Low objective task complexity	Instruction: You need to search for any information which could help you to complete your work task.
Low interdependent	
Immediate	

they were asked to select the statements they felt appropriate in terms of the simulated work task situation; they were required to assess the work task and search task attributes based on a 7 point-Likert scale.

Interactive information searching behavior: A number of interactive information searching behaviors were identified in Study 1, including ‘Query formulation’, ‘Selecting information’, ‘Obtaining information’, and so on. After examining the recordings of the experiments in Study 2, all these behaviors were categorized under different aspects of interaction, such as General interaction efforts, Interaction with Web resources, Interaction with library resources, Query-related interactive behavior, and the shift patterns between search stages. Considering the close relationships between interactive information searching behavior and users’ performance, the relationships between work tasks and performance of interaction were also examined. With respect to the measures of interactive information searching behavior, some were derived from Belkin et al. (2001b) and Jansen (2005). Table 8.2 lists these aspects of interaction (behaviors and performance), measures, and their operational definitions.

Individual differences: Previous studies indicated that several individual differences consistently affected users’ information searching behavior, including domain specific knowledge, search knowledge, search experience, search expertise, educational level, cognitive styles, gender, age, and so forth. However, this research cannot cover all these individual differences. Also, the participants of the study almost at the same level of search experience, search expertise, and computer experience (See 9.1). Therefore, only a few individual differences were taken into consideration, including gender, educational level (graduate students or undergraduate students), and academic background or major (social science and humanities or science and engineering).

8.2. Data Collection

In order to collect data, a set of instruments (see Appendix 4) were developed:

- Entry Questionnaire: This questionnaire collects demographic data, including educational background, age, gender, occupation, search expertise, search experience, and computer experience. It was revised based on Kelly (2004).
- Simulated Work Task Situation Evaluation Questionnaire: The first three questions (Q1, 2, and 3) ask the subjects regarding the generic facet 'Time (Frequency)', Time (Length)', and 'Process'. Other questions ask them to assess their level of the sub-facet of 'Users' perception of task' based on a 7 point-Likert scale, including "Difficulty", "Knowledge of task topic", "Knowledge of task procedure", and "Subjective task complexity". This study differentiated "Difficulty" from "Subjective task complexity" since several subjects explained them as different constructs in Study 1.
- Pre-search Questionnaire: This questionnaire first asks the subjects to describe their search tasks. With respect to the search tasks, Q1 asks the subjects to evaluate the generic facet 'Time (Frequency)'. It also asks them to assess the pre-search task difficulty and pre-search subjective task complexity. Besides, the subjects are required to assess their knowledge levels in terms of task topic and task procedure.
- Post-Search Questionnaire: After finishing the search for each simulated work task, the participants were asked to complete a post-search questionnaire,

which asks their perception on search results, search process, difficulty and complexity of the search tasks. Q1 asks whether the participants had enough time to complete the search. Q2a asks whether they obtained enough information for the work task. Based on the answers of Q2b and Q2c, the 'Process' of this search task could be known. Q3 and Q4 ask how the participants selected the information. Q15 and Q17 evaluate their success and satisfaction with their search process. Some measures are derived from Bell and Ruthven (2004), Hornbæk (2006), Maynard and Hakel (1997), Norris (2006), and Scholtz (2006).

- Follow-up interview: After the participants finish searching for each work task, a follow-up interview was conducted and the experimenter asked any questions which may be related to the relationships between tasks and interactive information searching behavior.
- Exit Interview: After the participants completed searches for all work tasks, an exit interview involving several open questions were conducted. This interview focused on the participants' general perception regarding how work tasks influenced their interaction with the systems. The interviews were recorded and transcribed.

Also, during the experiment, the participants were asked to think aloud. A software tool, Morae 2.0 logged all activities of the participants during the experiment.

Table 8.2. Measures and operational definitions

Interaction	Measures	Operational definitions
General interaction efforts	IR Systems consulted	The mean number of IR systems consulted by the participants for a work task. IR systems here include search engines, OPAC systems, and databases.
	Result pages viewed	The mean number of result pages viewed by the participants for a work task, regardless whether the result pages viewed from the Web or libraries.
	Items viewed	The mean number of items viewed by the participants for a work task, regardless whether the items viewed from the Web or libraries. Items here refer to web pages, full-text papers or articles (any format, such as .doc, .pdf., and .html), and bibliographic records.
	Items selected	The mean number of items selected by the participants for a work task, regardless whether the items were selected from the Web or libraries.
Interaction with Web sources	Search engines consulted	The mean number of search engines consulted by the participants for a work task.
	Web result pages viewed	The mean number of result pages viewed from the Web during the search for a work task.
	Portals visited	The mean number of portals visited for a work task. Portals here refer to any individual web sites serving as a direct or indirect entrance for items.
	Web items viewed	The mean number of items viewed by the participants for a work task from the Web.
	Web items selected	The mean number of items which are selected for further use. These items are judged as useful, somewhat useful, or possibly useful information to support a work task.
Interaction with library resources	Library resources consulted	The mean number of library resources consulted. Library resources include OPAC systems, databases, and other resources from a library web site.
	Library results pages viewed	The mean number of result pages viewed during the search for a work task from a library web site.
	Library items viewed	The mean number of items viewed through the links from a library, per work task.
	Library items selected	The mean number of items which are selected

		for further use for a work task. They are judged as useful, somewhat useful, or possibly useful information to support a work task.
Query-related interactive behavior	Number of iteration	The mean number of queries issued by the participants during the search for a work task.
	Unique queries	The mean number of unique queries issued by the participants during the search for a work task.
	Mean query length	The average length of all queries in the search for a work task, in words.
	Unique query terms	The mean number of unique words in all of the queries in the search for a work task.
	Unique non-stop query terms	The mean number of unique non-stop words in all of the queries in the search for a work task. Non-stop words include all words except the preposition and article.
Shift patterns	Salient shifts	The shifts whose probabilities are above .10.
	Reiterative shifts	The two shifts which involve the same search stages but in reverse direction and occur in the same search sequence.
Performance of interaction	Success	The average degree of the participants' self-assessed success for locating information to support a work task.
	User satisfaction	The average degree of the participants' self-assessed satisfaction with the search process for a work task.
	Time	The average time of the participants' dwelling in searching for a work task.
	Time/item selected	The ratio between time and the number of items selected, including useful, somewhat useful, or possibly useful pages, papers or articles, records, and citations. This is used to measure the efficiency of the search for a work task.

8.3. Experiment

Experimental design: Since six work task types were tested in Study 2, if all subjects follow the same order to conduct the simulated work task situations, learning effects are unavoidable. This influences the validity of the research. Therefore, to avoid this problem as well as balance the two varied facets, i.e., ‘Product’ and ‘Objective task complexity’, the six work tasks were assigned to the subjects in this way: (1) Intellectual tasks should be separated from each other, so do decision/solution tasks; (2) Low complexity work tasks should be separated form each other, so do Moderate and High complexity work tasks. Accordingly, for the first 12 participants each type of task appears in each position (1-6) twice. Table 8.3 shows how the six work tasks were assigned to each participant.

Table 8.3. Task assignment to the subjects

	Task 1	Task 2	Task 3	Task 4	Task 5	Task 6
S1, 13	IL	DM	IH	DL	IM	DH
S2, 14	IL	DH	IM	DL	IH	DM
S3, 15	IM	DL	IH	DM	IL	DH
S4, 16	IM	DH	IL	DM	IH	DL
S5, 17	IH	DM	IL	DH	IM	DL
S6, 18	IH	DL	IM	DH	IL	DM
S7, 19	DL	IM	DH	IL	DM	IH
S8, 20	DL	IH	DM	IL	DH	IM
S9, 21	DM	IL	DH	IM	DL	IH
S10, 22	DM	IH	DL	IM	DH	IL
S11, 23	DH	IM	DL	IH	DM	IL
S12, 24	DH	IL	DM	IH	DL	IM

Sampling: The participants were recruited from students in a university community. According to the design, at least 12 participants should be recruited. Considering the constraint of research resources (e.g. budget) as well as statistical significance of the final results, twenty-four participants were recruited. Each participant was paid 25 dollars as compensation. Specifically, among 24 participants, 10 are female and 14 are male. Some studies indicated that people from different academic domains, for example, social science or science, may have different information searching behavior (Case, 2002). This study took this issue into account. Twelve participants were recruited from social science and humanities, with six undergraduate students and six graduate students. The other 12 participants were from science and engineering, also with six undergraduate and six graduate students. Thus, in total 12 undergraduate students and 12 graduate students were recruited.

Tasks: Six simulated work tasks and their associated search tasks (See Table 8.1_1 to 8.1_6) were used for the experiment. According to the experimental design, the participants took different orders to search for the six work tasks. Table 8.3 lists the task assignment for each of them.

Setting: The experiments were conducted in a computer lab in the School of Communication, Information and Library Studies at Rutgers University. The software, Morae 2.0, was installed on the computer and the participants were informed that the whole experiment was recorded by the software before the experiment.

Experimental systems: Study 1 indicated that users usually selected to search any information systems which could provide information to support a specific work task. Thus, in Study 2, the participants could select any systems they felt appropriate for the work tasks during the experiment.

Procedures: The participants followed these procedures:

Step 1: Sign consent form

Step 2: Fill out Entry Questionnaire

Step 3: Fill out a Simulated Work Task Situation Evaluation Questionnaire for the first simulated work task

Step 4: Fill out a Pre-search questionnaire for the first search task

Step 5: Conduct the search (15 minutes)

Step 6: Fill out a Post-Search Questionnaire

Step 7: A follow-up interview in terms of the work task.

Step 8: Repeat from Step 3 and finish simulated work task situation 2-6.

Step 9: After finishing all searches, an exit interview was followed.

8.4. Data Analysis

This study generated both quantitative and qualitative data. In order to discover the relationships between work tasks and interactive information searching behavior, univariate tests were performed to process the quantitative data since it is more powerful with the small dataset than multivariate tests (Hinton, Brownlow, McMurray, & Cozens, 2004). This section specifies how the data was analyzed. Chapter 9 will report the results and findings. Figure 8.1 outlines the procedure of data analysis for Study 2.

8.4.1. Mark Interactive Behavior in the Recordings

As mentioned above, Morae 2.0 recorded all experiments. In total there were 24 recordings. This software could also assist the data analysis by allowing making marks for all interactive behavior, and helping calculate the search time for each work task after 'Start' and 'End' points were marked.

Bearing in mind the measures of interactive information searching behavior listed in Table 8.2, Table 8.4 lists all behaviors marked in the recording using Morae 2.0 and the codes used. The codes were assigned to behaviors based on convenience. Also, the participants' thinking aloud were transcribed and marked as "Q".

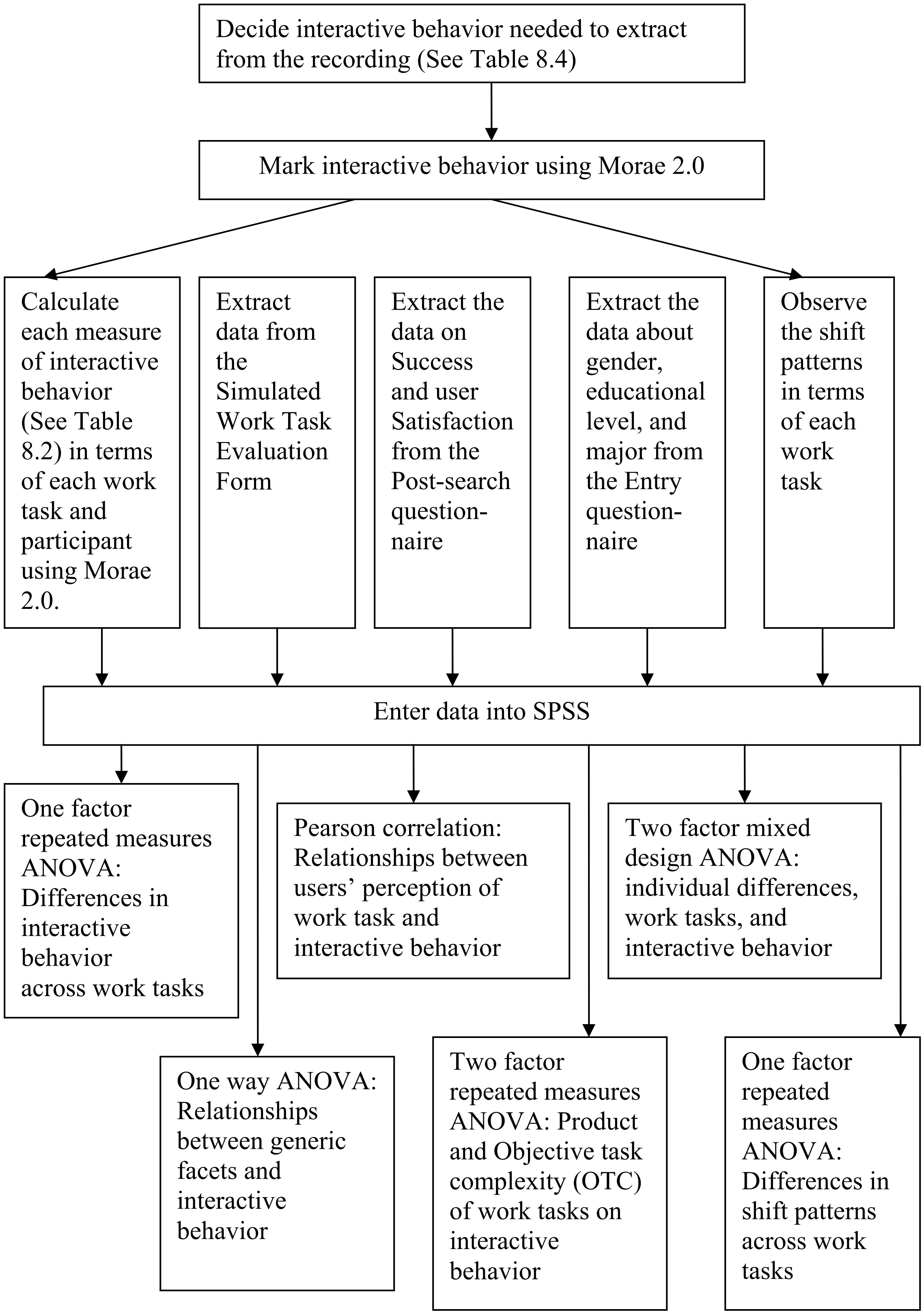

Figure 8.1. Data analysis of Study 2

Table 8.4. Interactive behaviors and codes

	Interactive behaviors	Codes	Explanation
IR Systems consulted	Go to a search engine	N	The participants log on to a search engine, e.g. Google.
	Go to an OPAC	K	The participants go to use an OPAC system, e.g. IRIS of Rutgers University Library.
	Go to a databases	M	The participants go to use a database, e.g. Academic Search Premier
Result pages viewed	View a result page	H	The participants viewed a result page which should include a list of search results.
Items viewed	View a web page	G	The participants view a web page which has specific content; sometimes it may involve links, but the links are not its main purpose.
	View a bibliographic record	C	The participants view a bibliographic record from searching library OPAC or databases.
	View a document (full-text paper or articles)	D	The participants view a full-text papers or articles from the Web or databases.
	View a pdf documents	P	The participants view a full-text papers or articles which is pdf format from the Web or databases.
Items selected	Useful page/useful record/useful document/useful citation	U	All items which the participants judge as useful, somewhat useful, and possibly useful for a work task or they specifically say they will use the items for some purpose.
Portals visited	View a web site	W	The participants view a web site, whose purpose is to provide links to other sites or web pages or papers/articles.
Number of iteration	Submit a query	R	The participants submit a search query to a system
Time	‘Start’ the search;	S	The participants start to do a search.
	‘End’ the search	E	The participants stop doing a search.

8.4.2. Relationships between Work Tasks and Interactive Information Searching Behavior

Q3 asks how work tasks affect interactive information search behavior, given that individual differences are taken into account. The data analysis first looked at how work tasks affected interactive behavior. As discussed in 8.1, the six work tasks were constructed based on the two varied facets, i.e., ‘Product’ and ‘Objective task complexity’, and some other constant facets. So work tasks were multi-faceted variables in this study. The data analysis first explored how a multi-faceted work task affected the participants’ interactive behavior.

After marking interactive behavior in the recording, the software, Morae 2.0, helped calculate the total numbers of IR system consulted, web pages viewed, and so on. All the data were input to SPSS. Unlike Study 1, in which mostly nonparametric tests were conducted since most of data were ordinal data, parametric tests were performed since most data collected in Study 2 were interval data.

To explore how different work tasks with a combination of different facets affected the participants’ interaction with the systems, ANOVA tests were conducted. Since the same group of participants completed the searches for all the six work tasks, one factor repeated measures ANOVA were performed (c.f. Hinton, Brownlow, McMurray, & Cozens, 2004) to examine how the six work tasks were different in terms of each measure of interactive behavior, for example, IR systems consulted, result pages viewed, items viewed, and so on. The results are reported in Section 9.2.

Due to the same reason, one factor repeated measures ANOVA was also used to examine how work tasks affected users' performance of interaction. Section 9.3 reports the results.

8.4.3. Relationships between Facets of Work Tasks and Interactive Information Searching Behavior

As mentioned above, a few generic facets (i.e. Time (Frequency), Time (Length), and Process and the sub-facets of the facet 'Users' perception of tasks' (i.e. Task difficulty, Subjective task complexity, Knowledge of work task topic, and Knowledge of work task procedure) could only be assessed by the participants. Through the questionnaire, the participants' assessment of these facets were collected and input to SPSS. To explore the relationships between these generic facets and interactive behavior, one way ANOVAs were carried out. 'Time (Length)' and 'Process' only have two values. This means two groups of work tasks. However, independent samples *t* tests were not performed because the participants conducted the searches for the two groups of work tasks might be the same or partly the same. In other words, the samples were not independent. Therefore, one way ANOVAs were conducted for more precisely explaining the results.

With the aim to probe the relationships between users' perception of tasks and interactive behavior, Pearson correlation were conducted through SPSS since in the questionnaire all these facets were measured by a 7-point Likert scale, and all interactive behaviors were interval variables.

8.4.4. Product and Objective task complexity (OTC) on Work Tasks and Interactive Behavior

'Product' and 'Objective task complexity' were two varied facets which were found more important to shape search tasks and interactive behavior than other facets in Study 1. Therefore, it is important to see how these two facets affect the participants' interactive behavior and how they interact with each other. Moreover, because the six work tasks were conducted by the same group of participants, two factor repeated measures ANOVA were performed (c.f. Hinton, Brownlow, McMurray, and Cozens, 2004). The Product main effects, Objective task complexity main effects, and the interaction between 'Product' and 'Objective task complexity' were examined. The results will be reported in Section 9.4.

8.4.5. Relationships between Individual Differences, Work Tasks, and Interactive Behavior

Finally, the data analysis took into account the influence of individual differences. As discussed in Section 8.1, only gender, educational level, and academic background were taken into account in this study. So the data analysis attempted to see how these three individual differences affected the relationships between work tasks and interactive behavior.

Again, ANOVA tests were performed. In terms of gender, level, and major, the samples are independent. For example, a participant is female, so she/he would never be a male at the same time. However, all the searches for the six work tasks were completed by dependent samples, i.e., the same group of participants. Accordingly, two factor mixed design ANOVA was employed (c.f. Hinton, Brownlow, McMurray, and Cozens, 2004) to examine the gender, level, and major main effects and interaction between the gender, level, major, and work tasks for interactive information searching behavior. The results will be reported in Section 9.5.

8.4.6. Shift Patterns between Stages

The shifts between search stages during the user's interaction with IR systems have been examined (e.g. Qiu, 1993b; Santon, 2003; Xie, 2000). However, except that Qiu (1993b) investigated how search state patterns in terms of different search tasks, the pervious studies usually focused on shifting behavior, and ignored the possible influence caused by different types of work tasks, This dissertation study attempted to identify the different transition patterns between search stages with respect to different types of work tasks.

To examine the shifts between search stages, the search stages were first identified from the recordings collected by Morae 2.0. For the purpose to ensure the reliability of the stages, only the stages which could be observed from the recording were take into account. These stages, explanation, and code number are showed in Table 8.5. Then, each search for a work task was coded as a sequence of these stages. For example, the search of S15 for IH (Task IH) was denoted as: 4 → 5 → 3 → 6 → 7 → 8 → 9 → 10 → 9 → 6 → 7 → 8 → 9 → 5 → 1 → 6 → 7 → 8 →11. It was called "a sequence". All other searches were translated into such sequences for further analysis.

Then, all the sequences were decomposed as a two-stage subsequence, that is, from one stage to the other; for example, the shift "1 → 6" means that the participants shift from 'Go to search engines' to 'Select search mode'. The probabilities of the shifts were calculated in terms of per work task. For example, the probability of 1 → 6 with respect to IL was computed as follows:

P = Occurrences of 1 → 6 / Total occurrences of 1 → n^1 *in IL*

(1: all shifts beginning from Stage 1)

The probabilities of the shifts between search stages with regard to intellectual (I) work tasks and decision/solution (D/S) work tasks and low (L), median (M), and high (H) complexity work tasks were also calculated. The probability of the shift (for example, 4 →5) in terms of a work task (for example, an intellectual work task) was calculated as follows:

P = Total occurrences of 4 →5 in IL, IM, and IH/Total occurrences of 4 → n^1 *in IL, IM, and IH*

(1: all shifts beginning from Stage 4)

Table 8.5. Search stages

Stages	Explanation	Code number
Go to search engines	The participants log on to search engines.	1
Go to databases	The participants log on to databases.	2
Go to OPAC systems	The participants log on to OPAC systems.	3
Go to individual web sites	The participants log on to individual web sites directly.	4
Browse web sites	The participants browse web sites. Browsing here means that the participants locate information without querying, but through clicking and following the links.	5
Select search modes	The participants use one search mode.	6
Formulate queries and submit	The participants formulate and submit search queries.	7
Review result pages	The participants review result pages.	8
Review items	The participants review items.	9
Select items	The participants select items.	10
Search end	The participants finish the search.	11

The probability of a shift (for example, 4 → 5) for a work task (for example, a high complexity work task) was calculated as follows:

P = Total occurrences of 4 →5 in IH and DH/Total occurrences of 4 → n^1 *in IH and DH*

(1: all shifts beginning from Stage 4)

Using these formulas, the probability of each shift between search stages was calculated. The probabilities of the shifts were observed and compared. If the probabilities of a type of shift, for example, the shift 4 →5 ('Go to individual web sites' to 'Browse web sites'), were very different in terms of each work task, one factor repeated measures ANOVA was performed to examine whether there was significant difference in the mean probabilities of this shift among the six work tasks, intellectual work tasks and decision/solution work tasks, or low complexity, median complexity, and high complexity work tasks. The mean probability of a shift was calculated in terms of all participants in the experiment. The reason to employ one factor repeated measures ANOVA was because all types of work task in this research were conducted by the same group of participants.

Chapter 9 will report the results of Study 2 based on the analysis described in this chapter.

Chapter 9. Results of Study 2

This chapter reports the results of Study 2. The participants' characteristics are presented first. How work tasks as a multi-faceted variable affect the participants' interactive information searching behavior is then reported, as well as how different facets or sub-facets of work tasks are related to interactive behavior. Two facets identified as key facets which affect search tasks and interactive behavior in Study 1 were varied in Study 2. This chapter reports how these two facets affect interactive information searching behavior and the interaction between them. Individual differences, i.e. gender, level, and major, are taken into account. This chapter reports how these differences affect the relationships between work tasks and interactive information searching behavior. Finally, the shift patterns between search stages in terms of different types of work tasks are probed and the results are presented as well.

9.1. Participants' Characteristics

9.1.1. Major and Age

As mentioned in Section 8.3, twelve participants were recruited from social science and humanities and the other twelve were from science and engineering. Specifically, these participants came from 20 majors, including Library and information science, Political science, Media studies, Communication, Sociology, Urban planning and policy, Chinese, Anthropology, Oceanography, Biomedical engineering, Computer science, Electronic and computer engineering, Math finance, and so on.

Twelve participants (50%) are between 18 to 27 years old, ten participants (42%) are between 28 to 37 years old, and only two participants (8%) are above 37 years old.

9.1.2. Computer Experience

The participants were asked to rate their experience in using computers and World Wide Web (WWW) browser based on a 1(None)-7(A great deal) scale and how often they use a computer for their work tasks, personal tasks, and entertainment respectively, also based on a 1(Never)-7 (Daily) scale in the Entry Questionnaire (See Appendix 4). Table 9.1_1 and Table 9.1_2 show the frequency and percentage of the participants who rated each scale. Most of participants rated their experience as '7 (Expert)'. Therefore, they are experienced with computers and using computers to complete their tasks, including work tasks.

Table 9.1_1. Participants' computer experience (N=24)

	1 (none)	2	3	4 (some)	5	6	7 (a great deal)
Experience in using computers	0	0	0	0	3 (12.5%)	6 (25%)	15 (62.5%)
Experience in using WWW browsers	0	0	0	1 (4.2%)	2 (8.3%)	8 (33.3%)	13 (54.2%)

The participants were also asked to assess their level of expertise with computers based on a scale from 1(Novice) to 7 (Expert). The mean rating and standard deviation (SD) are 5.58 and .78, respectively. Eleven out of 24 participants (45.8%) rated themselves as 5; nine out of 24 participants (35.7%) rated themselves as 6. So, most participants have relatively high computer expertise.

Table 9.1_2. Participants' computer experience (N=24)

	1 (never)	2 (once a year)	3 (several times of a year)	4 (monthly)	5 (several times a month)	6 (weekly)	7 (daily)
Using computer for work tasks	0	0	1 (4.2%)	0	0	1 (4.2%)	22 (91.7%)
Using computer for personal tasks	0	0	0	0	1 (4.2%)	1 (4.2%)	22 (91.7%)
Using computer for entertainment	0	0	2 (8.3%)	1 (4.2%)	0	1 (4.2%)	20 (83.3%)

9.1.3. Search Experience

The participants were asked to rate their experience in searching with search engines, OPAC, and indexing/abstracting services. They were also required to estimate the frequency of searching for information for assignments and entertainment. Table 9.2_1 and Table 9.2_2 report the percentage of the participants who rated each scale.

Table 9.2_1. Participants' search experience (N=24)

	1 (none)	2	3	4 (some)	5	6	7 (a great deal)
Search with search engines	0	0	0	1 (4.2%)	2 (8.3%)	8 (33.3%)	13 (54.2%)
Search with OPAC	0	1 (4.2%)	5 (20.8%)	6 (25%)	5 (20.8%)	4 (16.7%)	3 (12.5%)
Search with indexing/ abstracting service	7 (29.2%)	6 (25%)	5 (20.8%)	4 (16.7%)	0	1 (4.2%)	1 (4.2%)

Table 9.2_1 shows that most participants have much experience in searching search engines. However, almost half of the participants use library online catalogues only or less than “Some”, and most participants search with indexing or abstracting services less than “Some”. Particularly, 29.2% of the participants have never used that service.

Table 9.2_2 indicates that the participants frequently search for information about their assignments or work related projects and entertainment.

Nineteen participants (79.2%) rated 6 and 7 when they were asked whether they can usually find what they are looking for (1 as “Rarely” and 7 as “Often”). This means that they can frequently find what they want.

Table 9.2_2. Participants’ search experience (N=24)

	1 (never)	2 (once a year)	3 (several times of a year)	4 (monthly)	5 (several times a month)	6 (weekly)	7 (daily)
Search for assignment/ work-related project	0	0	2 (8.3%)	1 (4.2%)	1 (4.2%)	11 (35.8%)	9 (35.5%)
Search for entertain-ment	0	1 (4.2%)	0	4 (16.7%)	2 (8.3%)	7 (29.2%)	10 (41.7%)

The mean (SD) of the level of expertise of the participants in information search is 5.42 (.93). Nineteen participants (79.2%) rated themselves 5 and 6 (1 as “Novice” and 7 as “Expert”) when assessing their search expertise. No any participants rated themselves as 1, 2, or 3. The participants felt confident that they were experienced in information search. Four participants had professional training in information search before.

The average years that the participants have been doing online searching are 7.29 (2.66) years. More than half of participants (16, 67%) indicated that they have searched online above seven years. All participants listed Google as one of their favorite search engines. Six participants also listed Yahoo. Two listed Baidu. One subject listed Ask.com, Alltheweb, Altavista as his favorites besides Google. One subject wrote down Searchlight, a Rutgers University Library search engine, as her favorite.

In general, the participants recruited in Study 2 are experienced with computer and online information search. However, they do not frequently use library resources, though they frequently search for information to support their work tasks. Since the participants come from different majors and different levels (graduate vs. undergraduate) in a university, they could represent the population investigated in this study.

9.2. Multi-faceted Work Tasks and Interactive Behavior

This section reports how work tasks affect the participants' interactive information searching behavior, based on the investigation of their general interaction efforts, interaction with Web resources, interaction with library resources and query-related interactive behavior. Performance of their interaction is also examined. As described in Chapter 8.1, the simulated work task situations tested in Study 2 are a combination of different work task facets: merely two facets varied (i.e. Product and Objective Task Complexity), but others were kept constant. Mostly, one factor repeated measures ANOVAs were performed. If the Sphericity assumption is met, Sphericity Assumed F value will be reported; otherwise, Greenhouse-Geisser F value will be reported (c.f. Hinton, Brownlow, McMurray and Cozens, 2004) and noted.

9.2.1. General Interaction Effort

For the convenience to present the results, the six simulated work tasks assigned to the participants in the experiment are denoted as in Table 9.3. This section focuses on the effects of work tasks on the participants' general interaction effort with IR systems, namely, the effects of work tasks on the number of IR systems consulted, the number of result pages viewed, items viewed, and items selected.

Table 9.3. Work tasks tested in Study 2

Denotation	Task	Short description
IL	Intellectual/Low complexity	Writing a resume for applying for a journalist position as a course assignment
IM	Intellectual/Moderate complexity	Writing a research paper on history of Jazz as a course final project
IH	Intellectual/High complexity	Starting working on a research project about global warming and human life
DL	Decision(Solution)/Low complexity	Making decision for courses taken next semester
DM	Decision(Solution)/Moderate complexity	Answering questions about endowment effect for a take-home exam
DH	Decision(Solution)/High complexity	Applying for MBA programs

The participants could select any IR systems during the experiment, including library OPAC, search engines, and databases and indexes, and so forth, to search for information which could support their work tasks. To locate useful information, the participants needed to view result pages, items, and finally select items for supporting their work tasks. Table 9.4 lists the mean, standard deviation (SD), and *F* value (by one factor repeated measures ANOVA) in terms of IR systems consulted, result pages viewed, items viewed, and items selected across different work tasks.

In general, the participants consulted significantly different number of IR systems. They viewed significantly different number of result pages and items, and selected significantly different items to support their work tasks. The following sections specifically address these differences.

Table 9.4. General interaction efforts in terms of different work tasks

	IL	IM	IH	DL	DM	DH	*F*
IR systems consulted	1.13 (.54)	1.92 (.93)	1.96 (.91)	.25 (.44)	1.87 (.74)	1.04 (.36)	23.91**
Result pages viewed	4.58 (2.60)	4.75 (2.56)	6.38 (3.24)	1.04 (1.30)	6.42 (2.89)	4.67 (2.79)	13.87**
Items viewed	7.67 (5.05)	8.04 (3.77)	7.92 (5.14)	5.46 (3.67)	9.04 (3.25)	12.00 (7.01)	5.80**
Items selected	4.04 (2.05)	5.50 (2.30)	5.08 (4.85)	2.75 (1.48)	4.00 (1.72)	5.25 (3.03)	4.78**

** $p<.01$

9.2.1.1. General usage of IR systems and other resources

In total the participants conducted 144 searches (6 (work tasks) x 24 (participants)) in this study. For each task, the participants consulted different number of systems. For example, Subject 1 (S1) consulted four systems in order to search for IM, but he only consulted one system for IL. Table 9.4 illustrates that overall for IM, IH, and DM, the participants consulted more IR systems than for IL and DH, and the fewest IR systems for DL.

One factor repeated measures ANOVA indicated that there was a significant difference between the number of IR systems consulted for each work task (F (3.29, 75.64) = 23.91, $p<.01$) (Greenhouse-Geisser). Further Post Hoc tests (Bonferroni) indicated that:

- For IL the participants consulted significantly fewer IR systems than for IH ($p<.01$) and DM ($p<.01$), but significantly more than for DL ($p<.01$).
- The participants consulted significantly more IR systems for IM than for DL ($p<.01$) and DH ($p<.01$).
- For IH, the participants consulted significantly more IR systems than for IL ($p<.01$), DL ($p<.01$), and DH ($p<.01$).
- For DL, significantly fewer IR systems were consulted than all other work tasks ($p<.01$).
- For DM, significantly more IR systems were consulted than for IL ($p<.01$), DL ($p<.01$) and DH ($p<.01$).

Therefore, for different work tasks the participants were significantly different in using IR systems to locate useful information. More school-work-related work tasks, i.e. IM, IH and DM, seemed to more rely on IR systems, whereas among these three work tasks, there was not a significant difference in the number of IR systems consulted.

9.2.1.2. Result pages viewed

After the participants issue search queries, the systems return result pages. The participants go through these pages to locate useful information. This section examines whether work tasks affect the number of result pages the participants viewed for a work task. Overall, the participants viewed the most result pages for DM, and the least for DL. One factor repeated measures ANOVA detected that for different work tasks, the participants viewed significantly different number of result pages ($F\ (5, 115) = 13.87$, $p<.01$). Post Hoc test (Bonferroni) indicated that the difference occurred only between DL and other work tasks ($p<.01$). This means that the participants viewed significantly fewer result pages for DL compared to other work tasks, among which there was not a significant difference detected.

9.2.1.3. Items viewed

Items here refer to web pages, documents and library records. During the search, the participants went through these items to identify useful or possibly useful ones. In general, Table 9.4 shows that the participants viewed the most items for DH, but the least for DL. One factor repeated measures ANOVA yielded a significant difference in the number of items viewed across the work tasks (F (5, 115) = 5.80, P<.01). Post Hoc tests (Bonferroni) indicated that for DL the participants viewed significantly fewer items than for DM (p<.05) and DH (p<.01), but no significant difference was found between DM and DH.

9.2.1.4. Items selected

For each work task, the participants were required to tell whether the items they viewed were useful or not. They were also asked to tell a way to keep the items they felt useful for their work tasks. Since the participants also kept the items they felt possibly useful, here the label "items selected" is used to accommodate all items which were judged by the participants as useful, somewhat useful, and possibly useful. One factor repeated measures ANOVA indicated that there was a significant difference in the number of items selected across the work tasks (F (2.63, 60.42) = 4.78, p<.01) (Greenhouse-Geisser). Post Hoc tests (Bonferroni) found that for IL the participants selected significantly fewer items than for IM (p<.01); they selected significantly more items for IM than for IL (p<.01), DL (p<.01), and DM (p<.05); for DL they selected significantly fewer items than for IM (p<.01) and DH (p<.05).

9.2.1.5 Relationships between work task facets and general interaction effort

Some facets of work task were constant in this study (See Section 7.6 and 8.1) and others were assessed by the participants. These self-assessed facets by the participants include ‘Time(Frequency)’, ‘Time(Length)’, ‘Process’, ‘Degree of difficulty’, ‘Subjective task complexity’, ‘Knowledge of task topic’, and ‘Knowledge of task procedure’. This section examines the relationships between these facets and the participants’ general interaction effort. Table 9.5 reports the relationships between the generic facets of work tasks and users’ general interaction effort.

Table 9.5. Generic facets of work tasks and general interaction effort

Generic Facets	Values	IR systems consulted	Result pages viewed	Items viewed	Items selected
Time (Frequency)	Unique (N=22)	1.55 (.74)	6.32 (3.06)	9.14 (5.91)	4.55 (2.28)
	Intermittent (N=92)	1.28 (.87)	4.58 (3.04)	8.53 (5.78)	4.54 (3.28)
	Routine (N=30)	1.47 (1.18)	3.60 (3.14)	7.23 (3.38)	4.03 (2.06)
	F	.97	5.05**	1.03	.36
Time (length)	Short-term (N=122)	1.28 (.88)	4.32 (3.09)	8.27 (5.09)	4.41 (3.05)
	Long-term (N=22)	1.82 (1.01)	6.41 (2.96)	8.82 (5.42)	4.59 (2.11)
	F	6.65*	8.64**	.21	.07
Process	One-time (N=35)	1.09 (1.01)	3.86 (3.21)	6.91 (4.55)	3.66 (2.96)
	Multi-time (N=109)	1.45 (.84)	4.89 (3.10)	8.82 (5.23)	4.69 (2.87)
	F	4.23*	2.89	3.72	3.36

*p<.05
**p<.01

One-way ANOVA detected that there was a significant difference in the number of IR systems consulted between the short-term tasks (the tasks will be completed within three weeks) and long-term tasks (the tasks will be completed above three weeks) (*F* (1,

142) = 6.04, $p<.05$). One-way ANOVA also yielded a significant difference in the number of IR systems consulted between the one-time tasks and multi-time tasks (F (1, 142) = 4.23, $p<.05$). It was not significantly different among the unique, intermittent, and routine work tasks in terms of the number of IR systems consulted.

With respect to result pages viewed, the participants viewed the most pages for the unique work tasks, and more pages for the long-term and multi-time work tasks. One-way ANOVA detected a significant difference across the unique, intermittent, and routine work tasks (F (2, 141) = 5.05, $p<.01$) as well as between the short-term and long-term work tasks (F (1, 142) = 8.82, $p<.01$). Further Post Hoc tests (Tukey HSD) indicated that for the unique work tasks, the participants viewed significantly more result pages than for the intermittent ($p<.01$) and routine tasks ($p<.01$), but there was no significant difference between the intermittent and routine work tasks. However, it was not significantly different between the one-time and multi-time work tasks in terms of result pages viewed.

Also, there was not a significant difference found in the number of items viewed and selected across the unique, intermittent, and routine work tasks, between the short-term and long-term work tasks, and between the one-time and multi-time work tasks, though in general the participants viewed most items for the unique work tasks, and more items for the long-term and multi-time process work tasks.

Table 9.6 shows the correlation between users' perceptions of tasks and the number of IR systems consulted, result pages viewed, items viewed, and selected.
Significant correlation was detected between the number of IR systems consulted and work task difficulty (r (142) = .32, $p<.01$), subjective work task complexity (r (142) = .31, $p<.01$), and degree of knowledge with task topic (r (142) = -.36, $p<.01$). This means

that if work tasks were assessed as more difficult and more complex, the participants needed to consult more IR systems. However, if the participants were more knowledgeable with a work task, they consulted fewer IR systems. In addition, there existed a significant correlation between the number of result pages viewed and work task difficulty ($r(142) = .31$, $p<.01$), subjective work task complexity ($r(142) = .28$, $p<.01$), and knowledge of work task topic ($r(142) = -.37$. $p<.01$). This indicates that if a work task was more difficult, the participants viewed more result pages, so did a work task assessed as more complex. However, if the participants were less knowledgeable with the work task topic, they viewed more result pages. In addition, the number of items viewed was negatively and significantly correlated with the participants' knowledge of work task procedure ($r(142) = -.17$, $p<.05$). So it is possible that the participants viewed more items

Table 9.6. Correlations (r) between users' perception and IR systems consulted

Facets	Sub-facets	IR systems consulted	Result pages viewed	Items viewed	Items selected
User's perception of task	Work task difficulty	.32**	.31**	.12	.04
	Subjective work task complexity	.31**	.28**	.09	.09
	Knowledge of work task topic	-.36**	-.37**	-.13	-.13
	Knowledge of work task procedure	-.12	-.15	-.17*	-.12

** p<.01;
* p<.05

if they have less knowledge of work task procedure. However, no significant correlation was detected between items viewed and other sub-facets of users' perception. Also, there was not a significant correlation between items selected with all sub-facets of users' perception.

9.2.2. Interaction with Web resources

This section presents the interaction between the participants and Web resources, including search engines, portals, web result pages, and web items. Several measures are used here, such as number of search engines consulted, number of Web result pages viewed, portal viewed, items viewed, and items selected as defined in Section 8.2. Table 9.7 shows the mean and SD of these measures and the results of one factor repeated measures ANOVA.

Table 9.7. Interaction with Web resources in terms of different work tasks

	IL	IM	IH	DL	DM	DH	*F*
Search engines consulted	1.08 (.50)	1.13 (.53)	1.25 (.61)	.25 (.44)	1.42 (.65)	1.00 (.30)	16.62**
Web results pages viewed	4.50 (2.62)	3.54 (2.77)	4.38 (2.96)	1.00 (1.32)	5.46 (2.99)	4.58 (2.84)	10.21**
Portals visited	7.54 (4.11)	2.46 (2.13)	1.67 (1.63)	10.04 (7.68)	.88 (1.23)	6.29 (4.44)	19.90**
Web items viewed	7.67 (5.05)	6.54 (4.19)	6.42 (5.82)	5.33 (3.81)	7.42 (3.41)	11.92 (7.12)	6.41**
Web items selected	4.04 (2.05)	4.42 (2.64)	3.42 (3.79)	2.75 (1.48)	3.08 (1.53)	5.21 (3.08)	3.97*

** $p<.01$
* $p<.05$

9.2.2.1. Search engines consulted

In total the participants visited search engines 147 times for the six work tasks, and Google Web (for distinguishing from other Google products) was used 116 times (79%).

Other search engines visited include Google Scholar, Google Book Search, Yahoo.com, Ask.com, Askjeeves, and About.com.

The participants consulted the most search engines for DM, but the least for DL. One factor repeated measures ANOVA indicated that the participants consulted significantly different number of search engines (F (5, 115) = 16.62, p<.01) when searching for the six work tasks. Post Hoc tests (Bonferroni) indicated that for DL, the participants consulted significantly fewer search engines than for other work tasks (p<.01). In other words, the participants may not heavily depend on search engines for completing DL.

9.2.2.2. Web r*esult pages viewed*

One factor repeated measures ANOVA detected a significant difference (F (5, 115) = 10.21, p<.01) in the number of web result pages viewed across the work tasks. Post Hoc tests (Bonferroni) indicated that the significant difference only occurred between DL and other work tasks (p<.01). For DL the participants viewed significantly fewer result pages when searching the Web.

9.2.2.3. Portals visited

For DL, the subject visited the most portals, but for IH, the least portals were visited. One factor repeated measures ANOVA found a significant difference in the number of portals visited across different work tasks (F (2.41, 55.53) = 19.90, p<.01) (Greenhouse-Geisser). Post Hoc tests (Bonferroni) indicated that the participants visited significantly more portals for IL than for IM (p<.01), IH (p<.01), and DM (p<.01); for DL, they visited significantly more portals than for IM (p<.01), IH (p<.01), and DM (p<.01); for DH they also visited significantly more portals than for IM (p<.05), IH (p<.01), and DM (p<.01).

9.2.2.4. Web items viewed

For DH the participants viewed the most web items, whereas they viewed the least items for DL. One factor repeated measures ANOVA demonstrated a significant difference in the number of Web items viewed across different work tasks (F (5, 115) = 6.41, $p<.01$). Post Hoc tests (Bonferroni) detected that the difference occurred between IM and DH ($p<.05$), and between DL and DH ($p<.05$). The participants viewed significantly more items for DH than for IM and DL.

9.2.2.5. Web items selected

For DH the participants selected the most web items. Again, the least web items were selected for DL. One factor repeated measures ANOVA indicated that there was a significant difference in the number of items selected among the work tasks (F (2.69, 61.84) = 3.97, $p<.05$) (Greenhouse-Geisser). Post Hoc tests (Bonferroni) indicated that the difference only occurred between DL and DH ($p<.05$). The participants selected significantly more items for DH than for DL. However, there was not a significant difference in the number of items selected for other work tasks.

9.2.2.6. Relationships between work task facets and interaction with Web resources

This section examines the relationships between the participants' interaction with the Web and work task facets. Table 9.8 presents mean (SD) in terms of the participants' interaction with Web resources and the results of one-way ANOVA tests.

One-way ANOVA detected that overall the participants consulted significantly different number of search engines when searching for the unique, intermittent, and routine work tasks (F (2, 141) = 4.49, $p<.05$). Post Hoc tests (Tukey HSD) indicated that the participants consulted significantly fewer search engines for the routine work tasks than for the unique work tasks (p<.01). Also, there was a significant difference in the number of search engines consulted for the one-time and multi-time work tasks (*F* (1. 142) = 4.40, p<.05). For the multi-time work tasks, the participants consulted significantly more search engines than for the one-time work tasks.

Table 9.8. Generic work task facets and interaction with Web resources

Generic Facets	Values	Search engines consulted	Portals visited	Web result pages viewed	Web items viewed	Web items selected
Time (Frequency)	Unique (N=22)	1.32 (.65)	3,82 (4.03)	5.36 (3.05)	8.82 (5.89)	4.36 (2.44)
	Intermittent (N=92)	1.02 (.59)	4.75 (4.84)	4.07 (2.96)	7.82 (5.63)	3.95 (2.87)
	Routine (N=30)	.80 (.66)	5.73 (7.20)	2.37 (2.34)	5.80 (3.80)	3.03 (1.96)
	F	4.49*	.84	7.46**	2.34	1.90
Time (Length)	Short-term (N=122)	.99 (.64)	5.16 (5.56)	3.77 (2.87)	7.57 (5.24)	3.87 (2.67)
	Long-term (N=22)	1.18 (.59)	2.86 (3.03)	4.68 (3.41)	7.41 (6.37)	3.55 (2.65)
	F	1.70	3.56	1.77	.02	.28
Process	One-time (N=35)	.83 (.79)	4.63 (4.89)	3.57 (3.27)	6.23 (4.75)	3.46 (3.08)
	Multi-time (N=109)	1.08 (.56)	4.87 (5.45)	4.02 (2.87)	7.97 (5.54)	3.94 (2.51)
	F	4.40*	.06	.60	2.80	.86

**p<.01
* p<.05

Also, one-way ANOVA found that the participants viewed significantly different number of web result pages for the unique, intermittent work tasks, and routine work tasks (*F* (2, 141) = 7.46, p<.01). Post Hoc tests (Turkey HSD) indicated that the participants examined significantly more web result pages when searching for the unique work tasks than for the routine work tasks (p<.01); also for the intermittent work tasks they viewed significantly more web result pages compared to the routine work tasks (p<.05).

However, there was not a significant difference between the generic facets of work tasks and portals visited, web items viewed, and web items selected.

With respect to the correlation between users' perception of work tasks and the web interaction, Table 9.9 presents their correlation coefficient and significance.

Table 9.9. Correlation between user's perception and interaction with Web resources

Facets	Values	Search engines consulted	Portals visited	Web result pages viewed	Web items viewed	Web items selected
User's perception of task	Work task difficulty	.33**	-.19*	.25*	.11	.07
	Subjective work task complexity	.24**	-.24**	.17*	.07	.10
	Knowledge of work task topic	-.36**	.35**	-.29**	-.06	-.08
	Knowledge of work task procedure	-.32**	.14	-.18*	-.16	-.14

**p<.01
*p<.05

A significant correlation was found between work task difficulty and the number of search engine consulted (r (142) = .33, p<.01), portals visited (r (142) = -.19, p<.05), and web result pages viewed (r (142) = .17, p<.01). This means that for more difficult work tasks, the participants consulted more search engines, visited less portals, and viewed more web result pages.

It was also found that subjective work task complexity was significantly correlated with the number of search engines consulted (r (142) = .24, p<.01), portals visited (r

(142) = -.24, p<.05), and web result pages viewed (r (142) = .35, p<.01). The participants consulted more search engines, visited less portals, and viewed more web result pages if a work task was more complex based on their perception.

The participants' knowledge level of work task was detected significantly correlated with the number of search engines consulted (r (142) = -.36, p<.01), portals visited (r (142) = .35, p<.01), and web result pages viewed (r (142) = -.29, p<.01). This means that the participants consulted fewer search engines, visited more portals, and viewed fewer web result pages if they were more knowledgeable with the topic of a work task.

The participants' knowledge level of work task procedure was also found significantly correlated with the number of search engines consulted (r (142) = -.32, p<.01) and web result pages viewed (r (142) = -.18, p<.05). The participants consulted fewer search engines and viewed fewer web result pages if they were more knowledgeable with the procedure to complete a work task.

However, there is not significant correlations detected between the sub-facets of users' perception and web items viewed and web items selected.

9.2.3. Interaction with Library Resources

Since mostly the participants used databases and indexes in this study through library web sites, these resources and library OPAC systems are labeled "library resources". This section focuses on the participants' interaction with library resources, which is measured by the number of library resources consulted, library result pages viewed, library items viewed, and library items selected. Table 9.10 presents the mean (SD) of each work task and the results of one factor repeated measures ANOVA.

Table 9.10. Interaction with library resources in terms of different work tasks

	IL	IM	IH	DL	DM	DH	*F*
Library resources consulted	.04 (.21)	.79 (.98)	.71 (.75)	*.00 (.00)*	.46 (.72)	.04 (.20)	10.39**
Library result pages viewed	.13 (.45)	1.21 (1.69)	1.58 (2.57)	*.00 (.00)*	.96 (1.60)	.21 (.72)	6.22**
Library items viewed	.04 (.20)	1.46 (2.81)	1.50 (2.62)	*.00 (.00)*	1.63 (1.72)	.08 (.41)	6.48**
Library items selected	*.00 (.00)*	1.08 (2.04)	1.67 (4.05)	*.00 (.00)*	.92 (1.77)	.04 (.20)	3.28

**p<.01
Italic: not included in ANOVA tests

9.2.3.1. Library resources consulted

To collect supportive information for the work tasks, the participants consulted much fewer library resources compared to Web resources though they consulted library resources for most of work tasks (See Table 9.10). One factor repeated measures ANOVA detected a significant difference in the number of library resources consulted for IL, IM, IH, DM, and DH (F (2.55, 58.69) = 10.39, p<.01) (Greenhouse-Geisser). DL was not included since no participants consulted library resources for it. Post Hoc tests (Bonferroni) indicated that for IL, the participants consulted significantly fewer library resources than for IM (p<.05) and IH (p<.01), but for IM and IH, the participants consulted significantly more library resources than for DH (p<.01). Also, they consulted significantly more library resources for DM than for DH (p<.05). There was not a significant difference across IM, IH, and DM.

9.2.3.2 Library result pages viewed

In terms of library result pages viewed, Table 9.10 shows that the participants viewed the most library result pages compared to other work tasks for IH, whereas for DL they did not view any library result pages. One factor repeated measures ANOVA showed that the participants viewed significantly different number of library result pages for the different work tasks (F (2.14, 49.28) = 6.22, $p<.01$) (Greenhouse-Geisser). Again, DL was not included in the ANOVA test. Further Post Hoc tests (Bonferroni) indicated that there was a significant difference in library result pages viewed between IL and IM ($p<.05$), between IM and DH ($p<.05$), and between IH and DH ($p<.05$). That means for DH the participants viewed significantly fewer result pages than for IM and IH, while they viewed significantly more result pages for IM compared to IL. However, no significant difference was found between IM, IH, and DM.

9.2.3.3. Library items viewed

Library items refer to the papers and bibliographic records the participants viewed through library portals. The participants did not view any items through library web sites for DL, but viewed the most items for DM. It also could be seen that the participants viewed much fewer items through libraries compared to those viewed from the Web. One factor repeated measures ANOVA indicated a significant difference in the number of items viewed among IL, IM, IH, DM and DH (F (1.96, 45.17) = 6.48, $p<.01$) (Greenhouse-Geisser). Post Hoc tests (Bonferroni) found that significant differences existed between IL and DM ($p<.01$) and between DM and DH ($p<.01$). The participants viewed significantly more items for DM than for IL and DH, respectively.

9.2.3.4. Library items selected

It was found that no items were selected from library resources for IL and DL. However, the participants selected the most items from library resources for IH. One factor repeated measures ANOVA did not indicate a significant difference in library items selected among IM, IH, DM, and DH.

9.2.3.5. Relationships between work task facets and interaction with library resources

Table 9.11 shows the mean (SD) of the participants' interaction with library resources and the results of one-way ANOVA tests.

Table 9.11. Generic facets of work tasks and interaction with library resources

Generic Facets	Values	Library sources consulted	Library result pages viewed	Library items viewed	Library items selected
Time (Frequency)	Unique (N=22)	.23 (.43)	.50 (1.01)	.32 (.89)	.18 (.395)
	Intermittent (N=92)	.26 (.53)	.54 (1.34)	.68 (1.77)	.60 (2.38)
	Routine (N=30)	.67 (1.03)	1.23 (2.27)	1.43 (2.43)	1.00 (1.66)
	F	4.75*	2.45	2.73	1.02
Time (Length)	Short-term (N=122)	.29 (.62)	.47 (1.16)	.67 (1.71)	.54 (2.11)
	Long-term (N=22)	.64 (.85)	1.86 (2.64)	1.41 (2.46)	1.05 (1.73)
	F	5.21*	10.71**	2.98	1.12
Process	One-time (N=35)	.26 (.78)	.26 (.82)	.57 (1.15)	.20 (.53)
	Multi-time (N=109)	.37 (.63)	.82 (1.72)	.85 (2.03)	.75 (2.33)
	F	.71	3.49	.61	1.92

**p<.01
*p<.05

One-way ANOVA yielded a significant difference in the number of library resources consulted among the unique, intermittent, and routine work tasks (F (2, 141) = 4.75, p<.05). Post Hoc tests (Tukey HSD) showed that the participants consulted significantly fewer library resources for the unique work tasks and the intermittent work tasks than for the routine work tasks, both at p<.05 level.

In addition, one-way ANOVA found that the participants viewed significantly different number of library result pages for the long-term work tasks than for the short-term work tasks (F (1, 142) = 18.48, p<.01). However, there was not a significant difference found between the generic facets of work tasks and the number of items viewed and items selected.

Table 9.12 shows the correlation (r) between the sub-facets of users' perception of tasks and the measures of interaction with library resources.

Table 9.12. Correlation between users' perception and interaction with library resources

Facets	Values	Library resources consulted	Library result pages viewed	Library items viewed	Library items selected
User's perception of task	Work task difficulty	.12	.09	.03	-.03
	Subjective work task complexity	.20*	.19*	.05	-.01
	Knowledge of work task topic	-.16	-.13	-.20*	-.08
	Knowledge of work task procedure	.14	.10	.003	.007

*p<.05

As shown in Table 9.12, the participants' subjective work task complexity was found significantly correlated with the number of library resources consulted (r (142) = .20, p<.05) and library result pages viewed (r (142) = .19, p<.05). The participants consulted more library resources and viewed more library result pages if a work task was assessed more complex. The participants' knowledge level in work task topic was also found significantly and negatively correlated with the number of library items viewed (r (142) = -.20, p<.05). The participants consulted fewer library resources and viewed fewer library items if they were more knowledgeable with the topic of a work task.

9.2.4. Query-related Interactive Behavior

This section focuses on how work tasks influence query-related interactive behavior, including iteration, unique queries issued, query length, unique query terms used, and unique non-stop query terms used. All these actions were measured by the occurrences during the participants' interaction with the systems. Table 9.13 lists the mean (SD) and the results of one factor repeated measures ANOVA tests.

9.2.4.1. Iteration

Each time when the participants issued a search query to the systems, it was called one time of iteration. Iteration was measured by the number of queries issued to the systems for each work task. Table 9.13 shows that in general the most iteration occurred for DM, but the least for DL. One factor repeated measures ANOVA found a significant difference in the number of iteration across the work tasks (F (5, 115) = 11.79, p<.01). Post Hoc tests (Bonferroni) indicated that the participants issued significantly fewer queries for DL than for other work tasks (p<.01).

9.2.4.2. Unique queries issued

The participants issued the most unique queries for DM, and the least for DL. One factor repeated measures indicated a significant difference in the number of unique queries issued across all six work tasks (F (5, 115) = 8.84, p<.01). Post Hoc tests

(Bonferroni) detected that the participants issued significantly fewer unique queries for DL than for any other work tasks (p<.01).

Table 9.13. Query-related interactive behavior in terms of different work tasks

	IL	IM	IH	DL	DM	DH	*F*
Iteration	3.83 (2.10)	4.38 (2.76)	4.92 (2.34)	1.04 (1.46)	5.67 (2.20)	4.04 (2.97)	11.79**
Unique queries issued	3.00 (1.38)	3.46 (2.34)	3.88 (2.71)	1.00 (1.35)	4.33 (1.63)	3.83 (2.81)	8.84**
Mean query length	2.91 (.92)	2.69 (.73)	3.63 (.96)	1.10 (1.40)	3.05 (1.26)	3.15 (1.21)	16.41**
Unique query terms used	5.67 (2.68)	6.13 (4.01)	8.08 (4.09)	2.08 (3.15)	8.50 (5.70)	7.42 (4.42)	9.52**
Unique non-stop terms used	4.87 (2.21)	4.83 (3.33)	7.00 (3.62)	2.00 (3.04)	6.92 (3.86)	6.87 (4.06)	9.41**

**p<.01

9.2.4.3. Mean query length

Mean query length was calculated based on how many terms were used in a query on average when searching for a work task. It could be seen from Table 9.13, the participants issued the longest query for IH, but the shortest for DL. One factor repeated measures ANOVA found that it was significantly different in mean query length of the six work tasks (F (5, 115) = 16.41, p<.01). Post Hoc tests (Bonferroni) detected that the participants issued significantly shorter queries for DL than for any other work tasks (p<.01); also, they submitted significantly shorter queries to the systems for IM than for IH (p<.05).

9.2.4.4. Unique query terms

The total number of unique query terms for each work task was computed. In general, the participants used the most unique query terms for DM, and the least for DL. One factor repeated measures ANOVA found a significant difference in the number of unique query terms used across the six work tasks (F (3.67, 84.44) = 9.52, $p<.01$) (Greenhouse-Geisser). Post Hoc tests (Bonferroni) found that the participants submitted significantly fewer unique query terms to the systems for DL than for IL ($p<.01$), IM ($p<.05$), IH ($p<.01$), DM ($p<.01$), and DH ($p<.01$).

9.2.4.5. Unique non-stop terms

When unique query terms were calculated for each work task, the stop words, i.e., the articles and prepositions, were taken into account. However, these terms are meaningless for information retrieval. Therefore, unique non-stop terms were calculated for more closely examining users' interactive behavior.

Table 9.13 shows that the participant used the most unique non-stop query terms for IH, while the least for DL. One factor repeated measures ANOVA test indicated a significant difference in the number of non-stop query terms used across the work tasks (F (3.58, 82.39) = 9.41, $p<.01$) (Greenhouse-Geisser). Post Hoc tests (Bonferroni) found that the participants issued significantly fewer unique non-stop query terms for DL than for IL ($p<.05$), IH ($p<.01$), DM ($p<.01$), and DH ($p<.01$).

9.2.4.6. Relationships between work tasks facets and query-related interactive behavior

This section examines the relationships between work tasks and the participants' query-related interactive behavior. Table 9.14 lists the mean (SD) and the results of one way ANOVA tests.

One-way ANOVA yielded a significant difference in the number of iteration when the participants searched for the unique, intermittent, and routine work tasks (F (2. 141) = 6.25, p<.01). Post Hoc tests (Tukey HSD) found that they issued significantly more search queries to the systems for the unique work tasks than for the intermittent work tasks (p<.05) and routine work task (p<.01). For the short-term and long-term work tasks, the participants also issued significantly different number of search queries (F (1, 142) = 5.18, p<.05). There was not a significant difference detected for the one-time and multi-time work tasks in terms of number of iteration.

The participants also issued significantly different number of unique queries for the unique, intermittent, and routine work tasks (F (2, 141) = 7.78, p<.01). Post Hoc tests (Tukey HSD) indicated that for the routine work tasks, the participants issued significantly fewer unique queries than for the unique (p<.01) and intermittent work tasks (p<.01).

With respect to mean query length, one-way ANOVA demonstrated a significant difference across the unique, intermittent, and routine work tasks (F (2, 141) =6.02, p<.01). Post Hoc tests (Tukey HSD) found that the participants issued significantly longer queries for the unique work tasks than for the routine work tasks (p<.01). There was not a significant difference between the unique and intermittent work tasks. For the short-term and long-term work tasks, the participants also issued significantly different length of search queries (F (1, 142) = 4.41, p<.05), as well as for the one-time and multi-time work tasks (F (1, 142) = 8.86, p<.01).

One-way ANOVA detected that the participants used significantly different number of unique query terms for the unique, intermittent, and routine work tasks (F (2, 141) = 7.43, p<.01). Post Hoc tests (Bonferroni) showed that for the unique work tasks, the participants employed significant more unique query terms than for the routine work tasks (p<.01). In addition, one-way ANOVA found a significant difference between the short-term and long-term work tasks in the umber of unique query terms used (F (1, 142) = 5.11, p<.05). No significant difference was found between the one-time and multi-time work tasks.

Table 9.14. Generic facets of work task and interaction with work tasks

Generic Facets	Values	Iteration	Unique queries issued	Mean query length	Unique query terms used	Unique non-stop terms used
Time (Frequency)	Unique (N=22)	5.68 (2.61)	4.82 (2.72)	3.25 (1.13)	8.82 (5.02)	7.68 (4.03)
	Intermittent (N=92)	3.85 (2.72)	3.13 (2.13)	2.86 (1.37)	6.43 (4.57)	5.47 (3.81)
	Routine (N=30)	3.13 (2.37)	2.47 (1.85)	2.08 (1.18)	4.10 (3.22)	3.60 (2.55)
	F	6.25**	7.78**	6.02**	7.43**	8.08**
Time (length)	Short-term (N=122)	3.76 (2.70)	3.10 (2.21)	2.66 (1.35)	5.95 (4.45)	5.07 (3.62)
	Long-term (N=22)	5.18 (2.65)	4.09 (2.54)	3.30 (1.17)	8.32 (4.92)	7.36 (4.24)
	F	5.18*	3.60	4.41*	5.11*	7.11**
Process	One-time (N=35)	3.31 (2.84)	2.60 (2.08)	2.18 (1.53)	5.54 (5.40)	4.66 (4.21)
	Multi-time (N=109)	4.19 (2.68)	3.46 (2.31)	2.94 (1.23)	6.56 (4.29)	5.66 (3.64)
	F	2.77	3.83	8.86**	1.31	1.86

**p<.01
*p<.05

It was also found that the participants used significantly different number of unique non-stop query terms for the unique, intermittent, and routine work tasks (*F* (2, 141) = 8.08, p<.01). Post Hoc tests (Tukey HSD) indicated that for the unique work tasks, the participants used significantly more unique non-stop query terms than for the intermittent (p<.05) and routine work tasks (p<.01). One-way ANOVA also found that it was significantly different in the number of unique non-stop query terms used for the short-term and lone-term work tasks (*F* (1, 142) = 7.11, p<.01).

Table 9.15 shows the correlation coefficient (r) between the sub-facets of users' perception and the measures of query-related interactive behavior.

Table 9.15. Correlation between user's perception and query-related interactive behavior

Facets	Sub-facets	Iteration	Unique queries issued	Mean query length	Unique query terms used	Unique non-stop terms used
User's perception of task	Work task difficulty	.34**	.33**	.37**	.32**	.34**
	Subjective work task complexity	.30**	.28**	.35**	.28**	.31**
	Knowledge of work task topic	-.37**	-.33**	-.28**	-.27**	-.27**
	Knowledge of work task procedure	-.14	-.13	-.25**	-.13	-.14

**p<.01

It could be seen from Table 9.15 that work task difficulty was significantly and positively correlated with the number of iteration (r (142) = .34, p<.01), unique queries issued (r (142) = .33, p<.01), unique query terms (r (142) =.32, p<.01), unique non-stop query terms (r (142) =.34, p<.01), and mean query length (r (142) = .37, p<.01). This indicates that the participants issued more queries and more unique queries, used more unique query terms and unique one-stop query terms, and issued longer queries if a work task was more difficult.

Subjective work task complexity was also significantly and positively correlated with the number of iteration ($r\ (142) = .37$, $p<.01$), unique queries issued ($r\ (142) = .33$, $p<.01$), unique query terms ($r\ (142) = .28$, $p<.01$), unique non-stop query terms ($r\ (142) = .31$, $p<.01$), and mean query length ($r\ (142) = .35$, $p<.01$). The participants issued more queries and more unique queries, used more unique query terms and unique one-stop query terms, and issued longer queries if they felt that a work task was more complex.

The participants' knowledge level of work task topic was found significantly correlated with the number of iteration ($r\ (142) = -.37$, $p<.01$), unique queries issued ($r\ (142) = -.33$, $p<.01$), unique query terms ($r\ (142) =-.27$, $p<.01$), unique non-stop query terms ($r\ (142) = -.27$, $p<.01$), and mean query length ($r\ (142) = -.28$, $p<.01$). However, it is noticed that the correlation between them was negative. The participants issued more queries and more unique queries, used more unique query terms and unique one-stop query terms, and issued longer queries if they had less knowledge about a work task topic.

It was found that knowledge level of task procedure was significantly and negatively correlated with mean query length ($r\ (142) = -.25$, $p<.01$). This means that the participants issued longer queries if they had less knowledge on work task procedure.

9.3. Performance of Interaction

Though the participants' performance in terms of different types of work tasks is not a behavior issue, since it is a result of their interaction with the systems, this section examines the users' performance with respect to different types of work tasks. It will also probe the effects of different facets of work task on the performance of interaction.

9.3.1. Completion of Information Search for Work Tasks

After the search for each work task was over, the participants were asked to fill out a post-search questionnaire. The first two questions in this questionnaire asked them "1: Did you have enough time to complete the search for the work task?" and "2a: Did you get enough information to support your work task?" For both questions, they needed to check either "Yes" or "No". This section reports the completion of the search for the work tasks from these two perspectives, i.e., time sufficiency and information sufficiency. If the participants answered "Yes", that means they completed the search; if they checked "No", that means they did not complete the search for the work task. Table 9.16 and Table 9.17 present the results in terms of each work task.

Table 9.16 and Table 9.17 show that whether in terms of time sufficiency or information sufficiency, the most participants answered "Yes" for DL compared to other work tasks; but for IH, the most participants said "No", with only eight and six participants who completed the search respectively.

9.3.2. Task Performance

Task performance was measured by Success, Users' satisfaction, Time, and the ratio between time and total number of items selected to support the work task (Time/Items selected). The first two measures measure effectiveness and the other two measure efficiency. For Success, the participants were asked to self-assess the successfulness in

Table 9.16. Task completion in terms of time sufficiency

			Work tasks						Total
			IL	IM	IH	DL	DM	DH	
Have enough time?	Yes	Count	21	19	8	23	14	13	98
		% within work task	87.5%	79.2%	33.3%	95.8%	58.3%	54.2%	68.1%
	No	Count	3	5	16	1	10	11	46
		% within work task	12.5%	20.8%	66.7%	4.2%	41.7%	45.8%	31.9%
	Total	Count	24	24	24	24	24	24	144
		% within work task	100%	100%	100%	100%	100%	100%	100%

Table 9.17. Task completion in terms of information sufficiency

			Work tasks						Total
			IL	IM	IH	DL	DM	DH	
Get enough infor-mation?	Yes	Count	18	16	6	22	14	13	89
		% within work task	75.0%	66.7%	25.0%	91.7%	58.3%	54.2%	61.8%
	No	Count	6	8	18	2	10	11	55
		% within work task	25.0%	33.3%	75.0%	8.3%	41.7%	45.8%	38.2%
	Total	Count	24	24	24	24	24	24	144
		% within work task	100%	100%	100%	100%	100%	100%	100%

searching information for the work task after the end of the search for each work task.

Users' satisfaction was measured by the participants' self-assessed satisfaction with the search process for the work task. Time refers to how long the participants spent in searching information for a work task. But as mentioned in Section 8.3, the participants usually had 15 minutes to search for each work task. If they cannot complete, the experimenter asked them to stop. Thus, Time is not a precise measure for efficiency. Time/Item selected calculates how much time was spent on average for each item which was selected to support work task. Table 9.18 lists the mean (SD) of Success, Users' satisfaction, Time, and Time/Items selected in terms of each work task, and the results of one factor repeated measures ANOVA tests.

The participants rated DL as the most successful one, but IH as the least. One factor repeated measures ANOVA indicated a significant difference in Success of the search for each work task (F (2.85, 65.54) = 9.64, $p<.01$) (Greenhouse-Geisser). Post Hoc tests (Bonferroni) found that the participants felt they were significantly more successful for DL than for IL, IM, IH, and DH at $p<.01$ level respectively, as well as more successful than for DM ($p<.05$). In addition, they felt that they were significantly more successful for IL than for IH ($p<.05$), and they felt more successful for IM than for IH ($p<.05$).

Overall, the participants were most satisfied with the search for DL, but least for IH. One factor repeated measures ANOVA detected that the participants perceived significantly different in satisfaction with the search process for the work tasks (F (3.39, 77.93) = 12.53, $p<.01$) (Greenhouse-Geisser). Post Hoc tests (Bonferroni) found that the participants perceived that they were significantly more satisfied with DL than with IL, IH, DM, and DH at $p<.01$ level respectively, also than IM at $p<.05$ level. In addition, they perceived significantly more satisfied with IL than with IH ($p<.01$), and more satisfied with IM than with IH ($p<.01$).

Table 9.18. Performance of interaction in terms of different work tasks

	IL	IM	IH	DL	DM	DH	*F*
Success	5.54 (1.02)	5.71 (.87)	4.42 (1.47)	6.46 (.83)	5.08 (1.56)	5.37 (1.10)	9.64**
Satisfaction	5.58 (.93)	5.87 (.85)	4.21 (1.50)	6.50 (.72)	4.96 (1.49)	5.17 (1.31)	12.53**
Time	578.58 (233.97)	613.21 (217.12)	753.42 (220.21)	344.08 (171.58)	702.75 (222.38)	706.08 (229.79)	13.80**
Time/Item selected	172.53 (114.32)	131.18 (79.98)	249.33 (216.51)	144.21 (99.77)	196.39 (77.87)	175.15 (118.93)	3.15*

** p<.01
* p<.05

Though for each search the time was limited to 15 minutes, the participants spent different length of time for different work tasks. The participants spent the longest time for IH, but they spent the least of time for DL. One factor repeated measures ANOVA detected a significant difference in how long the participants spent on searching for the work tasks (*F* (5, 115) = 13.80, p<.01). Post Hoc tests (Bonferroni) showed that for DL the participants spent significantly less time than for all other tasks at p<.01 level.

In terms of Time/Item selected, the participants spent the longest time for locating each item which may useful for IH, but the least time for each item selected for DL. One factor repeated measures ANOVA found a significant difference in the ratio among the work tasks (*F* (2.70, 62.18) = 3.15, p<.05) (Greenhouse-Geisser). However, Post Hoc tests (Bonferroni) did not find significant differences between any pair of the work tasks.

The performance of work tasks for which the participants had enough time (Yes)/did not have enough time (No), and got enough information (Yes) /did not get enough information (No) was also calculated. Table 9.19 shows the mean (SD) and the results of one-way ANOVA tests.

For the work tasks the participants had enough time and those they did not have enough time, the participants were significantly different in terms of success (*F* (1, 142) = 60.87, p<.01), their satisfaction (*F* (1, 142) = 59.55, p<.01), time spending on the search (*F* (1, 142) = 33.68, p<.01), and the ratio of time and items selected (*F* (1, 142) = 7.12, p<.01).

The participants were also significantly different in success (*F* (1, 142) = 90.14, p<.01), their satisfaction (*F* (1, 142) = 106.66, p<.01), time spending on the search (*F* (1, 142) = 40.46, p<.01), and the ratio of time and items selected (*F* (1, 142) = 12.91, p<.01) when they engaged in the work tasks for which they got enough information and for which they did not get enough information.

Table 9.19. Performance of completed (Yes) and incompleted (No) searches

		Success	Satisfaction	Time	Time/items selected
Have enough time?	Yes (N=98)	5.92 (.96)	5.78 (1.05)	540.85 (232.22)	158 (113.27)
	No (N=46)	4.39 (1.34)	4.26 (1.20)	777.22 (218.30)	219.57 (154.27)
F		60.87**	59.55**	33.68**	7.12**
Got enough information	Yes (N=89)	6.07 (.78)	5.97 (.88)	523.17 (222.60)	148.65 (101.25)
	No (N=55)	4.40 (1.33)	4.21 (1.15)	767.15 (225.27)	225.84 (156.70)
F		90.14**	106.66**	40.46**	12.91**

**p<.01

9.3.3. Relationships between Work Task Facets and Performance of Interaction

It was calculated how the facets of a work task were related to task performance. Table 9.20 shows the mean (SD) of Success, Satisfaction, Time, and Time/Items selected in terms of each value of the generic facets and the results of one-way ANOVA tests.

Table 9.20. Generic work task facets and task performance

Generic Facets	Values	Success	Satisfaction	Time	Time/Items selected
Time (Frequency)	Unique (N=22)	4.59 (1.50)	4.41 (1.48)	728.91 (254.26)	194.37 (107.69)
	Intermittent (N=92)	5.38 (1.27)	5.26 (1.28)	616.25 (261.01)	180.73 (145.27)
	Routine (N=30)	6.20 (.76)	6.05 (.74)	534.13 (193.48)	158.25 (92.58)
	F	11.26**	11.56**	3.93*	.534
Time (length)	Short-term (N=122)	5.55 (1.29)	5.41 (1.30)	605.89 (255.84)	177.27 (129.13)
	Long-term (N=22)	4.77 (1.23)	4.66 (1.17)	674.41 (230.61)	182.92 (140.16)
	F	6.88*	6.37*	1.38	.035
Process	One-time (N=35)	5.91 (1.01)	5.86 (1.15)	470.57 (231.10)	157.62 (100.71)
	Multi-time (N=109)	5.28 (1.35)	5.11 (1.31)	663.17 (242.02)	184.72 (138.32)
	F	6.61*	9.01**	17.14**	1.15

**p<.01
*p<.05

It was found that it was significantly different in success among the unique, intermittent, and routine work tasks by one-way ANOVA (*F* (2, 141) = 11.26, p<.01). Post Hoc tests (Tukey HSD) found that for the unique work tasks, the participants felt significantly less successful than for the intermittent work tasks (p<.05) and routine work tasks (p<.01). Additionally, for the intermittent work tasks, they felt significantly less successful than for the routine work tasks (p<.01). The participants also felt significantly different in success for the short-term and long-term work tasks (*F* (1, 142) = 6.88, p<.05), and also for the one-time and multi-time work tasks (*F* (1, 142) = 6.61, p<.05).

One-way ANOVA found that for the unique, intermittent, and routine work tasks the participants felt significantly different in satisfaction with the search process (*F* (2, 141) = 11.56, p<.01). Post Hoc tests (Tukey HSD) demonstrated that the participants were significantly less satisfied with the search for the unique work tasks than for the intermittent work tasks ($p<.05$) and routine work tasks ($p<.05$). In addition, they felt significantly less satisfied with the search for the intermittent work tasks than for the routine work tasks ($p<.01$). The participants perceived significantly different between satisfaction with the short-term work tasks and the long-term work tasks ($F\ (1, 142) = 6.37$, $p<.05$). They also felt significantly different between satisfaction with the one-time work tasks and the multi-time work tasks ($F\ (1.\ 142) = 9.01$, $p<.01$).

There was a significant difference in terms of how much time the participants spent for the unique, intermittent, and routine work tasks during the experiment by one-way ANOVA ($F\ (2, 141) = 3.93$, $p<.05$). Post Hoc tests (Tukey HSD) indicated that for the unique work tasks, the participants spent significantly more time than for the routine work tasks ($p<.05$). It was not significantly different in terms of the time the participants spent for the short-term work tasks and long-term work tasks. However, one-way ANOVA found a significant difference in time spending for the one-time work tasks and multi-time work tasks ($F\ (1, 142) = 17.14$, $p<.01$).

One-way ANOVA did not find significant difference in the ratio of time and items selected among the unique, intermittent, and routine work tasks, between the short-term work tasks and long-term work tasks, and between the one-time and multi-time work tasks. Table 9.21 reports the correlation between the sub-facets of users' perception of task and task performance.

It could be seen that work task difficulty was significantly correlated with success ($r\ (142) = -.41$, $p<.01$), users' satisfaction ($r\ (142) = -.45$, $p<.01$), and time ($r\ (142) = .34$, p<.01). That means if a work task was more difficult, the participants felt less successful, less satisfied with the search process, and spent more time on it.

Table 9.21. Correlation between users' perception of tasks and task performance

Facets	Sub-facets	Success	Satisfaction	Time	Time/items selected
User's perception of task	Work task difficulty	-.41**	-.45**	.34**	.10
	Subjective work task complexity	-.32**	-.37**	.22**	-.04
	Knowledge of work task topic	.21*	.20*	-.34**	-.06
	Knowledge of work task procedure	.34**	.27**	-.31**	-.11

**p<.01;
*p<.05

Subjective work task complexity was also found significantly correlated with success (r (142) = -.32, p<.01), users' satisfaction (r (142) = -.37, p<.01), and time (r (142) = .22, p<.01). The participants felt less successful, less satisfied, and spent more time if they perceived a work task was more complex.

Knowledge of work task topic was significantly correlated with success (r (142) = .21, p<.05), users' satisfaction (r (142) = .20, p<.05), and time (r (142) =-.34, p<.01) as well. The participants felt more successful, more satisfied, and spent less time to search if they were more knowledgeable with a work task topic.

Likewise, knowledge of work task procedure was also significantly correlated with success (r (142) = .34, p<.01), users' satisfaction (r (142) = .27, p<.01), and time (r (142) =-.31, p<.01). If the participants had more knowledge on work task procedure, they felt more successful, more satisfied, and spent less time to search for it.

However, no significant correlation was found between any sub-facets of users' perception of tasks and the ratio of time and items selected.

9.4. Product and Objective Task Complexity (OTC) of Work tasks and Interactive Behavior

In this research two work task facets were found more important than others from Study 1. To further investigate their influence, these two facets were varied across their values to construct the simulated work tasks for Study 2. The facet 'Product' has two values, i.e., decision/solution and intellectual; the facet 'Objective task complexity (OTC)' has three values, i.e., low (L), moderate (M), and high complexity (H). This section is devoted to examining how these two facets affect the participants' interaction with the systems. Since the same participants completed the search for all these six work tasks, two factor repeated measures ANOVA were performed to explore their relationships. As mentioned in Section 9.2., if the Sphericity assumption is met, Sphericity Assumed *F* value will be reported; otherwise, Greenhouse-Geisser *F* value will be reported and noted.

9.4.1. Product and Objective Task Complexity on General Interaction Effort

General interaction effort is measured by the number of IR systems consulted, the number of result pages viewed, items viewed, and items selected for each work task. Table 9.22 lists mean (SD) of the participants' general interaction effort in terms of each value of product and objective task complexity (OTC). In addition, the results of two factor repeated measures ANOVA tests were reported, that is, *F* values of main effects and interaction of 'Product' and 'OTC' with respect to each measure of the participants' general interaction effort.

Table 9.22. Mean (SD), main effects, and interaction: 'Product', 'OTC', and general interaction effort

Facets	Values	IR systems consulted	Result pages viewed	Items viewed	Items selected
Product	I (N=72)	1.67 (.89)	5.24 (2.90)	7.88 (4.63)	4.88 (3.33)
	D (N=72)	1.06 (.85)	4.04 (3.30)	8.83 (5.56)	4.00 (2.39)
	F	26.01 **	7.42 *	1.24	.28
Objective task comple-xity (OTC)	L (N=48)	.69 (.66)	2.81 (2.71)	6.56 (4.51)	3.40 (1.89)
	M (N=48)	1.90 (.83)	5.58 (2.84)	8.54 (3.52)	3.75 (2.15)
	H (N=48)	1.50 (.92)	5.52 (3.12)	9.96 (6.42)	4.31 (3.40)
	F	40.09**	22.25**	8.45**	2.59
Product & OTC interaction	*F*	6.46 **	10.89**	6.77**	10.34**

**p<.01
*p<.05

The product main effects for the number of IR systems consulted (F (1, 23) = 26.01, p<.01) and result pages viewed (F (1, 23) = 7.42, p<.05) were found. The participants consulted significantly more IR systems and viewed more result pages for the intellectual work tasks than for the decision/solution work tasks. However, there was not product main effect for the number of items viewed and items selected.

In terms of the participants' general interaction effort, the objective task complexity main effects were found for the number of IR systems consulted (F (2, 46) = 40.09, p<.01), the number of result pages viewed (F (2, 46) = 22.25, p<.01), and the number of items viewed (F (2, 46) = 8.45, p<.01). There was not a main effect of objective task complexity for the number of items selected.

Considering the three levels of objective task complexity, i.e., low, moderate, and high, Post Hoc tests (Bonferroni) were carried out and found that in terms of the number of IR systems visited, the participants consulted significantly fewer IR systems for the low complexity work tasks than for the moderate ($p<.01$) and high complexity work tasks ($p<.01$); however, they consulted significantly more IR systems for the moderate complexity work tasks than for the high complexity work tasks. The participants viewed significantly more result pages for the moderate ($p<.01$) and high complexity work tasks than for the low complexity work tasks ($p<.01$). Furthermore, they viewed significantly fewer items for the low complexity work tasks than for the moderate ($p<.01$) and high complexity work tasks ($p<.01$). The results showed that the significant difference occurred between the low complexity work tasks and the moderate and high complexity work tasks. No significant difference was detected between the moderate complexity work tasks and the high complexity work tasks except with regard to the number of IR systems consulted.

The analysis yielded a significant interaction between ‘Product’ and ‘Objective task complexity’ in terms of the number of IR systems consulted (F (1.54, 35. 47) = 6.46, $p<.01$) (Greenhouse-Geisser), the number of items viewed (F (2, 46) = 6.77, $p<.01$), and the number of items selected (F (1.59, 36.67) = 10.34, $p<.01$) (Greenhouse-Geisser). Therefore, these two facets significantly interacted with each other and interactively affect the participants’ general interaction effort with the systems.

9.4.2. Product and Objective Task Complexity on Interaction with Web resources

This section reports the main effects of ‘Product’ and ‘Objective task complexity (OCT)’ and interaction between them with respect to the participants’ interaction with Web resources. Two factor repeated measures ANOVA were performed. Table 9.23

reports the mean (SD), the main effects of 'Product' and 'Objective task complexity' and the interaction between them.

Table 9. 23. Mean (SD), main effects, and interaction: 'Product', 'OTC', and interaction with Web resources

Facets	Values	Search engines consulted	Portals visited	Web result pages viewed	Web items viewed	Web items selected
Product	I (N=72)	1.15 (.55)	3.89 (3.83)	4.14 (2.78)	6.88 (5.03)	3.96 (2.90)
	D (N=72)	.89 (68)	5.74 (6.35)	3.68 (3.14)	8.22 (5.71)	3.68 (2.40)
	F	13.33**	1.23	8.33**	2.33	.28
Objective task comple-xity (OTC)	L (N=48)	.67 (.63)	8.79 (6.22)	2.75 (2.71)	6.50 (4.58)	3.40 (1.89)
	M (N=48)	1.27 (.61)	1.67 (1.89)	4.50 (3.01)	6.98 (3.81)	3.75 (2.24)
	H (N=48)	1.13 (.49)	3.98 (4.05)	4.48 (2.87)	9.17 (7.01)	4.31 (3.53)
	F	18.61**	45.75**	8.48**	5.03*	2.59
Product & OTC inter-action	*F*	15.79**	17.28**	6.05**	11.68**	10.34**

**p<.01
*p<.05

The product main effects were found for the number of search engines consulted (F (1, 23) = 13.33, p<.01) and the number of web result pages viewed (F (1, 23) = 8.33, p<.01). The participants consulted significantly more search engines and viewed significantly more result pages in the Web for the intellectual work tasks than for the decision/solution work tasks. However, the analysis did not yield product main effects for the number of portals visited, web items viewed, and web items selected.

The objective task complexity main effects were also found for the number of search engines consulted (*F* (2, 46) = 18.61, p<.01), the number of portals visited (*F* (1.49, 34.19) = 45.75, p<.01) (Greenhouse-Geisser), the number of web result pages viewed (*F* (2, 46) = 8.48, p<.01), and the number of items viewed (*F* (2, 46) = 5.03, p<.05). However, no objective task complexity main effect was found for web items selected. Post Hoc tests (Bonferroni) showed that for the low complexity work tasks the participants consulted significantly fewer search engines than for the moderate (p<.01) and high complexity work tasks (p<.01). They also viewed significantly fewer web result pages for the low complexity work tasks than for the moderate (p<.01) and high complexity work tasks (p<.01). Yet, they visited significantly more portals for the low complexity work tasks than for the moderate (p<.01) and high complexity work tasks (p<.01). They viewed significantly fewer web items for the low complexity work tasks than for the high complexity work tasks (p<.05).

The analysis yielded significant interactions between 'Product' and 'Objective task complexity' for the number of search engines consulted (*F* (2, 46) = 15.79, p<.01), the number of portals visited (*F* (1.43, 37.76) = 6.05, p<.01), the number of web result pages viewed (*F* (2, 46) = 17.28, p<.01), the number of web items viewed (*F* (2, 46) = 11.68, p<.01), and the number of web items selected (*F* (1.59, 36.67) = 10.34, p<.01).

9.4.3. Product and Objective Task Complexity on Interaction with Library Resources

Table 9.24 shows that two factor repeated measures ANOVA revealed significant product main effects for the number of library resources consulted (*F* (1, 23) = 13.94, p<.01) and the number of library result pages viewed (*F* (1, 23) = 5.59, p<.05). The participants consulted significantly more library resources and viewed significantly more library result pages for the intellectual work tasks than for the decision/solution work tasks. No significant product main effects were found for the number of library items viewed and selected.

Table 9.24. Mean (SD), main effects, and interaction: ‘Product’, ‘OTC’, and interaction with library resources

Facets	Values	Library resources consulted	Library result pages viewed	Library items viewed	Library items selected
Product	I (N=72)	.51 (.79)	.97 (1.88)	1.00 (2.30)	.92 (2.67)
	D (N=72)	.17 (.48)	.39 (1.08)	.57 (1.25)	.32 (1.10)
	F	13.94**	5.59*	2.27	4.07
Objective task comple-xity (OTC)	L (N=48)	.02 (.14)	.06 (.32)	.02 (.14)	.00 (.00)
	M (N=48)	.63 (.87)	1.08 (1.64)	1.54 (2.31)	1.00 (1.89)
	H (N=48)	.38 (.64)	.90 (1.20)	.79 (1.99)	.85 (2.95)
	F	14.73**	9.78**	11.52**	4.79*
Product & OTC interaction	*F*	5.59**	5.13**	5.48**	3.48*

**p<.01
*p<.05

The analysis showed significant objective task complexity main effects for the number of library resources consulted (F (1.48, 30.10) = 14.73, p<.01) (Greenhouse-Geisser), the number of library result pages viewed (F (1.56, 35.93) = 9.78, p<.01) (Greenhouse-Geisser), the number of library items viewed (F (1.37, 31.44) = 11.52, p<.01) (Greenhouse-Geisser), and the number of library items selected (F (1.48, 34.13) = 4.79, p<.05) (Greenhouse-Geisser). Post Hoc tests (Bonferroni) showed that the participants consulted significantly fewer library resources for the low complexity work tasks than for the moderate ($p<.01$) and high complexity work tasks ($p<.01$). They viewed significantly fewer library result pages for the low complexity work tasks than for the moderate ($p<.01$) and high complexity work tasks ($p<.05$). Significantly fewer library items were viewed for the low complexity work tasks than for the moderate ($p<.01$) and high complexity work tasks ($p<.05$). In addition, the participants selected significantly fewer items from library resources for the low complexity work tasks than for the moderate complexity work tasks ($p<.05$). It is noticed that the significant differences usually occurred between the low complexity work tasks and the moderate and high complexity work tasks.

Table 9.24 also shows significant interaction between 'Product' and 'Objective task complexity' for the number of library resources consulted (F (1.60, 36.69) = 5.59, $p<.01$) (Greenhouse-Geisser), the number of library results pages viewed (F (2, 46) = 5.13, $p<.01$), the number of library items viewed (F (2, 46) = 5.48, $p<.01$), and the number of library items selected (F (1.09, 24.99) = 3.48, $p<.05$) (Greenhouse-Geisser). The results indicate that 'Product' and 'Objective task complexity' were significantly interact with each other and interactively affected the participants' interaction with library resources.

9.4.4. Product and Objective Task Complexity on Query-related Interactive Behavior

Two factor repeated measures ANOVA tests were also employed to investigate how 'Product' and 'Objective task complexity' affected query-related interactive behavior. Table 9.25 shows the mean (SD) and the results of the analysis (F values).

Table 9.25. Mean (SD), main effects, and interaction: 'Product', 'OTC', and query-related interactive behavior

Facets	Values	Iteration	Unique queries issued	Mean query length	Unique query terms used	Unique non-stop query terms used
Product	I (N=72)	4.38 (2.42)	3.44 (2.05)	3.08 (.96)	6.63 (3.24)	5.57 (3.24)
	D (N=72)	3.58 (2.97)	3.06 (2.49)	2.43 (1.59)	6.00 (5.30)	5.36 (4.31)
	F	4.10	1.59	17.54**	.86	.32
Objective task comple-xity (OTC)	L (N=48)	2.44 (2.28)	2.00 (1.69)	2.01 (1.48)	3.88 (3.41)	3.44 (3.00)
	M (N=48)	5.02 (2.56)	3.90 (2.05)	2.87 (1.03)	7.31 (5.02)	5.88 (3.72)
	H (N=48)	4.48 (2.68)	3.85 (2.53)	3.39 (1.11)	7.75 (4.23)	6.94 (3.81)
	F	18.28**	16.20**	19.62**	17.34**	18.67**
Product & OTC interaction	*F*	9.76**	5.86**	12.62**	7.63**	6.73**

**p<.01
*p<.05

The analysis only revealed a significant product main effect for mean query length (*F* (1, 23) = 17.54, p<.01). Overall, the participants issued significantly longer queries for the intellectual work tasks than for the decision/solution work tasks.

Objective task complexity main effects were found for the number of iteration (*F* (2, 46) = 18.28, p<.01), the number of unique query issued (*F* (2, 46) = 16.20, p<.01), mean query length (*F* (2, 46) = 19.62, p<.01), the number of unique query terms used (*F* (2. 46) = 17.34, p<.01), and the number of unique non-stop query terms used (*F* (2, 46) = 18.67, p<.01). Post Hoc tests (Bonferroni) indicated that the participants conducted significantly fewer times of iteration for the low complexity work tasks than for the moderate (p<.01) and high complexity work tasks ($p<.01$); with respect to unique queries issued, the participants issued significantly fewer unique queries for the low complexity work tasks than for the moderate ($p<.01$) and high complexity work tasks ($p<.01$); they also issued significantly shorter search queries for the low complexity work tasks than for the moderate ($p<.01$) and high complexity work tasks ($p<.01$); as well, they used significantly fewer unique terms in the search queries for the low complexity work tasks than for the moderate ($p<.01$) and high complexity work tasks ($p<.01$); besides, they used significantly fewer non-stop unique query terms for the low complexity work tasks than for the moderate ($p<.01$) and high complexity work tasks ($p<.01$).

The analysis yielded significant interactions between 'Product' and 'Objective task complexity' for the number of iteration (F (2, 46) = 9.76, $p<.01$), the number of unique queries issued (F (1.53, 35.24) = 5.86, $p<.01$), mean query length (F (2, 46) = 12.62, $p<.01$), the number of unique query terms used (F (1.42, 32.61) = 7.63, $p<.01$) (Greenhouse-Geisser), and the number of unique non-stop terms used (F (1.25, 28.66) = 6.73, $p<.01$) (Greenhouse-Geisser). Therefore, though the work tasks were in the same level of complexity, due to different products they pursue, the participants engaged in different query-related interactive behavior.

9.4.5. Product and Objective Task Complexity on Performance of Interaction

This section focuses on how 'Product' and 'Objective task complexity' affect the performance of interaction. Table 9.26 shows the mean (SD) in terms of performance and the facet 'Product' and 'Objective task complexity' and the results of two factor repeated measures ANOVA.

Table 9.26. Mean (SD), main effects, and interaction: 'Product', 'OTC', and performance of interaction

Facets	Values	Success	Users' satisfaction	Time	Time/items selected
Product	I (N=72)	5.22 (1.26)	5.22 (1.34)	648.40 (233.46)	184.35 (154.66)
	D (N=72)	5.64 (1.33)	5.54 (1.38)	584.31 (268.18)	171.92 (101.17)
	F	8.76**	3.55	3.23	.59
Objective task comple-xity (OTC)	L (N=48)	6.00 (1.03)	1.04 (.94)	461.33 (235.02)	158.37 (107.10)
	M (N=48)	5.40 (1.29)	5.42 (1.29)	657.98 (222.07)	163.78 (84.75)
	H (N=48)	4.90 (1.37)	4.69 (1.48)	729.75 (223.92)	212.24 (176.82)
	F	16.34**	23.64**	27.42**	2.89
Product & OTC interaction	*F*	6.09**	8.52**	8.18**	4.32*

**p<.01
*p<.05

Two factor repeated measures ANOVA only yielded a product main effect for success (F (1, 23) = 8.76, p<.01). The participants assessed that they were significantly more successful in conducting search for the decision/solution work tasks than for the intellectual work tasks.

The analysis yielded significant objective task complexity main effects for success (F (2, 46) = 16.34, p<.01), users' satisfaction (F (2, 46) = 23.64, p<.01), and time (F (2, 46) = 27.42, p<.01). Post Hoc tests (Bonferroni) indicated that the participants felt significantly more success when engaging in the low complexity work tasks than in the moderate (p<.01) and high complexity work tasks (p<.01); they perceived significantly more satisfied with the search process of the low complexity work tasks than that of the moderate (p<.01) and high complexity work tasks (p<.01); in terms of time, the participants spent significantly less time when searching for the low complexity work tasks than for the moderate ($p<.01$) and high complexity work tasks ($p<.01$). It is noticed that for the moderate complexity work tasks and high complexity work tasks, the analysis did not revealed a significant difference in performance of interaction.

The significant interaction was also found between 'Product' and 'Objective task complexity' in terms of success (F (1.29, 29.68) = 6.09, $p<.01$), users' satisfaction (F (1.48, 34.06) = 8.52, $p<.01$), time (F (2, 46) = 8.18, $p<.01$), and the ratio of time and items selected (F (1.39, 30.01) = 4.32, $p<.05$). This indicates that 'Product' and 'Objective task complexity' significantly interacted with each other and affected the performance of interaction.

9.5. Individual Differences, Work Tasks, Interactive Behavior, and Performance

This section reports how work tasks affect interactive behavior if individual differences are taken into account. Since most participants rated themselves as experienced searchers and expert computer users, it is hard to investigate how different search experience and computer expertise affect the relationships between work tasks and interactive information searching behavior in this study.

As mentioned in section 9.1, the participants were recruited from different domains (i.e. science and engineering (SE) vs. social science and humanities (SH) and different levels (i.e. undergraduate (U) vs. graduate student (G)). Also, there are 10 female participants (F) and 14 male participants (M). So this section examines how these three individual differences function on the relationships between work tasks and interactive behavior. As addressed in Section 8.4, two factor mixed design ANOVA was performed to explore the individual difference main effects and interaction between the individual differences and work tasks for interactive information searching behavior.

9.5.1. Gender, Work Tasks, Interactive Behavior, and Performance

As mentioned before, in total there are 10 female and 14 male participants in this study. Two factor mixed design ANOVA yielded a significant gender main effect for unique queries issued (F (1, 22) = 4.51, $p<.05$). The male participants submitted significantly more unique queries to the systems compared to the female participants. In addition, the analysis yielded a gender main effect for users' satisfaction (F (1, 22) = 6.05, $p<.05$). The male participants felt significantly more satisfied with the search process for the work tasks than the female participants.

Table 9.27 reports the mean (SD) of the female and male participants' number of unique queries issued and users' satisfaction in terms of each work task.

Table 9.27. Mean (SD) of each work task in terms of gender, unique queries issued, and users' satisfaction

	Gender	IL	IM	IH	DL	DM	DH
Unique queries issued	F (N=10)	3.00 (1.76)	3.30 (2.98)	2.90 (1.20)	.60 (.84)	3.80 (1.81)	3.10 (1.79)
	M (N=14)	3.00 (1.12)	3.57 (1.87)	4.57 (2.62)	1.29 (1.59)	4.71 (1.44)	4.36 (3.32)
Users' satisfaction	F (N=10)	5.40 (1.08)	5.60 (1.27)	3.60 (1.43)	6.30 (.82)	4.20 (1.55)	5.20 (1.23)
	M (N=14)	5.71 (.83)	6.07 (1.27)	4.64 (1.45)	6.64 (.63)	5.50 (1.23)	5.14 (1.41)

9.5.2. Level, Work Tasks, Interactive Behavior, and Performance

In this study 12 graduate students and 12 undergraduate students were recruited for the experiment. This section reports how level (undergraduate vs. graduate student) affects the participants' interactive information searching behavior and users' performance.

The analysis detected significant level main effects for the number of library result pages viewed (F (1, 22) = 4.63, $p<.05$) and the number of library items viewed (F (1, 22) = 4.60, $p<.05$). The graduate students viewed significantly more library result pages and library items for the work tasks. A significant interaction between level and work tasks for the number of library result pages viewed were detected (F (5, 110) = 3.21, $p<.05$). Table 9.28 reports the mean (SD) of the number of library resources consulted, library result pages viewed and library items viewed for each work task with respect to the graduate (G) and undergraduate students (U).

9.5.3. Major, Work Tasks, Interactive Behavior, and Performance

Two factor mixed design ANOVA was used to explore how major (social science and humanities (SH) vs. science and engineering (SE)) affects the participants' interactive information searching behavior and performance. However, the analysis did not produce any significant major main effects for the interactive behavior and performance, as well as interaction between work tasks and major.

Table 9.28. Mean (SD) of library result pages and library items viewed

	Level	IL	IM	IH	DL	DM	DH
Library result pages viewed	G (N=12)	.25 (.62)	1.50 (2.11)	2.75 (3.19)	.00 (.00)	1.50 (1.93)	.42 (.10)
	U (N=12)	.00 (.00)	.92 (1.17)	.42 (.79)	.00 (.00)	.42 (.10)	.00 (.00)
Library items viewed	G (N=12)	.08 (.29)	2.25 (3.67)	2.42 (3.42)	.00 (.00)	2.42 (1.56)	.17 (.58)
	U (N=12)	.00 (.00)	.67 (1.30)	.58 (.90)	.00 (.00)	.83 (1.53)	.00 (.00)

9.6. Work Tasks and Shifting Behavior

Interactive behavior in the previous sections was viewed as individual activity, such as issuing search queries, consulting specific search engines, selecting useful items, and so on. This section further explores how work tasks influence the participants' interaction with the systems, but interactive behavior is viewed as a sequence, i.e., shifting between search stages, with the aim to reveal the shift patterns which may be shaped by different work tasks.

9.6.1. Shift Patterns between Search Stages in Different Work Tasks

9.6.1.1. General patterns in terms of work tasks

To explore the patterns of the shifts between search stages, each search for the work tasks was translated into a search sequence, denoted by the code of each stage (See Table 8.4). For the sake of observing the current situation and calculating the probabilities of moving on to a next stage, the search sequences of all searches were decomposed as a two-stage sequence, that is, from one stage to the other, for example, the shift 6 → 7 ('Select search modes' to 'Formulate queries and submit'). Table 9.29 shows that all shifts occurred during the searches for the work tasks.

Table 9.29. Observed shifts between search stages

Shifts between search stages	Denotation
Go to search engines, and then Go to individual web sites	1 → 4
Go to search engines, and then Select search modes	1 → 6
Go to search engines, and then Review result pages	1 → 8
Go to search engines, and then Search end	1 → 11
Go to databases, and then Browse web sites	2 → 5
Go to databases, and then Select search modes	2 → 6
Go to databases, and then Search end	2 → 11
Go to OPAC systems, and then Browse web sites	3 → 5
Go to OPAC systems, and then Select search modes	3 → 6

Go to individual web sites, and then Go to databases	4 → 2
Go to individual web sites, and then Go to OPAC systems	4 → 3
Go to individual web sites, and then Browse web sites	4 → 5
Go to individual web sites, and then Select search modes	4 → 6
Go to individual web sites, and then Formulate queries and submit	4 → 7
Go to individual web sites, and then Review items	4 → 9
Go to individual web sites, and then Select items	4 → 10
Go to individual web sites, and then Search end	4 → 11
Browse web sites, and then Go to search engines	5→ 1
Browse web sites, and then Go to databases	5→ 2
Browse web sites, and then Go to OPAC systems	5→ 3
Browse web sites, and then Go to individual web sites	5→ 4
Browse web sites, and then Select search modes	5→ 6
Browse web sites, and then Formulate queries and submit	5→ 7
Browse web sites, and then Review result pages	5→ 8
Browse web sites, and then Review items	5→ 9
Browse web sites, and then Select items	5→ 10
Browse web sites, and then Search end	5→ 11
Select search modes, and then Formulate queries and submit	6→ 7
Formulate queries and submit, and then Go to search engines	7→ 1
Formulate queries and submit, and then Browse web sites	7→ 5
Formulate queries and submit, and then Select search modes	7→ 6
Formulate queries and submit, and then Review result pages	7→ 8
Formulate queries and submit, and then Review items	7→ 9
Review result pages, and then Go to search engines	8→ 1
Review result pages, and then Go to databases	8→ 2
Review result pages, and then Go to OPAC systems	8→ 3
Review result pages, and then Go to individual web sites	8→ 4
Review result pages, and then Browse web sites	8→ 5
Review result pages, and then Select search modes	8→ 6
Review result pages, and then Formulate queries and submit	8→ 7
Review result pages, and then Review items	8→ 9
Review result pages, and then Select items	8→ 10
Review result pages, and then Search end	8→ 11
Review items, and then Go to search engines	9→ 1
Review items, and then Go to individual web sites	9→ 4
Review items, and then Browse web sites	9→ 5
Review items, and then Select search modes	9→ 6
Review items, and then Formulate queries and submit	9→ 7
Review items, and then Review result pages	9→ 8
Review items, and then Select items	9→ 10
Review items, and then Search end	9→ 11
Select items, and then Go to search engines	10→1
Select items, and then Go to databases	10→2

Select items, and then Go to OPAC systems	10→3
Select items, and then Go to individual web sites	10→4
Select items, and then Browse web sites	10→5
Select items, and then Select search modes	10→6
Select items, and then Formulate queries and submit	10→7
Select items, and then Review result pages	10→8
Select items, and then Review items	10→9
Select items, and then Search end	10→11

Table 9.30 shows the probabilities of all transitions between stages in terms of each type of work task. By comparing the probabilities of the shifts, the dissimilar ones among the work tasks are highlighted.

Table 9.30 shows that the shifts starting from Stage 2 (‘Go to databases’) and Stage 3 (‘Go to OPAC systems’) only occurred when the participants were engaging in IM, IH, and DM.

In terms of the shifts,

Table 9.30. Probability of the shifts between search stages

Shift	Work tasks					
	IL	IM	IH	DL	DM	DH
1 → 4	-	-	-	.08	-	-
1 → 6	.95	.97	.95	.92	.96	1.00
1 → 8	.02	.03	.05	-	.04	-
1 → 11	.02					
2 → 5	-	.50	-	-	-	-
2 → 6	-	.50	.91	-	1.0	-
2 → 11			.09			
3 → 5	-	-	.13	-	-	-
3 → 6	-	1.0	.88	-	1.0	-
4 → 2	-	-	.04	-	.13	-
4 → 3	.09	.29	.26	-	.14	.08
4 → 5	.64	.31	.52	.81	.23	.58
4 → 6	-	.13	-	-	.07	.18
4 → 7	.18	.18	.13	.06	.23	-
4 → 9	-	.06	.04	.10	.07	.09
4 → 10	-	-	-	-	.20	-

4 → 11	-	-	-	.03	-	-
5→ 1	.03	-	.06	.01	-	.06
5→ 2	-	.09	.19	-	.15	-
5→ 3	.01	.09	.08	.01	-	-
5→ 4	-	-	.06	-	-	.02
5→ 6	.16	.08	.08	.02	.07	.09
5→ 7	.03	-	-	.43	.29	.09
5→ 8	.03	.02	-	-	.14	.01
5→ 9	.60	.46	.32	.47	.36	.53
5→ 10	.10	.23	.21	.06	-	.15
5→ 11	.01	.02	.03	-	-	.05
6→ 7	1.0	1.0	1.0	1.0	1.0	1.0
7→ 1	-	-	.01	-	.01	-
7→ 5	.02	.01	-	.24	.03	.03
7→ 6	.01	-	-	-	.01	.01
7→ 8	.96	.90	.93	.39	.85	.91
7→ 9	.01	.09	.05	.36	.10	.06
8→ 1	.05	.03	.07	-	.05	.01
8→ 2	-	.02	-	-	-	-
8→ 3	-	-	-	-	.01	-
8→ 4	.04	.02	.05	-	.02	.02
8→ 5	.31	.15	.08	.35	.03	.30
8→ 6	.12	.19	.20	.07	.08	.13
8→ 7	-	.01	.01	.17	.01	.04
8→ 9	.47	.52	.55	.42	.71	.47
8→ 10	-	.03	.04	.03	.01	.01
8→ 11	.02	.04	.02	-	.02	.01
9→ 1	.05	.04	.04	.04	.07	.05
9→ 4	-	.03	.02	.04	.03	.01
9→ 5	.22	.07	.06	.21	-	.16
9→ 6	.04	.11	.07	.01	.11	.07
9→ 7	.01	-	-	.06	.04	.02
9→ 8	.04	.02	.04	-	.13	.03
9→ 10	.58	.72	.71	.60	.58	.63
9→ 11	.06	.02	.07	.05	.05	.03
10→1	.10	.09	.10	.02	.21	.12
10→2	-	.03	.01	-	.01	-
10→3	-	-	-	-	.02	-
10→4	.02	.02	.04	.10	.01	.03
10→5	.18	.14	.06	.18	.02	.15
10→6	.08	.07	.16	.02	.12	.06
10→7	.01	-	.01	.11	.01	.04
10→8	.08	.08	.12	-	.06	.01
10→9	.39	.48	.39	.30	.39	.48
10→11	.15	.10	.10	.28	.16	.10

- Some shifts occurred with higher probability for all work tasks, such as 1 → 6 (‘Go to search engines’ to ‘Select search modes’), 4 → 5 (‘Go to individual web sites’ to ‘Browse web sites’), 5 → 9 (‘Browse web sites’ to ‘Review items’), 6 → 7 (‘Select search modes’ to ‘Formulate queries and submit’), 7 → 8 (‘Formulate queries and submit’ to ‘Review result pages’), 8 → 9 (‘Review result pages’ to ‘Review items’), 9 → 10 (‘Review items’ to ‘Select items’), and 10 → 9 (‘Select items’ to ‘Review items’). Work tasks seemed not to affect these shifts.
- Some shifts occurred for only one task. For example, 2 → 5 (‘Go to databases’ to ‘Browse web sites’) only occurred when the participants searched for IM; 3 → 5 (‘Go to OPAC systems’ to ‘Browse web sites’) only occurred when the participant searched for IH; 4 → 10 (‘Go to individual web sites’ to ‘Select items’) only occurred for DM. Other shifts also happened for only one task, for example 1 → 4 (‘Go to search engines’ to ‘Go to individual web sites’) and 1 → 11 (‘Go to search engines’, to ‘Search end’) only for IL, and 4 → 11 (‘Go to individual web sites’ to ‘Search end’) only for DL. However, their probabilities were too low (<.10). These shifts may be related to work tasks.
- The probabilities of some shifts were not similar for different work tasks. These dissimilar shifts were highlighted in Table 9.30 and further tested by performing one factor repeated measures ANOVA analysis. The significant different shifts, the mean (SD) in terms of each type of work task, and test results are presented in Table 9.31.

In Table 9.31, one factor repeated measures ANOVA indicated:

- The mean probabilities of the shift 4 → 5 ('Go to individual web sites' to 'Brows web sites') were significantly different in terms of the six work tasks (F (5, 115) = 8.74, p<.01). Post Hoc tests (Bonferroni) found that the mean probability of this shift in DL was significantly higher than in IL (p<.01), IM (p<.01), IH (p<.01), DM (p<.01), and DH (p<.05).

Table 9.31. Significant shifts of each work task

Shifts	Mean probabilities (Standard deviation)						F
	IL	IM	IH	DL	DM	DH	
4 → 5	.21 (.41)	.19 (.38)	.33 (.45)	.73 (.42)	.10 (.29)	.23 (.42)	8.74**
5→ 7	.04 (.11)	-	-	.43 (.41)	.15 (.35)	.07 (.16)	9.70**
5 → 9	.55 (.30)	.33 (.39)	.20 (.35)	.40 (.36)	.16 (.34)	.55 (.33)	5.46**
7 → 5	.01 (.05)	.01 (.05)	-	.16 (.20)	.02 (.07)	.02 (.05)	10.04**
7 → 8	.97 (.07)	.93 (.14)	.93 (.14)	.36 (.40)	.88 (.15)	.94 (.11)	32.75**
7 → 9	.01 (.05)	.06 (.13)	.05 (.14)	.31 (.35)	.09 (.13)	.04 (.09)	9.17**
8 → 5	.36 (.29)	.22 (.31)	.08 (.14)	.20 (.35)	.05 (.13)	.32 (.25)	5.58**
8 → 9	.47 (.30)	.50 (.28)	.57 (.25)	.24 (.39)	.73 (.21)	.52 (.31)	6.97**
9 → 5	.24 (.22)	.05 (.08)	.07 (13)	.17 (.20)	-	.20 (.27)	4.52**
10 → 1	.09 (.16)	.12 (.16)	.15 (.27)	.02 (.10)	.26 (.28)	.14 (.17)	4.22**
10 → 5	.18 (.23)	.14 (.19)	.04 (.10)	.16 (.22)	.03 (.09)	.16 (.19)	3.75*

** p<.01
* p<.05

- The mean probabilities of the shift 5→ 7 ('Browse web sites' to 'Formulate queries and submit') were significantly different with respect to IL, DL, DM, and DH (F (1.81, 41.59) = 9.70, p<.01) (Greenhouse-Geisser) (this shift did not occur in IM and IH). Post Hoc tests (Bonferroni) indicated that the mean probability of this shift was significantly higher in DL than in IL (p<.01) and DH (p<.01). The shift 5 → 9 ('Browse web sites' to 'Review items') was also a significant shift since its mean probabilities were found significantly different across the six work tasks (F (5, 115) = 5.46, p<.01). Post Hoc tests (Bonferroni) found that the mean probability of this shift in IL was significantly higher than in IH (p<.05) and DM (p<.01), so did it in DH.

- The shift 7 → 5 ('Formulate queries and submit' to 'Browse web sites') was found to be a significant shift because its mean probabilities in terms of different work tasks were significantly different (F (1.60, 36.67) = 10.04, p<.01) (Greenhouse-Geisser). Post Hoc tests (Bonferroni) detected the significant differences occurred between DL and all others tasks. The mean probability of this shift was significant higher in DL than in all other work tasks (p<.05). The analysis also yielded a significant difference in the mean probabilities of the shift 7 → 8 ('Formulate queries and submit' to 'Review result pages') across the six work tasks (F (1.60, 36.90) = 32.75, p<.01). Post Hoc tests (Bonferroni) indicated that the mean probability of this shift in DL was significant lower than in other work tasks (p<.01). Besides, the mean probabilities of the shift 7 → 9 ('Formulate queries and submit' to 'Review items') were also found significantly different across the six work tasks (F (1.60, 36.86) = 9.17, p<.01) (Greenhouse-Geisser). Post Hoc tests (Bonferroni) detected that the mean probability of this shift in DL was significantly higher than in IL (p<.05), IM (p<.05), and DH (p<.05).
- The mean probabilities of the shift 8 → 5 ('Review result pages' to 'Browse web sites' were significantly different across the six work tasks (F (3.25, 74.73) = 5.58, p<.01) (Greenhouse-Geisser). Post Hoc tests (Bonferroni) found that the mean probability of this shift in IL was significantly higher than

in IH ($p<.01$) and DM ($p<.01$); also, its mean probability in DH was significantly higher than in IH ($p<.01$) and DM ($p<.01$). The analysis also produced a significant difference in the mean probabilities of the shift 8 → 9 (‘Review result pages’ to ‘Review items’) with respect to the different work tasks (F (5, 115) = 6.97, $p<.01$). Post Hoc tests (Bonferroni) found that the mean probability of this shift in DM was significantly higher than in IM ($p<.05$) and DL ($p<.01$), and its probability in IH was significantly higher than in DL ($p<.05$).

- The shift 9 → 5 (‘Review items’ to ‘Browse web sites’) was found to be a significant shift (F (2.71, 62.41) = 4.52, $p<.01$) (Greenhouse-Geisser). Post Hoc tests (Bonferroni) indicated that the mean probability of this shift in IL was significantly higher than in IH ($p<.05$).
- The analysis also yielded a significant difference in the mean probabilities of the shift 10 → 1 (‘Select items’ to ‘Go to search engines’) (F (3.07, 70.67) = 4.22, $p<.01$) (Greenhouse-Geisser) and 10 → 5 (‘Select items’ to ‘Browse web sites’) (F (3.54, 81.43) = 3.75, $p<.05$) (Greenhouse-Geisser). For the former, Post Hoc tests (Bonferroni) found that the mean probability was significantly lower in DL than in DM ($p<.01$) and DH ($p<.05$). The mean probability of the shift 10 → 5 was significantly lower in DM than in IL and DH ($p<.05$).

The above observation seems to indicate that though the work tasks is at the same level of complexity, if these tasks pursue different products (Intellectual or Decision/Solution), the shift patterns could be different. For example, for DL, the probability of the shift 7 → 9 (‘Formulate queries and submit’ to ‘Review items’) was significantly higher than for IL. Both of them were low complexity work tasks. Moreover, though the products of work tasks were the same or similar, the shift patterns were also different if the complexity level of the work tasks was different. For example, the mean probability of the shift 5 → 9 (‘Browse web sites’ to ‘Review items’) was significantly higher in IL than in IH, both of which were intellectual work tasks.

9.6.1.2. Reiterative shifts

Santon (2003) identified two types of shifting between search stages, i.e., reiterative shift and linear shift. The former involves two shifts which have the same stages but in reverse direction. That is, a shift occurs from Stage A to B; but at the same time, another shift from Stage B to A also occurs in the same search sequence. A linear shift means a shift only happens from Stage A to B. This study goes further to examine the difference among all shifts and reiterative shifts for different work tasks. Table 9.32 shows reiterative shifts and their probabilities with regard to each work task.

Table 9.32 shows that some reiterative shifts, for example, 9 → 10 (‘Review items’ to ‘Select items’)/10 → 9 (‘Select items’ to ‘Review items’), occurred with high probability during the searches for all work tasks.

Some occurred for most work tasks:

- 5 → 9 (‘Browse web sites’ to ‘Review items’)/9 → 5 (‘Review items’ to ‘Browse web sites’) and 5 → 10 (‘Browse web sites’ to ‘Select items’) /10 → 5 (‘Select items’ to ‘Browse web sites’) occurred for all other work tasks except for DM;
- 8 → 9 (‘Review result pages’ and ‘Review items’) /9 → 8 (‘Review items’ to ‘Review result pages’) took place for all other work tasks except for DL;

Table 9.32. Reiterative shifts and probabilities in different work tasks

IL	IM	IH	DL	DM	DH
1 → 8 (.02) 8 → 1 (.05)	1 → 8 (.03) 8 → 1 (.03)	1 → 8 (.05) 8 → 1 (.07)	-	1 → 8 (.04) 8 → 1 (.05)	-
5 → 8 (.03) 8 → 5 (.31)	5 → 8 (.02) 8 → 5 (.15)	-	-	5 → 8 (.15) 8 → 5 (.03)	5 → 8 (.02) 8 → 5 (.30)
5 → 9 (.60) 9 → 5 (.22)	5 → 9 (.46) 9 → 5 (.07)	5 → 9 (.32) 9 → 5 (.06)	5 → 9 (.47) 9 → 5 (.21)	-	5 → 9 (.53) 9 → 5 (.16)
5 → 10 (.10) 10 → 5 (.18)	5 → 10 (.23) 10 → 5 (.14)	5 → 10 (.21) 10 → 5 (.06)	5 → 10 (.06) 10 → 5 (.18)	-	5 → 10 (.15) 10 → 5 (.15)
8 → 9 (.47) 9 → 8 (.04)	8 → 9 (.52) 9 → 8 (.02)	8 → 9 (.55) 9 → 8 (.04)	-	8 → 9 (.71) 9 → 8 (.13)	8 → 9 (.47) 9 → 8 (.03)
9 → 10 (.58) 10 → 9 (.39)	9 → 10 (.72) 10 → 9 (.48)	9 → 10 (.71) 10 → 9 (.39)	9 → 10 (.60) 10 → 9 (.30)	9 → 10 (.58) 10 → 9 (.39)	9 → 10 (.63) 10 → 9 (.48)
-	4 → 9 (.06) 9 → 4 (.03)	4 → 9 (.04) 9 → 4 (.02)	4 → 9 (.10) 9 → 4 (.04)	4 → 9 (.07) 9 → 4 (.03)	4 → 9 (.09) 9 → 4 (.01)
-	7 → 8 (.90) 8 → 7 (.01)	7 → 8 (.93) 8 → 7 (.01)	7 → 8 (.39) 8 → 7 (.17)	7 → 8 (.85) 8 → 7 (.01)	7 → 8 (.91) 8 → 7 (.04)
-	8 → 10 (.03) 10 → 8 (.08)	8 → 10 (.04) 10 → 8 (.12)	-	8 → 10 (.01) 10 → 8 (.06)	8 → 10 (.01) 10 → 8 (.01)
5 → 7 (.03) 7 → 5 (.02)	-	-	5 → 7 (.43) 7 → 5 (.24)	5 → 7 (.29) 7 → 5 (.03)	5 → 7 (.09) 7 → 5 (.03)
7 → 9 (.01) 9 → 7 (.01)	-	-	7 → 9 (.36) 9 → 7 (.06)	7 → 9 (.10) 9 → 7 (.04)	7 → 9 (.06) 9 → 7 (.02)
6 → 7 (1.0) 7 → 6 (.01)	-	-	-	6 → 7 (1.0) 7 → 6 (.01)	6 → 7 (1.0) 7 → 6 (.01)
-	-	4 → 5 (.52) 5 → 4 (.06)	-	-	4 → 5 (.58) 5 → 4 (.02)
-	2 → 5 (.50) 5 → 2 (.09)	-	-	-	-
-	-	3 → 5 (.13) 5 → 3 (.08)	-	-	-
-	-	-	-	4 → 10 (.20) 10 → 4 (.01)	-

- 4 → 9 ('Go to individual web sites' to 'Review items') /9 → 4 ('Review items' to 'Go to individual web sites') and 7 → 8 ('Formulate queries and submit' to

'Review result pages') /8 → 7 ('Review result pages' to 'Formulate queries and submit') occurred for all other work tasks except for IL.

For IH and DH, both of which are high complexity work tasks, the participants engaged in the shifts 4 → 5 ('Go to individual web sites' to 'Browse web sites') /5 → 4 ('Browse web sites' to 'Go to individual web sites') , but they did not do this for all other work tasks.

Some reiterative shifts happened for only one work task. These shifts are highlighted in the bottom of the table, including 2 → 5 ('Go to databases' to 'Browse web sites') /5 → 2 ('Browse web sites' to 'Go to databases') for IM, 3 → 5 ('Go to OPAC systems' to 'Browse web sites') /5 → 3 ('Browse web sites' to 'Go to OPAC systems') for IH, and 4 → 10 ('Go to individual web sites' to 'Select items') /10 → 4 ('Select items' to 'Go to individual web sites') for DM. Moreover, though some reiterative shifts happened for different work tasks, they seemed to have different patterns. For example, 5 → 8 ('Browse web sites' to 'Review result pages') /8 → 5 ('Review result pages' to 'Browse web sites'), the former had much lower probability for IL, IM, and DH than the latter; however, for DL, the former had higher probability than the latter.

9.6.1.3. Salient shifts

This study assumed that the shifts whose probabilities were equal or higher than .10 were more possibly to occur than those whose probabilities was lower than .10, so these shifts were named "salient shifts". To further see the shift patterns, the salient shifts, regardless of reiterative or linear shifts, are listed in Table 9.33 in terms of each work task. For the convenience of comparison, the same shifts were listed in the same row and the unique salient shifts and significant shifts identified previously (See Table 9.31) were highlighted.

Table 9.33. Salient shifts and probabilities in terms of each work task

IL	IM	IH	DL	DM	DH
6 → 7 (1.0)	6 → 7 (1.00)	6 → 7 (1.0)	6 → 7 (1.0)	6 → 7 (1.0)	6 → 7 (1.00)
7 → 8 (.96)	7 → 8 (.90)	7 → 8 (.93)	7 → 8 (.39)	7 → 8 (.85)	7 → 8 (.91)
1 → 6 (.95)	1 → 6 (.97)	1 → 6 (.95)	1 → 6 (.92)	1 → 6 (.96)	1 → 6 (1.00)
4 → 5 (.64)	4 → 5 (.31)	4 → 5 (.52)	4 → 5 (.81)	4 → 5 (.23)	4 → 5 (.58)
5 → 9 (.60)	5 → 9 (.46)	5 → 9 (.32)	5 → 9 (.47)	5 → 9 (.36)	5 → 9 (.53)
9 → 10 (.58)	9 → 10 (.72)	9 → 10 (.71)	9 → 10 (.60)	9 → 10 (.58)	9 → 10 (.63)
8 → 9 (.47)	8 → 9 (.52)	8 → 9 (.55)	8 → 9 (.42)	8 → 9 (.71)	8 → 9 (.47)
10 → 9 (.39)	10 → 9 (.48)	10 → 9 (.39)	10 → 9 (.30)	10 → 9 (.39)	10 → 9 (.48)
8 → 5 (.31)	8 → 5 (.15)	-	8 → 5 (.35)	-	8 → 5 (.30)
9 → 5 (.22)	-	-	9 → 5 (.21)	-	9 → 5 (.16)
4 → 7 (.18)	4 → 7 (.18)	4 → 7 (.13)	-	4 → 7 (.23)	-
10 → 5 (.18)	-	-	10 → 5 (.18)	-	-
5 → 6 (.16)	-	-	-	-	-
8 → 6 (.12)	8 → 6 (.19)	8 → 6 (.20)			8 → 6 (.13)
10→11 (.15)	-	-	10→11 (.28)	10→11 (.16)	10→11 (.10)
10 → 1 (.10)	-	-	-	10 → 1 (.21)	10 → 1 (.12)
-	3 → 6 (1.00)	3 → 6 (.88)	-	3 → 6 (1.0)	-
-	2 → 6 (.50)	2 → 6 (.91)	-	2 → 6 (1.0)	-
-	2 → 5 (.50)	-	-	-	-
-	4 → 3 (.29)	4 → 3 (.26)	-	-	-
-	5 → 10 (.23)	5 → 10 (.22)	-	-	5 → 10 (.15)
-	-	5 → 2 (.19)	-	5 → 2 (.15)	-
-	-	10 → 6 (.16)	-	-	-
-	-	-	5 → 7 (.43)	5 → 7 (.29)	-
-	-		7 → 9 (.36)	-	-
-	-	-	7 → 5 (.24)	-	-
-	-	-	-	4 → 10 (.20)	-
-	-	-	8 → 7 (.17)	-	-
-	-	-	-	-	4 → 6 (.18)

From Table 9.33, it is observed:

- The shift 4 → 7 ('Go to individual web sites' to 'Formulate queries and submit') and 8 → 6 ('Review result pages' to 'Select search modes') were salient shifts for all intellectual work tasks but only for one decision/solution work task, while the shift 10 → 11 ('Select items' to 'Search end') was a salient shift for all decision/solution work tasks but only for one intellectual work task.
- The shift 4 → 3 ('Go to individual web sites' to 'Go to OPAC systems') was a salient shift when the participants searched for the intellectual work tasks, whereas the shift 5 → 7 ('Browse web sites' to 'Formulate queries and submit') as a salient shift only occurred for the decision/solution work tasks.
- The shifts 7 → 9 ('Formulate queries and submit' to 'Review items'), 7 → 5 ('Formulate queries and submit' to 'Browse web sites'), and 8 → 7 ('Review result pages' to 'Formulate queries and submit') were salient shifts only in DL.
- The shifts 2 → 5 ('Go to databases' to 'Browse web sites') and 4 → 10 ('Go to individual web sites' to 'Select items') were not only unique shifts but also salient shifts in IM and DM, respectively.

The observation above indicates that the participants engaged in different shift patterns when conducting different types of work tasks. To further look at the patterns of the shifts between search stages, the next sections examine the shifts occurring in the intellectual work tasks and decision/solution work tasks and different complexity levels of work tasks,.

9.6.2. Shift patterns between Search Stages in the Intellectual and Decision/solution Work Tasks

Study 2 varied the two critical facets identified in Study 1, i.e., Product and Objective task complexity, across the six simulated work task situations. This section reports the shift patterns in terms of the work task types based on the facet 'Product', that is, intellectual and decision/solution. The next section will present the different shift patterns in terms of the different levels of task complexity, namely, low, moderate, and high complexity.

9.6.2.1. Reiterative shifts of the intellectual and decision/solution work tasks

Table 9.34 lists all reiterative shifts and their probability for the intellectual work tasks and decision/solution work tasks.

This table shows that the two types of work tasks share most reiterative shifts with similar probability. Only the probability of the shift 5 → 7 ('Browse web sites' to 'Formulate queries and submit') for the intellectual work tasks was much lower than that for the decision/solution work tasks. One factor repeated measures ANOVA found that the mean probability of this shift in the intellectual work tasks (Mean (SD) = .02 (.05)) was significantly different from that in the decision/solution work tasks (Mean (SD) = .28 (.25) (F (1, 23) = 29.80, p<.01). It seems that its mean probability was significantly higher for decision/solution work tasks than that of intellectual work tasks.

The unique reiterative shifts in terms of different types of work task are listed in the bottom of the table. It could be seen that the shift 2 → 5 ('Go to databases' to 'Browse web sites') /5 → 2 ('Browse web sites' to 'Go to databases') and 3 → 5 ('Go to OPAC systems' to 'Browse web sites') /5 → 3 ('Browse web sites' to 'Go to OPAC systems')

Table 9.34. Reiterative shifts and their probabilities of the intellectual and decision/solution work tasks

Intellectual		Decision/Solution	
4 →5 5 → 4	.50 .01	4 → 5 5 → 4	.61 .01
5 → 8 8 → 5	.02 .17	5 → 8 8 → 5	.02 .17
5 → 9 9 → 5	.50 .11	5 → 9 9 → 5	.49 .11
5 → 10 10 → 5	.16 .12	5 → 10 10 → 5	.10 .12
7 → 8 8 → 7	.93 .01	7 → 8 8 → 7	.77 .04
8 → 9 9 → 8	.51 .03	8 → 9 9 → 8	.62 .06
9 → 10 10 → 9	.67 .42	9 → 10 10 → 9	.61 .41
1 → 8 8 → 1	.03 .05	1 → 8 8 → 1	.02 .03
4 → 9 9 → 4	.04 .02	4 → 9 9 → 4	.09 .02
5 → 7 7 →5	.02 .01	5 → 7 7 → 5	.23 .07
8 → 10 10 → 8	.02 .09	8 → 10 10 → 8	.01 .02
2 → 5 5 → 2	.26 .07	- -	- -
3 → 5 5 → 3	.07 .06	- -	- -
- -	- -	4 → 10 10 → 4	.05 .04
- -	- -	6 → 7 7 → 6	1.00 .01
- -	- -	7 → 9 9 → 7	.15 .04

only occurred in the intellectual work tasks, while the shift 4 → 10 (‘Go to individual web sites’ to ‘Select items’) /10 → 4 (‘Select items’ to ‘‘Go to individual web sites’), 6 → 7 (‘Select search modes’ to ‘Formulate queries and submit’) /7 → 6 (‘Formulate queries and submit' to 'Select search modes') , and 7 → 9 ('Formulate queries and submit' to 'Review items') /9 → 7 ('Review items' to 'Formulate queries and submit') only took place in the decision/solution work tasks.

9.6.2.2. Salient shifts of the intellectual and decision/solution work tasks

This section takes into account all shifts occurred during the searches for the intellectual and decision/solution work tasks, regardless that they are reiterative or linear shifts. Table 9.35 lists the salient shifts for the two types of work tasks. For the

Table 9.35. Salient shifts and probabilities of the intellectual and decision/solution work tasks

Intellectual		Decision/Solution	
6 → 7	1.00	6 → 7	1.00
1 → 6	.96	1 → 6	.97
7 → 8	.93	7 → 8	.77
3 → 6	.93	3 → 6	1.00
2 → 6	.70	2 → 6	1.00
9 → 10	.67	9 → 10	.61
8 → 9	.51	8 → 9	.62
4 → 5	.50	4 → 5	.61
5 → 9	.50	5 → 9	.49
10 → 9	.42	10 → 9	.41
2 → 5	.26	-	-
4 → 3	.21	4 → 3#	.05
8 → 5	.17	8 → 5	.17
8 → 6	.17	8 → 6	.10
4 → 7	.17	4 → 7#	.09
5 → 10	.16	5 → 10	.10
10 → 5	.12	10 → 5	.12
5 → 6	.12	5 → 6#	.07
9 → 5	.11	9 → 5	.11
10 → 1	.10	10 → 1	.13
-	-	5 → 7	.23
-	-	10→11	.16
-	-	7 → 9	.15

not salient shifts, for convenience to compare

convenience of comparison, the same shifts were listed in the same row. Dissimilar and unique salient shifts are highlighted.

It also could be seen that these two types of work task share most of shifts with similar probability. One factor repeated measures ANOVA yielded a significant difference in the mean probability of the shift 4 → 3 ('Go to individual web sites' to 'Go to OPAC systems') between the intellectual work tasks (Mean (SD) = .27 (.41)) and the decision/solution work tasks (Mean (SD) = .06 (.21)) (F (1,23) = 7.48, $p<.05$). No significant difference was found for the shift 4 → 7 ('Go go individual web sites' to 'Formulate queries and submit').

It was also noticed that the shift 2 → 5 ('Go to databases' to 'Browse web sites'), 4 → 3 ('Go to individual web sites' to 'Go to OPAC systems'), and 5 → 6 ('Browse web sites' to 'Select search modes') were salient shifts only for the intellectual work tasks with relatively high probabilities, whereas the shift 7 → 9 ('Formulate queries and submit' to 'Review items'), 5 → 7 ('Browse web sites' to 'Formulate queries and submit'), and 10 → 11 ('Select items' to 'Search end') were salient shifts merely for the decision/solution work tasks.

9.6.3. Shift Patterns between Search Stages in Different Complexity Levels of Work Tasks

The six simulated work tasks assigned to the participants in Study 2 were at different levels of complexity, i.e., high, moderate, and low. This section explores and compares the shifts between search stages in terms of these three complexity levels of work tasks.

9.6.3.1. Reiterative shifts of the low complexity, moderate complexity, and high complexity work tasks

Table 9.36 lists the probabilities of reiterative shifts in terms of the work tasks with different complexity levels. Dissimilar and unique shifts are highlighted.

Table 9.36 indicates that the three types of work tasks share most reiterative shifts with similar probabilities, though for some the probabilities are very different. For

Table 9.36. Reiterative shifts and probabilities of the low, moderate, and high complexity work tasks

Low complexity		Moderate complexity		High complexity	
1 → 8 8 → 1	.02 .04	1 → 8 8 → 1	.03 .04	1 → 8 8 → 1	.02 .04
4 → 9 9 → 4	.08 .02	4 → 9 9 → 4	.06 .03	4 → 9 9 → 4	.06 .01
5 → 7 7 → 5	.20 .11	5 → 7 7 → 5	.06 .02	5 → 7 7 → 5	.07 .01
5 → 8 8 → 5	.02 .31	5 → 8 8 → 5	.05 .08	5 → 8 8 → 5	.02 .17
5 → 9 9 → 5	.56 .21	5 → 9 9 → 5	.42 .03	5 → 9 9 → 5	.44 .11
5 → 10 10 → 5	.09 .18	5 → 10 10 → 5	.18 .09	5 → 10 10 → 5	.17 .11
7 → 8 8 → 7	.71 .04	7 → 8 8 → 7	.88 .01	7 → 8 8 → 7	.92 .02
8 → 9 9 → 8	.46 .02	8 → 9 9 → 8	.66 .07	8 → 9 9 → 8	.52 .04
8 → 10 10 → 8	.01 .05	8 → 10 10 → 8	.02 .07	8 → 10 10 → 8	.02 .06
9 → 10 10 → 9	.59 .35	9 → 10 10 → 9	.64 .44	9 → 10 10 → 9	.67 .44
7 → 9 9 → 7	.18 .03	7 → 9 9 → 7	.09 .02	- -	- -
6 → 7 7 → 6	1.00 .01	- -	- -	- -	- -
- -	- -	2 → 5 5 → 2	.33 .11	- -	- -
- -	- -	4 → 10 10 → 4	.10 .01	- -	- -
- -	- -	- -	- -	3 → 5 5 → 3	.13 .02
- -	- -	- -	- -	4 → 5 5 → 4	.56 .03

example, the probabilities of the shift 5 → 7 (‘Browse web sites’ to ‘Formulate queries and submit’) / 7 → 5 (‘Formulate queries and submit’ to ‘Browse web sites’) for the low complexity (L) work tasks were higher than those for the moderate and high complexity (H) work tasks. One factor repeated measures ANOVA detected that it was significantly different among the mean probabilities of the shift 5 → 7 (F (1.60, 36.74) = 8.61), $p<.01$) (Greenhouse-Geisser) and 7 → 5 (F (1.28, 29.32) = 11.17, $p<.01$) (Greenhouse-Geisser) across the three complexity levels of work tasks (See Table 9.38). Further Post Hoc tests (Bonferroni) indicated that the mean probabilities of the shift 5 →7 and 7 → 5 in the low complexity work tasks were significantly higher than those in the moderate complexity work tasks ($p<.05$) and high complexity work tasks ($p<.01$). This means that ‘Browse web sites’ and then ‘Formulate queries and submit’ and the reverse shift more possibly happened when the participants engaged in the low complexity work tasks.

The reiterative shift 7 → 9 (‘Formulate queries and submit’ to ‘Review items’) /9 → 7 (‘Review items’ to ‘Formulate queries and submit’) occurred only for the low and moderate complexity work tasks. Some unique pairs of reiterative shifts occurred only for one work task, such as the shift 6 → 7 (‘Select search modes’ to ‘Formulate queries and submit’) /7 → 6 (‘Formulate queries and submit’ to ‘Select search modes’) only for the low complexity work tasks, 2 → 5 (‘Go to databases’ to ‘Browse web sites’) /5 → 2 (‘Browse web sites’ to ‘Go to databases’) and 4 → 10 (‘Go to individual web sites’ to ‘Select items’) /10 → 4 (‘Select items’ to ‘Go to individual web sites’) only for the moderate complexity work tasks, and the shift 3 → 5 (‘Go to OPAC systems’ to ‘Browse web sites’)/5 → 3 (‘Browse web sites’ to ‘Go to OPAC systems’) and 4 → 5 (‘Go to individual web sites' to 'Browse web sites')/5 → 4 ('Browse web sites' to 'Go to individual web sites') only for the high complexity work tasks.

9.6.3.2. Salient shifts of the low, moderate, and high complexity work tasks

The salient shifts in terms of low, median, and high complexity work tasks are listed

Table 9.37. Salient shifts and their probabilities of the low, moderate, and high complexity work tasks

Low complexity		Moderate complexity		High complexity	
6 → 7	1.00	6 → 7	1.00	6 → 7	1.00
1 → 6	.95	1 → 6	.97	1 → 6	.98
7 → 8	.71	7 → 8	.88	7 → 8	.92
9 → 10	.59	9 → 10	.64	9 → 10	.67
-	-	2 → 6	.67	2 → 6	.91
5 → 9	.56	5 → 9	.42	5 → 9	.44
8 → 9	.46	8 → 9	.66	8 → 9	.52
10 → 9	.35	10 → 9	.44	10 → 9	.44
8 → 5	.32	8 → 5#	.08	8 → 5	.18
9 → 5	.22	9 → 5#	.03	9 → 5	.11
5 → 7	.20	5 → 7#	.06	5 → 7#	.07
-	-	2 → 5	.33	-	-
10→11	.20	10→11	.13	10→11	.10
-	-	-	-	3 → 5	.13
7 → 9	.18	7 → 9#	.09	7 → 9#	.06
-	-	8 → 3	.13	-	
10 → 5	.18	10 → 5#	.09	10 → 5	.11
8 → 6	.11	8 → 6	.13	8 → 6	.17
7 → 5	.11	7 → 5#	.02	7 → 5#	.01
4 → 7	.10	4 → 7	.19	4 → 7	.12
5 → 6#	.09	5 → 6#	.09	5 → 6	.10
5 → 10#	.08	5 → 10	.18	5 → 10	.17
4 → 5	.76	4 → 5	.30	4 → 5	.54
-	-	3 → 6	1.00	3 → 6	.88
-	-	4 → 3	.23	4 → 3	.18
10 → 1#	.07	10 → 1	.14	10 → 1	.11
10 → 6#	.05			10 → 6	.11
-	-	5 → 2	.11	5 → 2#	.06
9 → 6#	.03	9 → 6	.11	9 → 6#	.07

non-salient shifts

in Table 9.37. Again, all shifts were taken into consideration. For the convenience of comparison, the same shifts are listed in the same row. If one shift is not salient for one type of work task, but it is salient for others, this shift will be listed for all types of work tasks and "#" was used to indicate non-salient shifts. The unique salient shifts and dissimilar ones are highlighted in the table.

Table 9.37 shows that only part of shifts are shared by the three types of work tasks with similar probabilities. With respect to the unique salient shifts, it could be seen:

- After the participants 'Browse web sites' (5) for the low complexity work tasks, they then may 'Formulate queries and submit' (7), while they may 'Select search mode' (6) for the high complexity work tasks and 'Go to databases' (2) for the moderate complexity work tasks.
- The participants 'Formulate queries and submit' (7), and then they may 'Review items' (9) or 'Browse web sites' (5) for the low complexity work tasks, but they only 'Review result pages' (8) for the moderate complexity work tasks and high complexity work tasks.
- The shift 'Go to databases' (2) and then 'Browse web sites' (5) only occurred for the moderate complexity work tasks, while the shift 'Go to OPAC systems' and then 'Browse web sites' (5) occurred only for the high complexity work tasks.

To identify the significant shifts among the different complexity levels of work tasks, one factor repeated measures ANOVA were performed to test whether the mean probabilities of the dissimilar shifts were significantly different. Table 9.38 presents the mean probabilities and test results.

From Table 9.38, it could be seen that:

- The mean probabilities of the shift 8→ 5 (‘Review result pages’ to ‘Browse web sites’) were significantly different across the three levels of work tasks (*F* (1.46, 33.58) = 17.10, p<.01) (Greenhouse-Geisser). Post Hoc tests (Bonferroni) found that the mean probability of this shift for the low complexity work tasks was significantly greater than for the moderate (p<.01) and high level complexity work tasks (p<.05).

Table 9.38. Significant shifts in the low, moderate, and high complexity work tasks

Shifts	Mean probabilities and Standard deviation			*F*
	Low complexity	Moderate complexity	High complexity	
8→ 5	.36 (.24)	.08 (.08)	.20 (.15)	17.10**
9 → 5	.23 (.15)	.02 (.04)	.14 (.18)	14.40**
5 → 7	.22 (.22)	.05 (.12)	.06 (.12)	8.61**
4 → 5	.75 (.39)	.28 (.44)	.43 (.46)	12.83**
7 → 5	.09 (.12)	.02 (.04)	.01 (.02)	11.17**
10 → 1	.05 (.12)	.16 (.15)	.12 (.13)	4.77*
10 → 5	.19 (.14)	.10 (.12)	.13 (.16)	3.75*

** p<.01
* p<.05

- The analysis also yielded a significant difference in the probabilities of the shift 9→ 5 (‘Review items’ to ‘Browse web sites’) in the three complexity levels of work tasks (*F* (2, 46) = 14.40, p<.01). Post Hoc tests (Bonferroni) revealed that the mean probability of this shift in the moderate complexity work tasks was significantly lower than that in the low (p<.01) and high complexity work tasks (p<.05).
- For the shift 4 → 5 (‘Go to individual web sites’ to ‘Browse web sites’), the analysis produced a significant difference in the probabilities across the

different complexity levels of work task (F (2, 46) = 12.83, p<.01). Post Hoc tests (Bonferroni) found that the mean probability of this shift in the low complexity work tasks was significantly higher than that in the moderate (p<.01) and high complexity work tasks (p<.05).

- Both shifts 10 → 1 ('Select items' to 'Go to search engines') and 10 → 5 ('Select items' to 'Browse web sites') were found to be significant shifts in terms of the three complexity levels of work tasks (F (2, 46) = 4.77, p<.05 and F (2, 46) = 3.75, p<.05, respectively). Post Hoc tests (Bonferroni) revealed that the mean probability of the shift 10 → 1 in the low complexity work tasks were significantly lower than in the moderate complexity work tasks (p<.05). However, it was found that the probability of the shift 10 → 5 was significantly higher in the low complexity work tasks than in the moderate complexity work tasks (p<.05).

Comparing Table 9.35 and 9.37, the intellectual work tasks and decision/solution work tasks shared more shifts and had less unique salient shifts than the three complexity levels of work task. In other words, it seemed that objective task complexity led to more variety of shifting patterns compared to product of work tasks.

9.7. Summary of Study 2

To summarize, Study 2 recruited 24 participants and conducted an experiment to explore the relationships between work tasks and interactive information searching behavior. The results indicated that work tasks varied with the facet 'Product' and 'Objective task complexity' as well as combined multiple constant facets significantly affected the participants' interactive behavior, including their general interaction effort with the systems, interaction with Web resources and library resources, their query-related interactive behavior, and their performance. The self-assessed facets and sub-facets, such as ‘Time (Frequency)’, ‘Time (Length)’, ‘Process’, ‘Task difficulty’, ‘Subjective task complexity’, ‘Knowledge of task topic’, and ‘Knowledge of task procedure’, were also found significantly related to different aspects of users’ interaction with information systems.

Specifically, Table 9.39_1 and Table 9.39_2 show the relationships between work task facets and interactive information searching behavior. The controlled facets, i.e., ‘Product’ and ‘Objective task complexity’, are highlighted in the tables.

- The facet ‘Time (Frequency)’ of work tasks significantly affected the number of result pages viewed, the number of search engines consulted, the number of web result pages viewed, the number of library resources consulted, all query-related interactive behavior, success, satisfaction, and time.
- The facet ‘Time (Length)’ of work tasks significantly affected the number of IR systems consulted, the number of result pages viewed, the number of library resources consulted, the number of library result pages viewed, the number of iteration, mean query length, number of unique query terms used, number of unique non-stop terms used, success, and satisfaction.
- The facet ‘Process’ of work tasks significantly affected the number of IR systems consulted, the number of search engines consulted, mean query length, success, satisfaction, and time.
- Work task difficulty was significant correlated with the number of IR systems consulted, the number of result pages viewed, the number of search engines

consulted and portals visited, the number of web result pages viewed, all query-related interactive behavior, success, satisfaction, and time.

- Subjective task complexity was significantly correlated with the number of IR systems consulted, the number of result pages viewed, the number of search engines consulted and portals visited, the number of web result pages viewed, the number of library resources consulted and library result pages viewed, all query-related interactive behavior, success, satisfaction, and time.
- Knowledge of work task topic was significantly correlated with the number of IR systems consulted, the number of result pages viewed, the number of search engines consulted and portals visited, the number of web result pages viewed, the number of library items viewed, all query-related interactive behavior, success, satisfaction, and time.
- Knowledge of work task procedure was significantly correlated with the number of items viewed, the number of search engines consulted and web result pages viewed, mean query length, success, satisfaction, and time.
- The facet 'Product' significantly affected the number of IR systems consulted and result pages viewed, the number of search engines consulted and web result pages viewed, the number of library resources consulted and library result pages viewed, mean query length, and success.
- The facet 'Objective task complexity' significantly affected the number of IR systems consulted, the number of result pages viewed and items viewed, the number of search engines consulted, portals visited, web result pages and items

viewed, the participants' interaction with library resources, all query-related interactive behavior, success, satisfaction, and time.

- There existed a significant interaction between 'Product' and 'Objective task complexity' when examining their effects on the participants' interaction with information systems.
- It is also noticed that some aspects of interaction seem not influenced by any facets of work tasks, such as items selected, web items selected, and time/items selected.

However, individual differences, such as gender, level, and major, did not strongly affect the relationships between work tasks and the participants' interactive information searching behavior. Significant gender main effects for unique queries issued and users' satisfaction were found. The male participants submitted significantly more unique queries to the systems and felt more satisfied with the search process than the female ones. Level main effects for the number of library result pages viewed and the number of library items viewed were also detected. The graduate students viewed significantly more library result pages and library items than undergraduate students. A significant interaction between level and work tasks for the number of library result pages viewed was detected. This is the only significant interaction detected between individual differences and work tasks. The interaction indicated that level affected the relationships between work tasks and interactive information searching behavior.

The observation of shifting behavior among different types of work tasks demonstrated that always there were some shifts occurring regardless of the types of work tasks, for example, the shift 8 → 9 ('Review result pages' to 'Review items').

However, some significant shifts were detected in terms of the six types of work tasks, the intellectual work tasks and decision/solution work tasks, and the different complexity levels of work tasks. Also, some shifts or reiterative shifts only happened in only one type of work task, like the shift 4 → 5 ('Go to individual web sites' to 'Browse web sites')/5 → 4 ('Browse web sites' to 'Go to individual web sites') in the high complexity work tasks but not in the low and moderate work tasks. These shifts should be further analyzed whether it could be an indicator of a certain type of work task. Moreover, some reiterative shifts appeared in all other work tasks except one, for example, the shift 7 → 9 ('Formulate queries and submit' to 'Review items')/9 → 7 ('Review items' to 'Formulate queries and submit') in the low and moderate complexity work tasks, but not in the high complexity work tasks. So, the lacking of these reiterative shifts may also good indicator for some type of work tasks.

Chapter 10 will extensively discuss the results and findings in this chapter.

Table 9.39_1. Work task facets and interactive information searching behavior

	IR systems consulted	Result pages viewed	Items viewed	Items selected	Search engines consulted	Web results pages viewed	Portals visited	Web items viewed	Web items selected	Library resources consulted	Library result pages viewed	Library items viewed
Time (Frequency)		√			√	√				√		
Time (Length)	√	√								√	√	
Process	√				√							
Work task difficulty	√	√	√		√	√	√					
Subjective work task complexity	√	√	√		√	√	√			√	√	
Knowledge of work task topic	√	√			√	√	√					√
Knowledge of work task proce-dure			√		√		√					
Product	√	√			√	√				√	√	
Objective task complexity	√	√	√		√	√	√	√		√	√	√

√: Significant relationships

Table 9.39_2. Work task facets and interactive information searching behavior

	Library items selected	Iteration	Unique queries issued	Mean query length	Unique query terms used	Unique non-stop terms issued	Success	Satisfaction	Time	Time/ Item selected
Time (Frequency)		√	√	√	√	√	√	√	√	
Time (Length)		√	√	√	√	√	√	√		
Process				√			√	√	√	
Work task difficulty		√	√	√	√	√	√	√	√	
Subjective work task complexity		√	√	√	√	√	√	√	√	
Knowledge of work task topic		√	√	√	√	√	√	√	√	
Knowledge of work task procedure				√			√	√	√	
Product				√			√			
Objective task complexity	√	√	√	√	√	√	√	√	√	

√: Significant relationships

Chapter 10. Discussion

This chapter discusses the results and findings of this dissertation research, whose purposes were to answer the following research questions:

- *Q1: Are there insufficient or inappropriate facets or sub-facets or values when the faceted classification is used to classify work tasks and search tasks in a real context?*
- *Q2: What are the relationships between work tasks and search tasks in terms of their facets?*
- *Q3: How do work tasks affect users' interactive information searching behavior, given that individual differences are taken into consideration?*

Two sequential studies, Study 1 and Study 2, were conducted to explore these questions. Study 1 carried out an in-depth interview to collect 24 pairs of work tasks and their associated search tasks. A faceted classification was used to classify these tasks and examine Q1 and Q2. Based on the findings in Study 1, Study 2 conducted an experiment to further explore the relationships between work tasks and interactive information searching behavior. Individual differences were also taken into account. The shift patterns between search stages were investigated in terms of different types of work task as well.

10.1. Are There Insufficient or Inappropriate Facets or Sub-facets or Values When the Faceted Classification is Used to Classify Work Tasks and Search Tasks in a Real Context?

Previous task classifications usually take a hierarchical approach based on one aspect or a few aspects of tasks (Li & Belkin, 2007). This approach is not able to provide a holistic picture of work tasks or search tasks, and thus cannot comprehensively reveal the relationships between tasks and information behavior. To promote the research in this issue, a faceted approach has been taken into consideration in this dissertation research. That is, a faceted classification of tasks was employed to explore the relationships between work tasks, search tasks, and interactive information searching behavior. This classification was developed based on an extensive literature review (Li, 2004). It served as a framework and starting point for this dissertation research. However, since it was developed based on literature review, whether it was appropriate or sufficient for classifying the work tasks and search tasks in a certain context, i.e., a university community in this research, was unknown. Therefore, the first goal of Study 1 was to collect representative work tasks from different groups of people in this community and examine whether the classification was applicable.

10.1.1. Insufficient or Inappropriate Sub-facets

The results indicated that the facets seemed to be appropriate to classify the work tasks and search tasks in the university context. However, this faceted classification was not sufficient in terms of the sub-facets and values. Some sub-facets and values needed to be reconsidered. The sub-facet ‘Organization-based’ and ‘Structure’ were dropped based on the data. The former was identified from the literature in organizational management, since people there conducted work tasks directly related to the mission of an organization. However, for the work tasks in a university community, especially for faculty, staff, and students, such tasks were rare. Furthermore, though the tasks were organization-based, they ultimately were carried out by individuals. Thus, the sub-facet ‘Organization-based’ was not considered in this study.

The reason to drop 'Structure' was because its definition overlapped with a new sub-facet 'Knowledge of task procedure'. The sub-facet was adapted from MacMullin and Taylor (1984). In their classification for information problems, they did not take into account the user's perception, for example, the user's self-assessed knowledge in task procedure. However, in this faceted classification of tasks, 'User's perception' was considered as a facet under the category of 'Common attributes of tasks'. Therefore, in order to avoid the overlap between the sub-facets, 'Structure' was dropped. This helps to keep the classification simple.

It was also necessary to split 'Knowledge of task' into 'Knowledge of task topic' and 'Knowledge of task procedure'. 'Knowledge of task topic' refers to how much knowledge a user has on the topic of a task, while 'Knowledge of task procedure' refers to how much knowledge a user has on the method for completing a task. Further analyses in Study 1 and Study 2 showed the necessity of this separation. Neither of them was correlated with the other in work tasks (See Figure 7.2), nor in search tasks (See Figure 7.3). Study 2 also demonstrated that they affected interactive information searching behavior in different manners. 'Knowledge of work task topic' seems more heavily to affect users' interaction with the systems. Though Study 1 did not detect any possible influence of 'Knowledge of task procedure' on search task characteristics and interactive behavior, Study 2 indicated that if users had less knowledge about task procedure, they viewed more items; however, no significant correlation was detected between 'Knowledge of task topic' and the number of items viewed. In general, the users go to search for information because they do not have enough knowledge about a topic. In Study 2, the participants searched for information which could help them understand the topics. However, for some tasks they also do not have enough knowledge on how to carry out the tasks. For example, IL and DH are such tasks. For IL the participants did not know how to write a strong resume and what a journalist job position requires; for DH, they did not know the procedure to apply for the academic program and what MBA programs mean. Therefore, they need to search for both: task procedure and task topic. Therefore, it is possible that if users know more about task procedure, they do not need to search and view items related to task procedure, and thus they view fewer items in total. Moreover, from this perspective, associated search tasks of a work task sometimes are composed of 'search for topics' and 'search for procedures'. How these two kinds of searches contribute to users' interactive behavior needs to be further explored.

In information science, subjective or perceived task complexity has been investigated (e.g. Bell and Ruthven, 2004; Byström and Jarvelin, 1995), however, objective task complexity has not been a focus of such studies (Gwizdk & Spence, 2006). One reason is because it is not easy to measure. This research took one of the dimensions of complexity attributes proposed by Campbell (1988). Objective task complexity is defined as the quantity of activities which are required for completing a work task. This objective perspective seems reasonable. Study 2 indicated that 'Objective task complexity' was a critical facet of a work task in shaping users' interactive information behavior. Also, it significantly interacted with the other facet 'Product'. This interaction indicated that even for the work tasks at the same complexity level, if these tasks pursue different types of product, for example, an intellectual product or a decision or a solution, the users may have different behavior in interaction with the systems. For example, IH and DH are two work tasks at high complexity level. Since IH pursued a final research report while DH needed to make a decision and found a solution, the users went to significantly more library resources and viewed more library result pages for IH than for DH. Objective work task complexity was also significantly correlated with subjective work task complexity in both studies ($r_{(s)}$ (24) = .50, p<.01 in Study 1; $r_{(s)}$ (144) = .50, p<.01 in Study 2), but the correlations were not especially high. That means that the way to measure objective task complexity did not completely overlap with that to measure subjective task complexity.

10.1.2. Insufficient or Inappropriate Values

It was found that some values of the sub-facets were not sufficient to classify the real work tasks and their associated search tasks, and others were inappropriate or not applicable. Thus, some values were added, and others were dropped or adjusted in order to tailor the classification to the work tasks in a real context, namely, a university community in this research. Also, this adjustment made the classification more comprehensive and powerful to describe different situations related to work tasks and search tasks in a real context.

'Collaboration' was added to be a value of the facet 'Source of task' since it was a source different from 'Internal-generated' and 'External-assigned'. It is necessary to classify the work tasks which were generated from collaborative discussion, since it is hard to say whether such tasks were internal-generated or external assigned tasks.

The values of the sub-facet 'Time (frequency)' was adjusted as well. A previously used label 'Periodical' was changed to 'Intermittent'. Both 'Intermittent' and 'Routine' were redefined to differentiate the work tasks which were frequently and not frequently conducted. Thus, to clearly classify the work tasks which were first-time conducted,

conducted several times before, but not frequently, and conducted frequently, three labels were used, namely, ‘Unique’, ‘Intermittent’, and ‘Routine’. This change makes it easier to classify tasks from ‘Time’ facet and helps avoid ambiguity between ‘Periodical’ and ‘Routine’.

There were no products of search tasks in Study 1 which were classified as ‘Physical’ or ‘Decision/solution’. ‘Intellectual’ was the only value of the facet ‘Product’ which could be shared by both work tasks and their associated search tasks. This dilemma suggests a requirement to reconsider the values of the facet ‘Product’ of search tasks. Except ‘Intellectual’, several other values emerged from the data in Study 1, such as ‘Factual’, ‘Images’, and ‘Mixed’. ‘Mixed’ was a value to accommodate the work tasks which required different types of information to support, as WT 15 described by S8 in Study 1. This change makes the facet ‘Product’ the only facet whose values could not be shared by both work tasks and search tasks. However, this change is reasonable and necessary in order to adapt the faceted classification to a real context.

Study 1 also demonstrated the values of the facet ‘Process’ in the original faceted classification, i.e., ‘Creating’, ‘Evaluating’, ‘Choosing’, ‘Negotiating’, and ‘Executing’, were not sufficient. Some work tasks collected in Study 1 involved several values at the same time, for example, WT 13. This violated the basic requirement of a faceted classification, that is, all values should be mutually exclusive. Therefore, all these values were dropped. The new values ‘One-time’ and ‘Multi-time’ emerged from the interviewees’ description of the real work tasks. It is the way how people classify their tasks in terms of the process.

‘Mixed’ was also added as a new value for the facet ‘Goal (Quality)’ for some work tasks, since the data in Study 1 suggested that people may have multiple goals, among which some may be specific but others may be amorphous. This adjustment makes the classification more comprehensive and easier to use in practice.

For the facets or sub-facets in ‘Common attributes of tasks’, their values were adjusted to include ‘Low’, ‘Moderate’, and ‘High’, since based on the data in Study 1, people sometimes assessed their work tasks or search tasks as neither very hard nor easy ones. Therefore, ‘Moderate’ was a necessary value to accommodate these tasks. Originally, the values of ‘Objective task complexity’ were taken from the work task types identified by Campbell (1988). However, since ‘Objective task complexity’ was redefined and Study 1 did not collect enough detailed data to classify the work tasks and associated search tasks in Campbell’s way, the original values were dropped and ‘Low’, ‘Moderate’, and ‘High’ were used as its values. This approach was more convenient in testing their relationships, and turned out to be effective in the following analysis.

After adjusting all these insufficient sub-facets and values, the classification was refined. It became more appropriate to classify work tasks and search tasks in a real context. Since the purpose to develop a classification is to clearly and conveniently categorize different types of tasks, it is necessary to use it in practice and examine its sufficiency and appropriateness to classify real tasks. Study 1 carried out such study and made the faceted classification more adaptable to a real context. Previously, since most classifications of tasks only classify tasks in one organization or a type of organization (e.g. Byström & Järvelin, 1995; Tushman, 1978; Whitley & Frost, 1973), these classifications are usually not necessary to test in practice. The only comprehensive classification for information problems, that developed by MacMullin and Taylor (1984), has never been completely used to classify information problems in a real context. Hence, it was never known whether it could fit to classifying information problems in a real context well.

This study attempted to adapt a faceted classification of tasks to a real context based on the examination of empirical data. It took a different approach from Hansen (1999) and Kim and Soergel (2005). Their research focused on identifying different task characteristics which may promote the research in interface design or information seeking behavior. However, they did not integrate these task characteristics into a framework that is able to direct how these task characteristics could be used to conduct empirical studies. This dissertation moves a step forward. It not only identified different facets of tasks based on a literature survey and empirical studies, but also incorporated them into a framework and then employed it to guide an empirical study. The results and findings in this dissertation demonstrate a powerful framework, and thus secure the effectiveness in taking a faceted approach to conceptualizing tasks.

In the future, if the faceted classification proposed here will be used in other real contexts, for example, to classify the tasks in a business environment, some facets and values may still need to be adjusted. Study 1 provides a way how this could be done.

10.2. What are the Relationships between Work Tasks and Search Tasks in Terms of Their Facets?

Based on the refined faceted classification, the 24 pairs of work tasks and their associated search tasks collected in Study 1 were classified. The usage of the same classification scheme for these two levels of tasks provided an opportunity to probe their inter-relationships, that is, the relationships between the facets of work tasks and search tasks, as well as intra-relationships, namely, the relationships between the facets of work tasks and between the facets of search tasks. This section addresses these two sorts of relationships respectively.

10.2.1 Inter-relationships between Work Tasks and Search Tasks

Study 1 indicated that these two levels of tasks were related to each other in some facets. This means that work tasks really shape search tasks, but not in every aspect. Based on the results of Study 1, the facets of search tasks could be characterized into three groups: strongly affected, moderately affected, and weakly affected by work tasks.

10.2.1.1 Facets of search tasks strongly affected by work tasks

‘Time (Length)’, ‘Objective task complexity’, and ‘Subjective task complexity’ of search tasks seem more strongly affected by work tasks, since there are at least five facets or sub-facets of work tasks related to them. ‘Time (Length)’ of search tasks are associated with ‘Time (Frequency)’, ‘Time (Length)’, ‘Goal (Quantity)’, ‘Objective task complexity’, ‘Interdependence’, ‘Difficulty’, and ‘Subjective task complexity’ of work tasks. This facet of search tasks seems the most sensitive to work tasks compared to others. However, due to the limitations of the data, this study cannot answer how these facets of work tasks affect Time (Length) of search tasks.

‘Objective task complexity’ of search tasks was related to ‘Objective task complexity’, ‘Urgency’, ‘Difficulty’, ‘Subjective task complexity’, and ‘Knowledge of task topic’ of work tasks. Among these work task facets, the highest correlation coefficient between objective work task complexity and search task complexity (See Figure 7.1) indicates that objective work task complexity plays the most important role in shaping objective search task complexity. Considering how these two variables were defined in this study, this result suggests that work tasks with more sub-tasks or activities require searching more information systems.

The significant correlation between ‘Urgency’ of work tasks and ‘Objective task complexity’ of search tasks indicates that for urgent work tasks, people usually needed to consult more information systems. That may be because for urgent work tasks people need to gather as much reliable information as possible within limited time. On the one hand, people believe that if they consult different systems and get similar information, the information may be more reliable. On the other hand, because of time limitation, they have no patience to deeply explore one system. So once they cannot find information in one system in a short time, they will abandon it and move to another one.

It was not surprising to find that ‘Difficulty’ and ‘Subjective task complexity’ of work tasks were significantly correlated with objective search task complexity. If work tasks are perceived as more difficult and complex, people need to search more information systems for gathering supportive information.

The negative correlation between knowledge of work task topic and objective search task complexity indicates that if people are less knowledgeable with the work task topic, they may need to consult more information systems. This may be because people need more knowledge about the work task topic. They may believe that they can gather more information if they search more information systems.

‘Subjective task complexity’ of search tasks was also a facet which is strongly affected by work tasks. Though the same work task facets which affect objective search task complexity also affect subjective search task complexity, their roles are different.

The highest correlation coefficient between them indicated that work task 'Difficulty' was the most important facet which determined subjective search task complexity. However, work task difficulty was not significantly correlated with search task difficulty but relatively highly correlated with subjective search task complexity. This indicates that for difficult work tasks, people usually feel that search is a more complex activity, but it does not mean it is difficult. This supports that 'Difficulty' and 'Complexity' are different constructs from the users' point of view.

The result of Study 1 indicated that objective work task complexity was significantly and positively correlated with subjective search task complexity. This means that for a work task with more sub-tasks, people may feel more complexity when searching for information to support it. It is possible that people need to search for all or most sub-tasks of the work task and thus increase the complexity of search task. However, more empirical evidence is needed to support this claim.

Even if a significant and positive correlation was found between subjective work task and search task complexity, it was also found that compared to other facets which were significantly correlated with subjective search task complexity, the correlation coefficient between them was the smallest one. This indicates that subjective work task complexity is not the most important facet which shapes subjective search task complexity.

The significant correlation between 'Urgency' of work tasks and subjective search task complexity indicated that if people were engaging in an urgent work task, they may feel more complexity when gathering useful information from information systems for this work task. The negative correlation between knowledge of work task topic and subjective search task complexity indicates that people may feel more complexity in searching when they search for information for a work task with which they were less knowledgeable.

Based on the discussion above, it could also be seen that ‘Objective task complexity’, ‘Difficulty’, ‘Subjective task complexity’, ‘Urgency’ and ‘Knowledge of task topic’ are the most important facets of work tasks which shape search tasks’ characteristics.

10.2.1.2. Facets of search tasks moderately affected by work tasks

For some other facets of search tasks, such as ‘Urgency’, ‘Knowledge of task topic’, and ‘Interdependence’, only the corresponding facet of work task was found significantly correlated with them. However, though only one facet of work tasks was related to these search task facets respectively, due to the relatively high correlation coefficient, it could say that if people are engaging a more urgent work task, they will also feel more urgency in gathering information for it. If a work task itself is interdependent, people will also feel that collaboration with other people is necessary when searching information systems to collect useful information. Since in most situations, the topic of a work task is the same one as the topic of its associated search tasks, people usually have the same knowledge level with them. Therefore, they are highly correlated with each other. In other words, it is easy to know their knowledge level of their search tasks if their work task knowledge level is known.

Therefore, it could be seen that the understanding of the relationships between work tasks and search tasks provides a capability to predict the characteristics of search tasks. This provides a possibility to personalize information searching based on understanding of the user’s work task.

10.2.1.3. Facets of search tasks weakly affected by work tasks

However, some facets are not easy to know through work tasks' facets, for instance, difficulty of search tasks. Study 1 indicated that difficulty of a search task was not significantly correlated with any user's perception of work task. It was interesting that objective complexity and subjective complexity of a work task were not significantly related to search task difficulty based on Study 1. However, both of them were significantly correlated with subjective search task complexity. This suggests that difficulty and subjective task complexity based on users' perception are two different constructs and should be examined separately, though some researchers use them interchangeably (Gwizdka & Spence, 2006; Kim, 2005; 2006a, 2006b; Bell & Ruthven, 2004). The only facet which affected search task difficulty is 'Process'. The results illuminated that the associated search tasks of multi-time work tasks were significantly more difficult than those of one-time work tasks. According to S7 in Study 1, multi-time work tasks were more demanding in selecting appropriate keywords and reformulating search queries. It was also not easy to locate "the stuff you really want" from different things that pop up and that needed to take time to evaluate. Only for some professional searchers, like S8 in Study 1, the difficulty level does not matter in spite of a multi-time work task.

Also, it was interesting to find that users' self-assessed level of knowledge of a work task topic was not significantly correlated with the difficulty of its associated search task in Study 1. One reason may be because some participants did not think that knowledge of task topic affected their information search too much, as S3 in Study 1 said: "I have already had some experience in information searching. It was not very difficult for this case." It seems that search task difficulty is more related to users' search experience. S2 in study 2 also commented: "I don't think the familiarity with the topic affected the easiness of my search that much. Even if I am not familiar with the topic, but if I did this type of task before, the search is not that difficult." Therefore, search task difficulty seems not related to the facets of work tasks too much.

Some other facets of search tasks which were not affected by the facets of work tasks include 'Source of task', 'Task doer', 'Time (Frequency)', 'Process', 'Goal', and 'Knowledge of task procedure'. Study 1 indicated that most search tasks were internal generated tasks and individual tasks. Also, it was reasonable that a user's knowledge level of search task procedure was not related to any facets of a work task, because it mostly relies on the user's search experience and search knowledge. For other facets, since they have no any relationships with work task facets, it is hard to estimate these facets' characteristics of search tasks through examining the characteristics of work task facets. This calls for further investigation of the factors which may shape these facets of search tasks.

10.2.2. Intra-relationships between Work Tasks and Search Tasks

Study 1 explored the relationships between the attributes of the two levels of tasks, i.e., work tasks and search tasks, respectively. It was found that these attributes were related to each other differently at these two levels of tasks except objective task complexity (See Figure 7.2 and 7.3). 'Objective task complexity' was significantly correlated with difficulty, subjective task complexity, and knowledge of task topic in both levels of tasks. It was interesting to see that difficulty of work tasks was highly correlated with subjective task complexity and urgency of work tasks; however, there was no significant correlation between difficulty and subjective task complexity and urgency at search task level. Besides, objective work task complexity was significantly correlated with work task interdependence; however, this relationship was not found at search task level. It was also interesting to find that knowledge of search task procedure was significantly and negatively correlated with search task interdependence. That means that for a more interdependent search task, the user's knowledge of how to pursue this search task was lower. This may be the reason why the users need to collaborate during the search. As noted above, no work task facets were related to knowledge of search task procedure, but search task interdependence is significantly correlated with it.

These different relationships in terms of the two levels of tasks indicate that they have different attributes, and are basically different constructs. This provides empirical evidence to support that there are two levels of tasks which related to users' interaction with information systems. Previously, Kelly (2006) provided empirical evidence to support this distinction.

Theoretically, Ingwersen (1992) proposed that work tasks and search tasks were two levels of task. Byström and Hansen (2005) also proposed a three-level task model and suggested that work tasks, information seeking tasks, and information search tasks should be at different levels. Pharo (2002) put forward a search situation transition (SST) model which views work tasks and search tasks as two distinct variables involving several aspects respectively. However, these studies empirically examine neither the inter-relationships between nor intra-relationships of work tasks and search tasks. Thus, most studies in information science area have taken only search tasks into account (e.g. Marchionini, 1989); some studies viewed work tasks and search tasks as an integrated variable, for instance, Kim (2006a); some viewed them as a context which triggers information search, for example, Kuhlthau (1991), Vakkari et al. (2003), and Wang (1997). These studies in fact were not able to reveal the possible influence of work tasks on information searching behavior. This dissertation goes beyond the previous studies and explores the relationships between work tasks and search tasks.

Moreover, since work tasks are usually well-defined in contrast to search tasks (Ingwersen, 1992, 1996), the deficiency of knowledge of the relationships between them makes it hard to understand information search through the characteristics of work tasks. As well, the exploration of the relationships between work tasks and search tasks provides a chance to examine how work tasks could shape search tasks. The findings help people understand the nature of work tasks and search tasks better. It also illustrates that it is imperative to look at work tasks and search tasks as two distinguished variables when investigating their effects on the interaction between users and information systems. Understanding work tasks and search tasks in this way should benefit research in task-based information retrieval.

10.3. How do Work Tasks Affect Users' Interactive Information Searching Behavior, Given that Individual Differences are Taken into Consideration?

Previous studies, for instance, Algon (1999), Byström (1996; 1999; 2002) and Ellis and Haugan (1997), were usually concerned with work tasks and information seeking behavior. These studies did not address how work tasks affect information searching behavior. Based on Wilson (1999a), information seeking behavior and information searching behavior are in fact at two different levels. Only a few studies addressed the relationships between work tasks and information searching behavior, for instance, Pharo

(2002). However, Pharo (2002) examined the influence of work tasks on search strategies and relevance judgments rather than users' specific interactive activities, such as information items viewed or selected. Although Kim (2006a) examined some users' interactive activities with the Web, she conceptualized tasks in a different way. In her study, as mentioned before, "task" is a combination of work tasks and search tasks. In distinction from such previous studies, the current dissertation takes a faceted approach to examining the relationships between work tasks and different aspects of interactive information search behavior. Chapter 9 reports the research results in detail. This section discusses these results and findings, specifically to answer how work tasks affect users' interactive information searching behavior.

Study 2 revealed many significant relationships between work tasks and interactive information searching behavior. Interactive information searching behavior was viewed as a multi-dimensional construct. Several aspects of interaction were examined in this research, including users' general interaction effort with IR systems, their interactions with Web resources and library resources respectively, query-related interactive behavior, and shifting behavior. Considering the close relationships between behavior and performance of interaction, this section will also discuss the relationships between different types of work tasks and performance of interaction based on the results reported in Chapter 9.

10.3.1. Effects of Work Tasks as Multi-faceted Variables on Interactive Behavior

This dissertation described work tasks based on a faceted classification. In other words, work tasks involved different facets; namely, work tasks were viewed as a multi-faceted variable. This is different from previous studies which usually considered work tasks as a single-faceted variable. For example, in Byström's studies (1999), work tasks were described based on different levels of task complexity, which is defined based on users' *a priori* determinability of the process to complete a work task. Algon (1999) classified work tasks based on consideration of the interaction among people in a project team. Although Xie (1998, 2000) viewed work tasks as a variable with different levels, task goal was the facet according to which she classified work tasks. These studies did help people understand how work tasks affect users' information searching behavior from specific aspects of work tasks. However, because of the typical limitation to a single aspect of work task, a comprehensive understanding of the relationships between work tasks and users' interaction with information systems could not be achieved. Therefore, in this research, work tasks were described by different facets: Source of task, Goal (Quantity), Product, Objective task complexity, Interdependence, and Urgency. However, due to the constraint of a quasi-experiment in Study 2, only two facets, namely, Product and Objective task complexity, were varied. Other facets were kept constant. So, six work task types were tested in Study 2: Intellectual/Low objective task complexity (IL), Intellectual/Moderate objective task complexity (IM), Intellectual/High objective task complexity (IH), Decision/Solution/Low objective task complexity (DL), Decision/Solution/Moderate objective task complexity (DM), and Decision/Solution/High objective task complexity (DH).

To test how these six types of work tasks affect interactive behavior, six simulated work task situations were developed and assigned to the participants in Study2. These situations were developed based on the real work tasks collected in Study 1 but minor changes were made for adapting to the experimental situations. Therefore, in Study 2, the six work tasks were combination of work tasks types and specific situations. Any significant differences in interactive behavior between these six work tasks may result from the work tasks types and specific situations. The results of Study 2 indicated a significant difference of these six work tasks in the most of aspects of interactive behavior.

10.3.1.1. Effects of work tasks on users' general interaction effort with IR systems

Study 2 demonstrated significant differences in the number of IR systems consulted, result pages viewed, items viewed and selected across the six work tasks. This reflects that different work tasks require that users exert different effort and need different quantities of information to address the task. Specifically, based on the significant differences in the number of IR systems consulted and the transcripts of the exit interviews, the six work tasks could be categorized into three groups of work tasks: highly depending on interaction with IR systems, like IM, IH and DM; moderately depending on interaction with IR systems, like IL and DH; low dependence on interaction with IR systems, like DL. The first group of work tasks required intellectual knowledge to be accomplished, the second group of work tasks needed facts to be accomplished, but the participants did not know exactly where the sources were, and the third group of task needed the facts that the participants clearly knew where they could find, as S16 said in the exit interview: "I think this (DL) is the easiest, because the sources for information are known. So I just have to go there to find it and get it down." This tells that for the work tasks for which the users know the information sources, they usually do not need to consult too many IR systems. Also, this indicates that school-work related work tasks, like IM, IH, and DM, are the tasks which most rely on interaction with IR systems for supportive information.

With respect to the number of result pages and items viewed, DL was significantly different from other work tasks. This also may be because DL was a work task for which most of the participants exactly knew where the sources were, they did not need to conduct too many searches, and thus viewed significantly fewer result pages and items. The analysis also yielded a significant difference in the number of items selected for the six work tasks, especially between IM and other work tasks. However, further analysis did not find any facets of work tasks were significantly associated with it. This means that though the single facet was not the reason leading to significant difference in items selected, a work task as a multi-faceted variable which combined all these single facets may be the reason. This suggests that investigating work task as a multi-faceted variable is required.

In general, the school-work related tasks required searching more IR systems for supportive information. Moreover, significant differences in result pages and items viewed were found between DL and other work tasks; as a school-work related work task, the participants selected significantly more items for DM than for other work tasks.

10.3.1.2. Effects of work tasks on users' interaction with Web resources

Study 2 found that the participants consulted significantly different search engines and web result pages. However, the differences only occur between DL and other work tasks. This result indicated that DL was very different from other work tasks. The reason was also because most of the participants knew exactly what information they needed and where they could find the information. They did not need to use search engines to locate useful information. In particular, based on observation, most participants who visited search engines for DL did so to locate the URL of the department or university registrar. So, they mostly issued “navigational queries” to search engines (Broder, 2002).

In this study, a portal was defined as an entrance of information items. That is, it basically provides links to the items, i.e., web pages or articles. Usually, the participants needed to browse the portal in order to locate the useful links. In terms of the number of portals visited, the six work tasks could be divided into two groups. One group includes IL, DL, and DH and the other includes IM, IH, and DM. For the first group of work tasks, the participants visited significantly more portals compared to the other group. In this study, the participants visited portals from the links in result pages or they logged on to an individual web site. So, IL, DL, and DH were work tasks which more depended on browsing to obtain information than IM, IH, and DM. As previously mentioned, IM, IH, and DM are more school-work-related work tasks, and DL and DH are typical decision making work tasks. This seems to suggest that decision making work tasks may rely on browsing to locate useful information better.

Significant differences were found between DL and DH in the number of both web items viewed and selected. This indicates that different complexity levels of decision/solution work tasks may require viewing and selecting significantly different numbers of web items. However, no significant differences were found between different complexity levels of intellectual work tasks in the number of web items viewed and selected. This illuminates that they require almost similar number of web items to support.

Therefore, in terms of interaction with Web resources, there was no big difference among the intellectual work tasks. Nevertheless, for decision/solution tasks with different complexity levels, searchers interacted differently with Web resources.

10.3.1.3. Effects of work tasks on users' interaction with library resources

Section 9.1 shows that the participants in fact do not frequently use library resources for their work tasks in practice. During the search for the six work tasks in the experiment, they consulted more sources from search engines than from library resources.

For DL, the participants did not consult any library resources. For IM, IH, and DM the participants consulted most library resources, but for DH and IL, they consulted significantly fewer library resources compared to IM, IH, and DM. Moreover, the participants viewed significantly more items for DM than for IL and DH. This also demonstrates that there are two groups of tasks: one group depends on library resources, including IM, IH, and DM, and the other group does not need library resources too much, including IL, DL, and DH. It could be seen that for the group of work tasks for which the participants consulted more IR systems in general, they also consulted more library resources.

In this study, the number of IR systems consulted was the sum of the number of search engines consulted and library resources consulted. Since there was no significant difference in consulting search engines for IL, IM, IH, DM, and DH, it could be concluded that the significant differences in the number of IR systems between the group of IM, IH, and DM and the group of IL, DL and DH was mostly caused by consulting different number of library resources. This also could be seen that consulting library resources means that the participants had to exert significantly more effort locating useful information for some work tasks. Also, as a school-work related work task, the participants viewed significantly more library items for DM. It also could be seen that for the group of work tasks which require browsing significantly more portals, i.e., DL and DH (decision/solution work tasks and also non-school-work-related work tasks), searchers consult and view significantly fewer library resources and items. Therefore, the work tasks which depended on browsing to pinpoint useful information usually did not heavily rely on library resources.

10.3.1.4. Effects of work tasks on users' query-related interactive behavior

Query-related interactive behavior was measured by the number of iterations and unique queries issued, mean query length, the number of unique query terms and unique non-stop query terms used. Even though there were significant differences in all the measures across the six work tasks, the significant differences mostly occurred between DL and other work tasks. This means that only to the work tasks like DL, a decision/solution work task at low complexity level, the users possibly issued significantly fewer queries, shorter queries, and fewer query terms. As proposed above, the main reason may be because most participants knew exactly what information they needed and where they could locate the information for DL. Also, between IM and IH, two intellectual work tasks with different complexity levels, the participants issued significant shorter queries for IM than for IH. This suggests that maybe lower level complexity was a reason leading to shorter queries. For other work tasks, there are no significant differences found in any measures, though query formulation and submission was a very important way for users to interact with information systems.

10.3.1.5. Effects of work tasks on interactive behavior when individual differences were taken into account

In this study, only three individual differences were taken into account, i.e., gender, academic level (undergraduate vs. graduate students), and major (social science and humanities vs. science and engineering). Even though some previous studies found that gender (e.g. Lorigo et al., 2006), academic level and major (e.g. Zhang & Chignell, 2001; Case, 2002) significantly affected the users' information searching behavior, the results of this study indicated that work tasks played a dominant role in affecting the participants' interactive information searching behavior, and the effects of these individual differences were weak. Gender was found to affect unique queries issued and users' satisfaction. Male participants issued significantly more unique queries and felt significantly more satisfied with their search process for the work tasks. However, this study cannot answer why the female and male participants were different in these two aspects.

Level was found to significantly affect the number of library items viewed. A significant interaction between level and work tasks was found in the number of library result pages viewed. This indicates that undergraduate and graduate students interact differently with library resources to some extent. Moreover, though work tasks were found to significantly affect the participants' interaction with library resources, for the same work task, different levels of students may behave significantly differently in using library resources.

Even if the users from different majors or academic backgrounds may have different mental models (Zhang & Chignell, 2001), this study did not find any effects of major on the participants' interactive behavior. However, the effects of work tasks on interactive behavior continually proved to be important.

Therefore, compared to the effects of work tasks on interactive behavior, individual differences investigated in this study were not powerful factors in shaping users' interactive information searching behavior. However, this study only examined three individual differences, namely, gender, level, and major. Cognitive differences were not taken into account, which have turned out to be powerful in affecting users' information searching behavior in several studies (Kim & Allen, 2002; Ford et al., 2005b)

In short, work tasks affected interactive behavior in many aspects, but individual differences examined in this study did not dramatically affect it. These differences did not strongly moderate the relationships between work tasks and interactive information searching behavior.

10.3.2. Effects of the Facets of Work Tasks on Interactive Behavior

This section specifically addresses the effects of different facets of work tasks on interactive behavior. The facets examined in this study include some controlled facets, such as 'Product' and 'Objective task complexity', uncontrolled generic facets, including several generic facets of work tasks , i.e., 'Time (Frequency)', 'Time (Length)', and 'Process', and 'Users' perception of tasks', such as work task difficulty, subjective work task complexity, knowledge of work task topic, and knowledge of work task procedure.

10.3.2.1. Effects of the controlled generic facets of work task on interactive behavior

Two facets of work tasks were controlled in this study, i.e., 'Product' and 'Objective task complexity'. By varying the values of these two facets, six work tasks types were tested in Study 2. The results indicated that these two facets affected interactive information searching behavior in different degrees. As could be seen in Chapter 9, objective task complexity of work tasks affected almost all aspects of interactive information searching behavior, except the number of items selected, web items selected, and time/item selected. That may be because when different numbers of sub-tasks were involved in a work task, it was necessary to view significantly different numbers of web and library items, as well as selecting significantly different numbers of library items. It is also noticed that objective task complexity was the only facet which affected web items viewed and library items selected. The results suggest that the users may behave very differently in interacting with information systems when they conduct work tasks which involve different quantities of sub-tasks or activities.

The facet of ‘Product’ was also found to significantly affect some aspects of interactive behavior, such as the number of IR systems consulted, result pages viewed, search engines consulted, web result pages viewed, library resources consulted, library result pages viewed, and mean query length. Compared to the facet ‘Objective task complexity’, it affected much fewer aspects of interactive behavior. Therefore, the facet ‘Objective task complexity’ seems more strongly to shape users’ interactive behavior than the facet ‘Product’.

The significant interaction between ‘Product’ and ‘Objective task complexity’ was found almost in all aspects of interactive information searching behavior. This indicates that to any aspects of interactive behavior, though the work tasks were at the same level, for example, they were low complexity work tasks, if the products they pursued were different, the users’ interactive information searching behavior may be significantly different when they searched for these low complexity work tasks. This significant interaction indicated that work tasks should be considered as a multi-faceted variable. Only considering one facet of work tasks cannot reveal the real relationships between work tasks and interactive information searching behavior.

It also could be seen that mostly, to the different complexity levels of work tasks, significant differences in interactive behavior were detected between the low complexity work tasks and the moderate and high complexity work tasks, and there was no significant difference between the moderate and high complexity work tasks. In the follow-up interviews during the experiment, it was found that for the high complexity work tasks, the users usually needed to search several times, so for their initial search (in the experiment), their purpose was to explore the search pattern. As S19 said, in the initial search, her purpose was to know "how to search" for this work task and to "create profile then search" later. But for the moderate complexity work tasks, most of the users just needed to search one time and during this time they tried to locate all necessary information, that is, a comprehensive search. Further analysis found that 35% of moderate complexity work tasks were assessed as "need to search more times", whereas 63% of high complexity work tasks need to search more times. The analysis also indicates that for more complex work tasks, the users usually need to search more times ($r_{(s)}$ (144) = .43, $p<.01$). Therefore, for the moderate complexity and high complexity work tasks, the users seemed to conduct different types of search tasks during the experiment. They exerted almost the same effort for these two types of search for the work tasks with different levels of complexity. Thus there were not too many significant differences between them in interactive behavior. Also due to these reasons, this study seemed not able to pinpoint the differences between the moderate complexity and high complexity work tasks in affecting interactive information searching behavior.

10.3.2.2. Effects of the uncontrolled generic facets of work tasks on interactive behavior

Several generic facets or sub-facets of work tasks and users' perception of work tasks could not be controlled since these facets heavily depend on users' personal judgment on specific work tasks. These facets include 'Time (Frequency)', 'Time (Length)', 'Process', work task difficulty, subjective work task complexity, knowledge of work task topic, and knowledge of work task procedure.

All these facets or sub-facets significantly affected all aspects of query-related interactive behavior. In addition, the sub-facet 'Time (Frequency)' significantly affected the number of search engines and library resources consulted and the number of result pages and web result pages viewed. The sub-facet 'Time (Length)' significantly affected the number of IR systems and library resources consulted and the number of result pages and library result pages viewed. This sub-facet did not affect the user's interaction with Web resources. The facet 'Process' significantly affected only the number of IR systems and search engines consulted. Therefore, with respect to these three uncontrolled generic facets, 'Time (Frequency)' and 'Time (Length)' seem more strongly related to interactive information searching behavior. This is different from the results in Study 1, which did not reveal any relationships between these two sub-facets and interactive behavior. This also reflects that it is necessary to conduct experiments like Study 2 for closely observing the relationships between the facets and interactive behavior.

10.3.2.3. Effects of users' perception of work tasks on interactive behavior

Study 2 showed that work task difficulty, subjective work task complexity, and knowledge of work task topic affected many aspects of interaction. Work task difficulty was found to significantly affect the number of IR systems and search engines consulted, the number of result pages and web result pages viewed, the number of items viewed and web items viewed, the number of portals visited, and all query-related interactive behavior. It was found that work task difficulty did not significantly affect the user's interaction with library resources. That means that the users did not consult more library resources, view more library result pages and items and select more library items even though they felt that work tasks were more difficult.

However, subjective work task complexity significantly affected the number of library resources and the number of library result pages viewed. If the users perceived greater complexity of a work task, they needed to consult more library resources and view more library result pages. This indicates that perceived complexity of work task is a reason that users interact differently with library resources. Besides, subjective work task complexity was significantly correlated with all aspects of interactive behavior which were significantly correlated with work task difficulty. This indicates these two facets are significantly correlated with each other ($r(144) = .84$, $p<.01$), as found in Study 1, though they affected interactive behavior differently to some extent.

Knowledge of work task topic was found significantly correlated with the number of IR systems and search engines consulted, the number of result pages and web result pages viewed, the number of portals visited, the number of library items viewed, and all query-related interactive behavior. Among these sub-facets of users' perception, knowledge of work task topic was the only one which was significantly correlated with the number of library items selected. The results also showed a negative correlation between them. That means that only when the users felt less knowledgeable for work tasks, they may select more library items to support the work tasks.

Knowledge of work task procedure was found significantly correlated with the number of items viewed, the number of search engines consulted, the number of portals visited, and all aspects of query-related interactive behavior. Compared to the other three sub-facets of users' perception, this one seems not a very strong factor affecting interactive behavior. This is not surprising since in Study 1, it was found to have no significant relationships with search tasks.

It also could be seen that the common attributes of tasks investigated here, including the sub-facets of users' perception and objective work task complexity, were significantly correlated with the number of portals visited, positively or negatively. There are not any generic facets which were found significantly related to it. As discussed before, visiting a portal in fact means that the users browse the web site in order to locate the useful links which lead to an item. Therefore, the common attributes rather than generic facets of work tasks may be the factors which lead users to browse more or fewer web sites. It also could say that it is common attributes of work tasks that decide to what extent work tasks depend on users' browsing efforts to locate useful information.

Consequently, the common attributes of work tasks seem more important in shaping users' interactive information behavior. Furthermore, based on the highest correlation coefficient, knowledge of work task topic was more strongly correlated with general interaction and interaction with Web resources; both work task difficulty and knowledge of work task topic were more strongly correlated with query-related interactive behavior; subjective task complexity was more strongly correlated with interaction with the library resources compared to other sub-facets of users' perception of work tasks.

Also, though different work tasks significantly affected the number of items selected and web items selected, no facets or sub-facets were found related to it. This suggests that work tasks should be considered as a multi-faceted variable, as mentioned before; otherwise, some relationships may not be revealed.

Previous studies have concentrated on the examination of users' search tactics, term selection, or search strategies when the users search one specific IR system (e.g. Vakkari et al., 2003), or the Web (e.g. Kim, 2006a). However, Study 1 found that the subjects in fact consulted different information sources in order to collect useful information for a work task. To examine the effect of work tasks on users' interactive activities in a more realistic manner, the participants in Study 2 could select any information sources they felt appropriate for the specific simulated work task situations. In addition, this dissertation used measures of users' interaction with information systems similar to those of Belkin et al. (2001a, 2001b, 2001b, 2002, 2003a, 2003b). Compared to Belkin et al.'s studies in which the participants were required to interact with one or two systems, this dissertation was able to investigate users' interaction with information systems more comprehensively. Though Pharo (2002) and Freund, Toms, and Clarke (2005) explored how work task as an independent variable affects users' search strategies and their interaction with document genres, they did not touch upon the specific interactive activities examined in this dissertation. Therefore, the findings of this dissertation research could enrich people's understanding of the effect of work task as on human information behavior.

10.3.3. Effects of Work Tasks on Shift Patterns between Search Stages

Study 2 examined the shift patterns between search stages among different work task types: the six work tasks tested in study 2, the intellectual work tasks and decision/solution work tasks, and the low, moderate, and high complexity work tasks.

10.3.3.1. Shift patterns across the different work tasks

Study 2 also attempted to investigate the shift patterns between search stages across the work tasks. Though there were some shifts evenly occurring for all work tasks, the results indicated some shifts were sensitive with the type of work tasks, for example, DL, which was a decision/solution work task with low complexity level. The participants conducted significantly more the shift 4 → 5 ('Go to individual web sites' to 'Brows web sites') in DL than in other work tasks. As discussed before, searchers in DL consulted significantly fewer IR systems and visited significantly more portals compared to other work tasks. Going to individual web sites and then browsing web sites were the major way for users to gather information for DL. Also for DL, the users needed to conduct web site search after browsing the web sites. The usual way was to select search terms from a drop down menu. Therefore, the mean probability of the shift 5→ 7 ('Browse web sites' to 'Formulate queries and submit') was also significantly higher in DL than in other work tasks. Moreover, the mean probability of the shift 7 → 5 ('Formulate queries and submit' to 'Browse web sites') in DL was also significantly higher than in other work tasks. However, since the probabilities were quite small, these results might not be meaningful. The mean probabilities of the shift 5 → 9 ('Browse web sites' to 'Review items') were equally high for IL and DH and they were significantly higher in these two work tasks than in others. This means that for IL and DH, the users were more likely to browse web sites, and from the browsing to find the links that lead to promising items for the work tasks. The mean probabilities of the shift 8 → 5 (‘Review result pages’ to ‘Browse web sites’) in IL and DH were also found to be significantly higher than in other work tasks. The users seemed more to prefer to browse web sites from the links in the result pages for IL and DH compared to other work tasks. The mean probability of the shift 9 → 5 (‘Review items’ to ‘Browse web sites’) in IL was also significantly higher than in IH. That means for IL, the users prefer to go back to browse web sites after reviewing items.

Therefore, it seems that the shifts from ‘Browse web sites’ to other stages or from other stages to ‘Browse web sites’ more possibly happened in IL, DL, and DH, rather than in IM, IH, or DM. This also supports that IL, DL, and DH are work tasks which may more depend on browsing to locate useful information, and for IM. IH, and DM, browsing is not the major strategy to locate supportive information.

The mean probability of the shift 7 → 8 (‘Formulate queries and submit’ to ‘Review result pages’) in DL was significantly lower than in other work tasks. This was because for DL, the users consulted significantly fewer search engines and issued significantly fewer search queries to the systems and the queries they usually issued were selected from the drop down menu. Such kind of search query usually produces items or web sites for browsing. Therefore, it could be seen that the mean probabilities of the shift 7 → 9 (‘Formulate queries and submit’ to ‘Review items’) and the shift 7 → 5 (‘Formulate queries and submit’ to ‘Browse web sites’) in DL were significantly higher than in other work tasks. This indicates that for work tasks like DL the users may more possibly move to review items and browse web sites after they formulated and submitted search queries than in other work tasks. For other work tasks, the participants formulated queries in a search box and they usually then reviewed result pages from search engines or library resources.

The mean probability of the shift 8 → 9 ('Review result pages' to 'Review items') was significantly higher in DM than in IM and DL. It also could be seen that the reiterative shifts 5 → 9 ('Browse web sites' to 'Review items')/9 → 5 ('Review items' to 'Browse web sites') and 5 → 10 ('Browse web sites' to 'Select items') /10 → 5 ('Select items' to 'Browse web sites') appeared in all other work tasks except in DM. Though the shifts from 'Browse web sites' to other search stages happened, the users did not conduct the shift 9 → 5 and 10 → 5 for DM. This informs that for DM, the users did not need to repeatedly review the same web sites for useful information. This indicates that on the one hand, the users could easily locate the useful items from a web site; on the other hand, since DM was a decision/solution work task and asked users to answer several questions, for such tasks, they only needed to find the answers and did not need to collect comprehensive information. So, after they reviewed or selected items, they did not need go back to the web sites to browse them again. Therefore, browsing seems not the main strategy for users to locate useful information for DM. Also, the results showed that for DM, the users visited significantly fewer portals than for IL, DL, and DH. This illustrates that though DM was a decision/solution work task, it was different from DL and DH, both of which more depend on browsing than searching for useful information.

After closely examining the shift patterns of different types of work tasks, the salient shifts whose probabilities were above .10 were extracted. The shifts 4 → 7 ('Go to individual web sites' to 'Formulate queries and submit'), 3 → 6 ('Review result pages' to 'Select search modes'), and 2 → 6 ('Go to databases' to 'Select search modes') were salient shifts for IM, IH, and DM; the shift 4 → 3 ('Go to individual web sites' to 'Go to OPAC systems') were salient shifts for IM and IH, but it did not happen in any decision/solution work tasks. Since the stages 'Formulate queries and submit', 'Go to databases', 'Go to OPAC system', and 'Select search modes' were related to search for information from search engines or library resources, this supports that for IM, IH, and DM, searching was the major way to locate useful information.

10.3.3.2. Effects of 'Product' and 'Objective task complexity' on the shift patterns

Study 2 found that the mean probability of the shift 5 → 7 ('Browse web sites' to 'Formulate queries and submit') was significantly different between the intellectual work tasks and decision/solution work tasks. For the decision/solution work tasks, the users more preferred to conduct this shift since browsing was the basic strategy for some decision/solution work tasks, as addressed before. Some unique shifts occurred in the decision/solution work tasks, like the shift 7 → 9 ('Formulate queries and submit' to 'Review items') and 5 → 7 ('Browse web sites' to 'Formulate queries and submit'). This indicates that the decision/solution work tasks did not follow the general shifts patterns of search process. Usually, when a user issues search queries, she/he may review the result pages; if she/he browses a web site through the links in a result pages, she/he usually reviews items. However, for the decision/solution work tasks, they did not follow this pattern. This suggests that product of a work task could shape the shift patterns between the search stages.

Though there were some unique reiterative shifts for the decision/solution work tasks, due to the small probabilities (<.10), these shifts may not explain to much about the shift patterns of the decision/solution work tasks.

The mean probability of the shift 4 → 3 ('Go to individual web sites' to 'Go to OPAC systems') was significantly higher in the intellectual work tasks than in the decision/solution work tasks. This illustrates that the users more possibly conducted the shift 4 → 3 for the intellectual work tasks than for the decision/solution work tasks. This is because the intellectual work tasks more depended on interaction with library resources to locate useful information than the decision/solution work tasks. Therefore, the facet 'Product' of work tasks affects the shift patterns of work tasks.

With respect to the sub-facet 'Objective task complexity', a reiterative shift 5 → 7 ('Browse web sites' to 'Formulate queries and submit') / 7 → 5 ('Formulate queries and submit' to 'Browse web sites') was a significant reiterative shift since for the low complexity work tasks, the mean probability was significantly higher than the mean probability of the moderate and high complexity work tasks respectively. Moreover, in terms of the work tasks with different complexity levels, both the mean probabilities of the shift 8→ 5 ('Review result pages' to 'Browse web sites') and 4 → 5 ('Go to individual web sites' to 'Browse web sites') were found significantly higher in the low complexity work tasks than in the moderate and high complexity work tasks. This indicates that for the work task with lower complexity level the users may more depend on browsing web sites to locate useful information. Also, Study 2 found more significant shifts among the low, moderate, and high complexity work tasks in contrast with those between the intellectual and decision/solution work tasks. This indicates that the facet

'Objective task complexity' of work tasks may be a more influential facet in shaping the shift patterns compared to the facet 'Product'.

The investigation of users' shifting behavior in this study is different from previous studies which also address users' shifting behavior. This dissertation focused on the effect of work tasks on the shift patterns between search stages. Though several studies have examined shift patterns, the search stages identified in different studies are different due to the different research goals. Compared to other studies, for example, Qiu (1993b) and Santon (2003), both of which considered users' cognitive stages while formulating a query and engaging in a search, the present dissertation took a simple but more reliable way to identify the search stages, i.e., only taking the search stages which could be directly observed from the recordings into account. This helped to explore how different work tasks may affect the shift patterns between these search stages. Moreover, since Qiu's study addressed the effects of search tasks on the shift patterns and Santon's study was more concerned with the interaction between intermediaries and users, this dissertation research adds knowledge to this area. The effect of work tasks on the shift patterns is revealed, as well as the effect of two critical facets of work tasks, i.e., 'Product' and 'Objective task complexity'.

10.4. How do Work Tasks Affect Users' Performance of Interaction?

Though this dissertation research aimed to investigate the relationships between work tasks and interactive information search behavior, because of the close relationships between behavior and performance, it is also concerned with the performance (that is, *effectiveness*) of interaction.

The factors which affect users' search performance have been well documented in information science area; particularly, how individual differences, such as search expertise, search experience, domain specific knowledge, and so on, affect search performance (e.g. Fenichel, 1981; Zhang, Anghelescu, and Yuan, 2005) and how search tasks affect users' search performance (e.g. Marchionini, 1989; Qiu, 1993a). However, how work tasks and their different facets affect users' performance has not previously been investigated in depth. This dissertation intended to probe the effect of work tasks on users' interaction with information systems and add to knowledge in this area.

In Study 2, four measures were used to measure the performance, such as Success (in locating useful information), Satisfaction (with the search process), Time (dwelling in the search), and Time/item selected (average time for each item finally selected). The first two measure the effectiveness of the interaction and the other two measure the efficiency of the interaction.

10.4.1. Effects of Work Tasks on Performance of Interaction

The results indicated that work tasks affected the performance of interaction greatly. The users felt significantly more successful and satisfied with DL than other work tasks. They also felt more successful and satisfied with IL and IM than IH. That suggests that more complex work tasks resulted in lower perceived effectiveness of interaction. Also, the users spent significantly less time for DL. This means that for the decision/solution work tasks with low complexity level, the users may have higher efficiency. However, though in general the average time for each item selected was significantly different across the work tasks, there was no significant difference between the work tasks.

Therefore, from this angle, the efficiency in different work tasks had no significant difference.

It was found that for the work tasks the users assessed that they had enough time and could get enough information for them, they also felt significantly more successful and satisfied. However, for the work tasks on which they spent significantly more time and average time for each item they selected, they felt significantly less successful and satisfied. This suggests that users spent more time on the search for a work task, they may feel less effective; moreover, though they spent more time, the time was still not enough and they did not obtain enough information for this work task. Therefore, when searching for work tasks, spending more time did not mean the time was enough nor that the users collected enough information.

10.4.2. Effects of Generic Facets of Work Tasks on Performance of Interaction

In terms of different facets of work tasks, it was found that Time (Frequency) significantly affected the users' perception of success and satisfaction. For more frequently conducted work tasks, they felt more successful and satisfied with the interaction. Also, they spent significantly more time in searching for the less frequently conducted work tasks. This may be because they had more experience and thus felt more comfortable to conduct routine work tasks.

It was also interesting to see that for the short-term and long-term work tasks, there was no significant difference in the time spent during the search in the experiment. The reason was that most long-term work tasks (73%) were assessed as 'need to search more times', while only 32% of short-terms work tasks needed to search more times.

Therefore, as the reasons discussed before, the users may just explore the search pattern in their initial search for these long-term work tasks, but they exerted great efforts to locate as much information as possible for the short-term work tasks. Therefore, it was hard to reveal whether they spent significantly different time in total for the short-term and long-term work tasks in this study, as well as the average time to locate each item they selected. However, the users were significantly more successful and satisfied with the search for the short-term work tasks than for the long-term work tasks. This may be because 91% of long-term work tasks in fact were high complexity work tasks, for which the users perceived less success and satisfaction in this study.

The results showed that the facet ‘Process’ of work tasks also affected performance. The users felt significantly more successful and satisfied with the one-time work tasks than multi-time work tasks. Also, the users spent significantly less time for one-time work tasks. Again, in fact 94% of multi-time work tasks were high complexity work tasks. Therefore, objective work task complexity may also be a reason leading to users’ unsuccessful and dissatisfied perception.

However, the facet ‘Product’ seemed not an influential factor in the performance of interaction between users and information systems, except that the users felt that they were significantly more successful for the decision/solution work tasks than for the intellectual work tasks. This seems to illuminate that for the intellectual work tasks it is more difficult to locate useful information than decision/solution work tasks.

10.4.3. Effects of Common Attributes of Work Tasks on Performance of Interaction

The results indicated that objective work task complexity affected users' performance dramatically. For complex work tasks, the users felt less successful in locating useful information and less satisfied with search process. Moreover, they spent significantly more time in information searching. Again, there was no significant difference found between the moderate and high complexity work tasks in performance. This may be also because they conducted an initial search for the high complexity work tasks but a comprehensive search for the moderate complexity work tasks. Thus, further investigation of the differences in performance between the moderate complexity work tasks and high complexity work tasks is called for.

Study 2 found that the sub-facets of the users' perception of work tasks, such as work task difficulty, subjective work task complexity, knowledge of work task topic, and knowledge of work task procedure, were all found significantly correlated with users' success, satisfaction, and time. Considering the highest correlation coefficient, work task difficulty had the strongest correlation with success and satisfaction compared with other sub-facets of users' perception of tasks. For more difficult work tasks, the users felt less successful, less satisfied, and they spent more time in searching, as was also the case for the sub-facet 'Subjective task complexity' of work tasks. Knowledge of work task topic and procedure are positively correlated with success and satisfaction, but negatively correlated with time. It looks like knowledge of work task procedure was more strongly correlated with success and satisfaction than knowledge of work task topic. This is unexpected since in Study 1 there were no significant relationships found between knowledge of work task procedure and any aspects of search tasks and interactive behavior. Consequently, further exploration is called for.

The results of this dissertation demonstrate that in addition to the individual differences and search tasks addressed by previous studies, work tasks are also an important factor influencing people's searching performance or effectiveness.

In summary, this chapter addressed how this dissertation research could answer the research questions and interpreted the possible reasons leading to the results and findings. Also, how this dissertation connects to other studies in this area is explicated. It is found that this research adds new knowledge to task-based information retrieval. Work tasks and their specific facets are critical in shaping users' interactive information searching behavior. The next chapter will give an overview of the whole study, presenting its most significant findings, identifying some limitations to their interpretation, discussing theoretical, methodological and practical implications of the results, and pointing to some directions for further research.

Chapter 11. Conclusions

11.1. Overall Summary of this Dissertation Research

This dissertation research began by developing a faceted classification of tasks, based on a broad survey of the literature of "task", and then refined that classification to make it applicable to classifying work tasks and search tasks in a university community. Based on this refined faceted classification, the dissertation investigated the relationships between work tasks, search tasks, and interactive information searching behavior. This research found that work tasks were related to search tasks in different but not in all aspects. Different facets of work tasks significantly influenced the length of the time to search, the numbers of information systems consulted, and users' perceived complexity of the search. The degree of urgency and interdependence of the search and knowledge of search task topics were also significantly related to work tasks. However, search task difficulty and knowledge of search task procedure were not strongly related to work tasks.

The study also found that work tasks and search tasks were different constructs with different relationships among attributes: task difficulty was significantly correlated with task urgency and subjective task complexity at the work task level, but not at the search task level; task interdependence was significantly correlated with users' knowledge of task procedure at the search task level, but not at the work task level. Therefore, it is necessary to investigate their effects on information searching behavior individually.

This research revealed that work tasks significantly shaped users' interaction with information systems in various aspects, such as the users' interaction with Web resources, library resources, and search queries they issued. The research found that it was necessary to consider work tasks as multi-faceted variables, which proved to be effective in revealing the relationships between work tasks and interactive information searching behavior.

In terms of different facets of work tasks, common attributes of work tasks were more powerful in shaping interactive information behavior than generic facets of work tasks. It was found that objective work task complexity played a critical role in shaping users' interactive information search behavior. This sub-facet was significantly related to the most aspects of users' interaction with information systems. For low complexity work tasks users depended more on browsing individual web sites, but for higher complexity work tasks they depended more on querying to find supportive information; for higher complexity work tasks they were more likely to interact with library resources than for lower complexity work tasks. The facet 'Objective task complexity' of work tasks more strongly affected the shift patterns than the facet 'Product' of work tasks since dramatically more significant shifts were found in work tasks at different complexity levels. The shifts from the stage 'Browse web sites' to other search stages or the shifts from other search stages to 'Browse web sites" had significantly higher probabilities for work tasks at lower complexity level. However, the shifts involving 'Go to databases', 'Go to OPAC systems', 'Select search modes' and 'Formulate search queries' were more probable in higher complexity work tasks.

The sub-facets of users' perception of tasks were also found significantly to affect different aspects of users' interactive information searching behavior. Among these sub-facets, users' self-assessed knowledge level of work task topic, degree of work task difficulty and subjective work task complexity played an important role. They affected different aspects of interactive information searching behavior with different degrees of strength. Subjective work task complexity was significantly correlated with the number of library resources consulted and library result pages viewed, while work task difficulty was not. Knowledge of work task topic was the only sub-facet of users' perception of task that was significantly correlated with the number of library items viewed. The results also showed that task difficulty and task complexity are different concepts, though they are correlated with each other. Previously, these two constructs have usually been viewed as interchangeable variables (e.g. Kim, 2006a; Bell & Ruthven, 2004). This dissertation suggests that their effects on information searching behavior should be investigated separately. In addition, knowledge of work task procedure was found only significantly correlated to a few aspects of interactive behavior. This supports the finding in Study 1. That is, this sub-facet is weakly related to search tasks and interactive information searching behavior.

Among the generic facets of work tasks, the frequency to conduct a type of work task and the duration time to complete a work task were the more critical generic facets in shaping users' interaction with information systems, since they affected more aspects of users' interactive information searching behavior than others. As to products of work tasks, it was found that users interacted differently with information systems when conducting intellectual work tasks than decision/solution work tasks. They issued shorter queries for intellectual work tasks at lower complexity level than at higher complexity level; they conducted more querying searches for intellectual work tasks at higher complexity level than at lower complexity level. In general for decision/solution work tasks, users more possibly located useful information through browsing web sites; yet, for low complexity decision/solution work tasks their search queries were significantly shorter than for decision/solution work tasks at higher complexity level. In particular, most of the queries for this task type were navigational queries.

Except that ‘Product’ of work tasks only affected success, all other facets of work tasks were significantly correlated with users’ performance during the interaction, such as their success, satisfaction, dwelling time, and the average time spent for each item selected.

The most important finding of this dissertation is that a faceted approach to conceptualizing tasks is feasible, effective, and necessary for the investigation of the effects of tasks on human information behavior. This dissertation research started from a faceted classification of tasks, and suggested that work tasks should be considered as a multi-faceted variable. In addition, the research explored the relationships between different work task facets and interactive behavior. Many significant relationships have been revealed. Furthermore, the results of this dissertation showed that though many work task facets were significantly related to interactive behavior, the degree is different depending on different facets. This cannot be seen if only one aspect of task is considered as in previous studies (e.g. Algon, 1999; Byström, 1999). Therefore, this faceted approach offers a way to comprehensively examine how work tasks affect search tasks and interactive information searching behavior. This helps in understanding the nature of work tasks, search tasks, and interactive information searching behavior better.

11.2. Limitations

The answers to the research questions posed by this dissertation research have some limitations in their interpretation. First, in Study 1, only one interviewee recruited from administrators is far from enough, since their work tasks vary in practice. It is hard to say the work tasks collected from the interviewee who represents this group of people are typical work tasks for this group. However, since their work tasks are not tested in Study 2, the negative influence to the whole research may be alleviated. Also, due to the time limitation, only 12 interviewees and 24 participants were recruited for Study 1 and Study 2 respectively. This small sample size may affect the generalization of this research.

Objective task complexity was operationalized as the quantity of activities and sub-tasks involved and the number of information systems visited. This simplified operationalization may not precisely measure the attributes of objective task complexity, especially as compared to the manner in which subjective task complexity was identified. Since there were no constraints on how participants were to determine subjective task complexity, it can be assumed that several separate factors influenced their ratings, as compared to the single factor in objective task complexity. Also, objective work task complexity was significantly correlated with subjective work task complexity, though the correlation coefficient is not high. This means that these two constructs overlap with each other to some extent. This may reduce the effects of objective task complexity on interactive behavior even if these two sorts of complexity really affected some different aspects of interactive behavior.

Due to the limitation of the experiment, only one simulated work task situation was developed for each work task type. It is hard to pinpoint whether it was work task types or the specific situations which affected interactive behavior. However, the simulated work task situations used in Study 2 proved to be valid. First, these simulated work task situations were revised based on the real work tasks collected in Study 1; second, the development of these situations was based on the proposals of Borlund (2000. p.86). She summarized the three conditions which were necessary for a simulated work task situation to work as a real task based on her research findings; finally, the simulated work task situations did work to help detect the significance difference in users' interactive information searching behavior when they were engaging in information searching for these situations.

In addition, due to the limitation of the data, only gender, level, and major as individual differences were examined and the research did not examine any cognitive individual differences, which have proved to be critical in affecting interactive information searching behavior. Finally, since this research was conducted in a specific context, i.e., a university community, it may not be generalizable to other contexts, like a business environment.

11.3. Implications

However, the implications of this dissertation research are also salient. It provides a refined faceted classification of tasks which is applicable to a university context. Moreover, it helps understand the relationships between work tasks and search tasks, and work tasks and interactive information searching behavior better. Many previous studies examined how search tasks affected interactive information behavior, and usually ignored the influence of work tasks. Also, though people have realized that work tasks motivate search tasks, the relationships between them were usually neglected. This dissertation found that only some facets of search tasks were significantly related to work tasks and others were not. It provided empirical evidence to support that work tasks and search tasks were variables at different levels of tasks related to information search, and thus their effects on interactive information searching behavior should be accounted separately. It also revealed a variety of significant relationships between work tasks and interactive information searching behavior, and found that both generic facets and common attributes of work tasks affected users' interaction with information systems in different degrees. It was found that work tasks were important factors shaping users' interaction with information systems in various aspects, and thus they could not be ignored when considering how tasks affected users' information searching behavior. All these findings shed light on task-based information retrieval and make contributions to the knowledge in this field.

This dissertation research also provides insight into the indicators of work task characteristics. In fact, when users interact with information systems, their work tasks are implicit. However, it is helpful to understand work tasks' characteristics for adapting information systems or personalization of information retrieval to users' specific work tasks. This dissertation revealed a variety of significant relationships between work tasks and interactive information searching behavior. Consequently, it provides a chance to understand work task characteristics through observing users' interactive behavior. For example, if a user more prefers to browse web sites than to issue search queries, she/he may be engaging in a low complexity work task; this work task more possibly pursues a decision or solution. If a user more prefers to search library web sites, it is more possible that she/he is conducting an intellectual work tasks at higher complexity level. These indicators help information systems provide corresponding support and thus improve the interaction between users' and information systems. Therefore, this dissertation research could help adapt information systems to the users' specific work tasks better.

Moreover, this dissertation research illustrates that taking a faceted approach to conceptualizing tasks is effective to probe the relationships between tasks and information behavior. In this way, a variety of significant relationships between work tasks and search tasks and between work tasks and interactive information searching behavior have been revealed. The research first refined the classification to adapt it to a specific context, and then based on it to explore the relationships between work tasks and interactive information searching behavior. This research design could serve as a template for the studies which also take the faceted classification to investigate the relationships between tasks and information searching behavior in other contexts. Nevertheless, if the faceted classification is employed to other contexts other than a university community, its applicability for that context should be first examined. Without doubt, this dissertation provides a valuable way to accomplish it, that is, to collect representative work tasks and their associated search tasks from different groups of people in that context, and then by classifying these tasks to see whether there are inappropriate and insufficient facets and values. Furthermore, the relationships between interactive behavior and both work tasks and different facets of work tasks should be examined since different significant relationships may be revealed.

11.4. Future Studies

As noted above, future studies will still take the faceted approach to conceptualizing tasks, based on which to investigate the relationships between work tasks and users' interaction with information systems in other contexts, such as in industries, hospitals or other domains, like in health information retrieval, everyday-life information retrieval, and so on. Since this study indicates that work tasks and search tasks are constructs at different levels, it is necessary to investigate and compare their different effects on users' interaction with information systems in different contexts. This dissertation research was unable to detect the differences in users' interactive information searching behavior when they conduct moderate complexity work tasks and high complexity work tasks. In order to learn whether this is due to the definition of task complexity, the sample size should be enlarged and work task situations with respect to each work task type should be increased in future experiments.

Since some facets of search tasks have no relationships with work tasks, it is hard to estimate these facets' characteristics of search tasks through examining the characteristics of work task facets. This calls for further investigations of the factors which may shape these facets of search tasks. The limitation of this study in the definition for objective task complexity calls for the exploration of a more precise way to measure objective task complexity and subjective task complexity, especially considering both of them are important attributes which affect users' interaction with information systems. A possible way is to view them as multi-dimension variables and identify their dimensions respectively. These dimensions should be mutually exclusive or reduce the overlapping between them as much as possible.

To conclude, this dissertation research has contributed to better understanding of the relationships between work tasks and search tasks, the relationships between work tasks and interactive information searching behavior, and a faceted approach to conceptualizing tasks. The research findings have theoretical, practical, and methodological implications for task-based information retrieval and personalization of information retrieval. Future studies will further investigate related issues and continually contribute to this area.

Appendix 1: Task Form

Please briefly describe three to four recently completed or current tasks related to your work or study. All tasks you describe here should require you to search for information from any online information sources, such as search engines, indexes and databases from library website, and so on. Your description should include:

- What this task is about, and
- What information sources you go to for collecting necessary information.

Task 1:

Task 2:

Task 3:

Task 4:

If you would like to add more tasks, please use the following space:

Thank you!

Appendix 2: Interview Protocol

Interview procedure:

1) Ask the interviewees to read a short description of the study
2) Explain the procedure of interview to the interviewees
3) Ask them the questions about their general work tasks (the first question)
4) Ask the questions about the first work task and its associated search task
5) Ask the questions about the second work task and its associated search task.

All questions asked will be the same for the first and the second pair of work and search tasks.

Interview questions

- Could you please describe some typical work tasks with respect to your academic work, such as preparing a course, doing a project, or preparing to write a proposal for funding application, and so on?
- For X types of task you just identified, can you think a recent instance when you had to consult any information sources in order to accomplish the task?
- (For each instance, ask the following questions) Can you describe that task in detail?
  1. Was this work task generated by yourself or assigned to you by someone else? If someone else, who?
  2. Did you work as a group member or work alone for this work task?
  3. Do you frequently do this type of work task in your work? How frequent?
  4. Please describe any knowledge you had about this work task before you carried it out, both knowledge of how to do the work task in general, and knowledge of the specific topic.
  5. How long did it take you (or will it take you) to finish this work task?
  6. Can you please describe the goal of this work task?
  7. What is the final result of this work task? Is it a report, a paper, a solution for some issues, or anything else?
  8. Could you please describe how complex this work task was? And why?
  9. Could you please describe to what extent you needed your colleague's support in order to finish this work task? What kind of support did he/she give to you?
  10. [if the task has been completed] Could you please describe how you went about completing this work task? for example, the procedures to finish it?
      [if the work task has not been finished] Do you have any ideas how you're going to finish it? for example, the procedures to complete it?
  11. Before doing this work task, did you have any ideas about these procedures?
  12. How salient is this work task and why? (if the subject ask what "salient" mean, give an explanation) That is, is it very important that it be completed, or not so very important?
  13. How urgent is this work task and why? That is, did it have to be done immediately, or could you take your time over it?
  14. How difficult did (do) you find this work task and why?

15. What any other aspects of this work task do you find important?
16. For this type of task, what kind of information sources do you usually go to?

Now, let's move to the search task you conducted for the work task we just discussed.

- Why did you decide to do the search? And in which stage of the work task you decide to do the search?
- What type of information were you looking for? for example, journal articles, statistical data, travel information, and so on.
- What sources did you go to? [If they happen to say in OPAC, Google, and other databases, then] Why did you decide to look there?
- Can you describe how you went about conducting this search?

17. Was this search task generated by yourself or assigned to you by someone else? If someone else, who?
18. Did you work as a group member or work alone for this search task?
19. Do you frequently do this type of search task in your work? How frequent?
20. Please describe any knowledge you had about this search task before you carried it out, both knowledge of how to do the search task in general, and knowledge of the specific topic.
21. How long did it take you (or will it take you) to finish this search task?
22. Can you please describe the goal of this search task?
23. What is the final result of this search task? Is it a report, a paper, a solution for some issues, or anything else?
24. Could you please describe how complex this search task was? And why?
25. Could you please describe to what extent you needed your colleague's support in order to finish this search task? What kind of support did he/she give to you?
26. [if the task has been completed] Could you please describe how you went about completing this search task? for example, the procedures to finish it?
    [if the task has not been finished] Do you have any ideas how you're going to finish it? for example, the procedures to complete it?
27. Before doing this search task, did you have any ideas about these procedures?
28. How salient is/was this search task and why? (if the subject ask what "salient" mean, give an explanation) That is, is it very important that it be completed, or not so very important?
29. How urgent is/was this search task and why? That is, did it have to be done immediately, or could you take your time over it?
30. How difficult did/do you find this search task and why?
31. What any other aspects of this search task do you find important?

- What were your expectations from the search? Did you get what you want?
- Did the information you obtained help you to complete your work task? If yes, How? If no, why not?

Appendix 3: Classification and Coding Scheme

Categories	Facets	Sub-facets	Values/Codes	Operational definitions/Rules	Examples (Work tasks and Search tasks follow the same rules, though mostly work tasks are used as examples)
Generic facets of tasks	Source of tasks		Internal-generated	A task motivated by a task doer. It is a self-motivated task	"***Q****: Was this work task generated by yourself or assigned to you by someone else?* ***A****:* ***This one ought to be myself"*** Based on the highlighted sentence, WT2 is classified as an "internal-generated" task.
			Collaboration-based	A task motivated through discussion among a group of people	"***Q****: Was this work task generated by yourself or assigned to you by someone else?* ***A****:* ***Both. First we discuss with our advisor, then we make the decision"*** Based on the highlighted sentences, WT1 is classified as a "collaboration-based" task.
			External-assigned	A task assigned by task setters	*"****Q****: Was this work task generated by yourself or assigned to you by someone else?* ***A****:* ***assigned by the professor."*** Based on the highlighted sentence, WT5 is classified as an "external-assigned" task.
	Task doer		Individual	A task conducted by one task doer	*"****Q****: Did you work as a group member or work alone for this work task?* ***A****:* ***Work alone, definitely."*** Based on the highlighted sentence, WT2 is classified as an "individual" task.
			Individual in a group	A task assigned and completed by different group members separately, though they are in a group	*"****Q****: Did you work as a group member or work alone for this work task?* ***A****: Um, it is like a mixed both.* ***Each of us has to write something about Jazzlism.*** *Like I had history of Jazz. Someone has a style, like in Jazz, just like that. In the end, like a paper we actually write.* ***We handle that independent****,* ***and in the end we put all of them together, like a group project. We present it to the class. So, I guess it is independent paper, but as a***

					whole in a group." Based on the highlighted sentences, WT10 is classified as an "individual in a group" task.
			Group	A task conducted by a group of people (at least two people)	*"**Q**: Did you work as a group member or work alone for this work task? **A**: **Yes, I work with her, as a group member."*** Based on the highlighted, WT14 is classified as a "group" task.
	Time	Frequency	Unique	A task conducted at the first time	*"**Q**: Do you frequently do this type of work task in your work? How frequent? **A**: **The first time**."* Based on the highlighted, WT2 is classified as a "unique" task.
			Intermittent	A task conducted more than one time but assessed by task doer as not frequently conducted	"***Q**: Do you frequently do this type of work task in your study?* ***A**: write papers, **not really**."* Based on the highlighted, WT11 is classified as a "intermittent" task.
			Routine	A task assessed by task doer as frequently conducted	"***Q**: Do you frequently do this type of work task in your work? **A**: **All the time. Highly frequently.***" Based on the highlighted, WT15 is classified as a "routine" task.
		Length	Short-term	A task which could be finished within one month	"***Q**: How long did it take you (or will it take you) to finish this work task? **A**: This essay? I **would say five to eight hours.***" Based on the highlighted, WT3 is classified as a "short-term" task.
			Long-term	A task which has to be finished for more than one month	*"**Q**: How long did it take you (or will it take you) to finish this work task? **A**: **This task is never done.** I have to do this task at least ten times a day if I am with company, you know, with different companies, new companies, that we established contacts with. I am always doing this. This is part of what I do regularly.*" Based on the highlighted, WT17 is classified as a "long-term" task.
	Product		Physical	A task which produces a physical product	For WT7, the subject aimed to produce a device for her experiment, so it is classified as a "physical" task.

			Intellectual	A task which produces new ideas or findings	"***Q****: What's the final result of this work task?* ***A****:* ***It is the dissertation.***" Based on the highlighted, WT2 is classified as an "intellectual" task.
			Decision (Solution)	A task which makes a decision or solves a problem	"***Q****: What is the final result of this work task? Is it a report, a paper, a solution for some issues, or anything else?* ***A****:* ***It is like answers to this question.*** *I don't know how to call that. May be short essay.*" Based on the highlighted, WT4 is classified as a "decision (solution)" task.
			Factual information (for ST)	A task locating facts, data, or other similar items in information systems	"***Q****: What is the final result of this search task? Is it a report, a paper, a solution for some issues, or anything else?* ***A****:* ***Roster, I get the roster.***" For ST22, the subject search for rosters, which include data, so it is classified as a task locating "factual information".
			Image (for ST)	A task locating image in information systems	***"A****: the two types, one is the kind of knowledge type. I first search out those, the image or diagram related to my system have similar characteristics to my system. So I did that to use the Internet to* ***search some images****."* The subject need to gather some "images.", so ST7 is classified as a search task producing "image."
			Mix product (for ST)	A task locating different types of items in information systems	*"****A****: Looking for* ***other studies that have been done in the area of food safety****, and um, looking and see if anyone has examined web site that has to do with this topic,* ***with quality articles too****, things in general about web quality that we could apply to our work for helping for our instrument. We look for instruments, but out there are important … could help us, and review the research literature about doing user studies. " "****A****: I don't know, final results? We found* ***a lot of web sites.*** *We also find* ***a lot of web objects.****"*ST15 is aimed at locating different types of information, such as articles (intellectual product), facts, web sites, and web objects (factual information), so it is classified as a task locating "mixed product".

	Process		One-time task	A task accomplished through one process	WT3 is a task to write an essay. The subject completed the task within five to eight hours. She did not need repeatedly write the same essay. So WT3 is classified as a "one-time task."
			Multi-time task	A task accomplished through repeatedly engaging in the same or similar process	"***A***:*...Meanwhile, I also talk to the people working in the workshop because they definitely know much more than me and what kind of parts that is the best one to fit what I need.* ***So it is kind of back and forth, and talking to them and then come back to catalogue ordering and going back and forth for like a month and finally to start ordering****, and after all the parts arrived and start building, and eventually we set up thing in the lab and we start testing run.* ***The testing run sometimes worked, sometimes failed, when it is failed we get together discuss what is the problem and try to fix it. So, repeating.****"* WT7 is a task to develop a device for a scientific experiment, which involved repeated process during ordering the parts and building the device, so it is classified as a "multi-time task".
	Goal	Quality	Specific goal	A task with a goal that is explicit and measurable	"***Q****: Can you please describe the goal of this work task?* ***A****: That's one requirement for me to* ***get the grade for the class****.*" Based on this description, WT4 is classified as a "specific goal" task.
			Amorphous goal	A task with a goal that cannot be measurable	"***Q****: Can you please describe the goal of this work task?* ***A****:* ***Help us to understand what we have learned in the class better to memorize to understand better the medical and biological issues.*** *That is the main task.*" The goal of WT5 is not an explicit one, but the direction of the work task, so WT5 is classified as a "amorphous goal" task.
			Combined goal	A task with both	"*A: I found* **most relevant text book**, **articles** *for this*

				concrete and amorphous goals	*course.* *A: I do have to do search online to look* ***for the Chinese term*** *for getting better understanding."* ST5 has two goals, with a specific one (to get grade) and an abstract one (to better understand the topic), so ST5 is a task with "combined goal".
		Quantity	Multi-goal	A task with two or more goals	"*A: I found* ***most relevant text book***, ***articles*** *for this course.* *A: I do have to do search online to look* ***for the Chinese term*** *for getting better understanding."* ST5 has two goals, with a specific one (to get grade) and an abstract one (to better understand the topic), so ST5 is a task with "Multi- goal".
			Single-goal	A task with only one goal	"*Q: Can you please describe the goal of this work task?* *A: That's one requirement for me to* ***get the grade for the class***." The goal of WT4 is to get the grade for the class, so WT4 is classified as a "single-goal" task.
Common attributes of tasks	Task characteristics	Objective task complexity	High complexity	A work task involved at least five activities during engaging in the task; a search task involved searching at least three types of information sources	In order to complete WT15, the subject need to ***discuss*** with her group members, ***search*** background information about the topic and related studies, ***meet*** people in other institutions, ***develop*** instruments, ***conduct*** user study, ***go to conference*** to present their research, and ***write*** the paper for publication. This task involved more than five activities, so it is classified as a "high complexity" task. To complete ST15, the subject searched ***search engines*** (Google and Ask.com), ***library subscribed databases*** (e.g. Academic Search Premier), ***general web sites*** (e.g. New York Times web site), and so on. Therefore, ST15 is classified as a "high complexity" search task.
			Moderate	A work task involved three or four activities during engaging in the task; a search task	In order to complete WT1, S1 ***talked*** to other people (including his advisor), ***read*** books to find the manual, ***conducted*** the experiment. So WT1 is classified as a "moderate" task in terms of objective task complexity.

				involved searching two types of information sources	To complete ST12, the subject searched an **OPAC system** and **Google**, so ST12 is classified as a "moderate" search task.
			Low complexity	A work task involved one or two activities during engaging in the task; a search task involved searching one type of information sources	For WT8, The task involved **analyzing** the image and **answering** the question, so WT5 is classified as a "low complexity" task. "*Q: What specific sources did you go to? A: **Well, I just used the Google**.*" Based on the highlighted, ST4 is classified as a "low complexity" task.
		Interdependence	High interdependence	A task conducted through collaboration among a group of people (at least two people)	"***Q**: Could you please describe to what extent you needed your colleague's support in order to finish this work task? What kind of support did he/she give to you? **A**: **Well, I absolutely need my students' colleagues support, because I cannot do all of these on my own.** So they **did a quite bit of information research. They did a lot of the logistics, to set up the user session.** I did a lot of work with the instrument, but they help … and testing and they help to develop the individual protocol. And I am sure when come time to writing articles, with the presentation three, we did the jointly. **Absolutely critical, I cannot do that on my own**.*" The subject needed a lot of help from other group members in order to complete WT15, so WT15 is classified as a "high interdependence" task.
			Moderate	A task conducted by one task doer with suggestions or help from other people or group members	"***Q**: Could you please describe to what extent you needed your colleague's support in order to finish this work task? What kind of support did he/she give to you? **A**: **I need some help from my advisor for, basically is about the topic.** Were it be a good one for me to pick this topic. It is something like that and then I just work by myself.*" The subject needed some help from his advisor for WT3, so WT3 is classified as a "moderate"

					interdependence task.
			Low interdependence	A task conducted by one task doer without any help from other people	"**Q**: *Could you please describe to what extent you needed your colleague's support in order to finish this work task? What kind of support did he/she give to you?* **A**: ***No. This is really simple. Not like a big deal, I guess."*** The subject did not need any help from other people for WT9, so this task is classified as a "low interdependence" task.
	Users' perception of tasks	Salience of a task	High salience	A task assessed by the task doer as highly important	"*Q: How salient is this work task and why? That is, is it very important that it be completed, or not so very important? A:* ***Yes, it is very important.*** " Based on the highlighted, WT1 is classified as a "high salience" task.
			Moderate	A task assessed by a task doer as moderate important or the degree of salience depends on specific situations	"**Q**: *How salient is/was this search task and why? That is, is it very important that it be completed, or not so very important?* **A**: *The search task, well,* ***it is personal, sometimes you can, if you forget it, you skip this one. It is fine. Still you know the book, but the thing is that if you want to make a good order, if you want to make your collection good, if like I describe healthy, the more search task, you do the better job you had***." Based on the highlighted, ST24 is classified as a "moderate" salience task.
			Low salience	A task assessed by the task doer as not important	No "low salience" tasks are identified among the tasks collected in Study 1.
		Urgency	Immediate (urgent)	A task assessed by a task doer as highly urgent	"**Q**: *How urgent is this work task and why? That is, did it have to be done immediately, or could you take your time over it?* **A**: ***Yes, I have the deadline.*** " Based on the highlighted, ST1 is classified as an "immediate" task.
			Moderate	A task assessed by the task doer as moderately urgent or the degree of	"**Q**: *How urgent is this work task and why? That is, did it have to be done immediately, or could you take your time over it?* **A**: ***The urgency depends on how urgent it***

				urgency depends on specific situations	***is for you (the client)***." Based on the highlighted, WT20 is classified as a "moderate" task in terms of urgency.
			Delayed (not urgent)	A task assessed by the task doer as not urgent	"*Q: How urgent is this work task and why? That is, did it have to be done immediately, or could you take your time over it? A:* ***I have one week to do it, but it doesn't take me so long. I can sit down and have it done***." Based on the highlighted, WT9 is classified as a "delayed" task
		Difficulty	High difficulty	A task assessed by a task doer as high difficulty	"***Q****: How difficult did (do) you find this work task and why?* ***A****:* ***It is difficult*** *in that I did not really have a focus point until much later on my research. I was not really sure what I do, and there just so much about my Chinese poetry, so took me a while to narrow down.*" Based on the highlighted, WT12 is classified as a "high difficulty" task.
			Moderate	A task assessed by a task doer as moderate difficulty or the degree of difficulty depends on specific situations	"***Q****: How difficult did (do) you find this work task and why?* ***A****: The task itself is difficult?* ***It seems it is OK****.* ***It is not difficult****, but if you want to…****In different stages, the difficulty level is different.*** *For example, the testing part is difficult. But for collecting information, just need some time, some patience to get information to compare and also* ***I don't think it is difficult. But it is also not so easy****, because you have to choose several schools for you. I like the best. Yeah. That is not that easy, just like I said, it is moderate complex.*" Based on the highlighted, WT6 is classified as a "moderate difficulty" task.
			Low difficulty	A task assessed by a task doer as not difficult or easy to complete	"***Q****: How difficult did (do) you find this work task and why?* ***A****:* ***No, that is easy.***" Based on the highlighted, WT9 is classified as a "low difficulty" task.
		Subjective task complexity	High complexity	A task assessed by a task doer as highly complex	"***Q****: Could you please describe how complex this work task was? And why?* ***A: The work task is quite complex, because it is challenge in interpreting the data,***

					challenge the knowledge and the language, everything. " Based on the highlighted, WT2 is classified as a "high complexity" task.
			Moderate	A task assessed by a task doer as moderately complex or the degree of complexity depends on specific situations	"***Q***: *Could you please describe how complex this work task was? And why?* ***A***: ***It is somehow complex in the first place***. *If you do the first time, it seems like a lot of things (to do). When you get used to it, you get the scale, it is not that difficult.*" Based on the highlighted, WT1 is classified as a "moderate" task in terms of subjective task complexity.
			Low complexity	A task assessed by a task doer as simple	"***Q***: *Could you please describe how complex this work task was? And why?* ***A***: ***It is not too complicated***. ***It is based on what the professor taught in the class in the chapters, so that is not complicated.***" Based on the highlighted, WT5 is classified as a "low complexity" task.
		Knowledge of task topic	High knowledge	A task assessed by a task doer as highly knowledgeable on the task-related topic	"***Q***: *Please describe any knowledge you had about this work task before you carried it out, both knowledge of how to do the work task in general, and knowledge of the specific topic.* ***A***: ***I took this course before, so of course I know the stuff.*** *But how to do the work task, for me, it is pretty hard. I never taught before. So I really have no idea how to teach.*" Based on the highlighted, WT13 is classified as a "high knowledge" task in terms of knowledge of task topic.
			Moderate	A task assessed by a task doer as moderately knowledgeable on the task-related topic or the degree of knowledge on the task topic depends on specific situations	"***Q***: *Please describe any knowledge you had about this work task before you carried it out, both knowledge of how to do the work task in general, and knowledge of the specific topic.* ***A***: *That is fairness judgment.* ***Yeah, some kind of from class reading. I need more understanding to formulate to finish the essay.***" Based on the highlighted, WT3 is classified as a "moderate" task in terms of knowledge of task topic.

			Low knowledge	A task assessed by a task doer as not knowledgeable on the task-related topic	"***Q****: Please describe any knowledge you had about this work task before you carried it out, both knowledge of how to do the work task in general, and knowledge of the specific topic.* ***A****:* ***Not too much****. Biology I learn a little bit in high school. Chemistry I learn a little in high school. The one is the introduction course also for undergraduate biology. So I learn somehow a quite new thing for me. Yeah.*" Based on this description, WT5 is classified as a "low knowledge" task in terms of knowledge of task topic.
		Knowledge of task procedure	High knowledge	A task assessed by a task doer as highly knowledgeable on the method or procedures to completing the task	"***Q****: Please describe any knowledge you had about this work task before you carried it out, both knowledge of how to do the work task in general, and knowledge of the specific topic.* ***A****: Well. That is a broad way question. If I started this work three years ago, when I start co-op program work three years ago, because I have no knowledge in Placebro, I have to be trained in Placebro.* ***But now before every task, I have to look up for students' profile, faculty profile. I already know that. I have been working for many years****, my second nature for me to find out all the information*." The subject has been working on this task for several years and known how to do it, so WT17 is classified as a "high knowledge" task in terms of knowledge of task procedure.
			Moderate	A task assessed by a task doer as moderately knowledgeable on the method or procedures to completing the task or the degree of knowledge on the method or procedures depends on specific situations	*"A: For the task itself, it is easy for me. It is similar to applying for school. In terms of applying for school, it is similar. For applying for MBA program, I am not very familiar."* The subject knew how to apply for a general program but did not know much about applying for MBA program, so combining these two aspects, this task is regarded as "moderate" in KTT (WT5).

			Low knowledge	A task assessed by the task doer as not knowledgeable on the method or procedures to completing the task	"***Q****: Please describe any knowledge you had about this work task before you carried it out, both knowledge of how to do the work task in general, and knowledge of the specific topic.* **A***: I took this course before, so of course I know the stuff.* ***But how to do the work task, for me, it is pretty hard. I never taught before. So I really have no idea how to teach***." Based on the highlighted, WT13 is classified as a "low knowledge" task in terms of knowledge of task procedure.

Appendix 4: Instruments (for Study 2)

Consent Form (Study 2)

Thank you for agreeing to participate in this dissertation research. This study is aimed at investigating the relationship between work task and interactive information searching behavior. For this purpose, your participation will involve engaging in the following activities, which will take about two and a half hours:

1. You will read and sign this consent form and ask any questions that you may have. You will receive a copy of this form for your future reference.
2. You will fill out an Entry Questionnaire about your background and previous search experience.
3. You will fill out a Simulated Work Task Situation Evaluation Questionnaire based on your understanding of the given simulated work task situation.
4. You will be asked to fill out a Pre-search Questionnaire before you do the search.
5. You will be asked to search for six simulated work task situations.
6. After each search, you will be asked to fill out a Post-search Questionnaire.
7. During the experiment, you will be asked to think aloud.
8. After completing all the searches, you will be given an exit interview.
9. The total duration of participation in this project is approximately 2.5 hours.

The results of the searches that you do and the questionnaires will be reported, but without any reference to you specifically. The names of all subjects will be held confidential, and all results will be reported anonymously.

The data that are collected will be used for understanding how work task affects search task and interactive behavior. These data will be available only to the researcher on this project. All of the collected data will remain confidential.

The amount of compensation for this study will be $25.00 (cash), depending on the completeness of the participation. You can withdraw prior to completion without any compensation.

As a participant, you may withdraw from this research at any time, without any penalty to you.

I, ____, have read and understood this description and agree to participate in the study. As a participant, I consent to being recorded as I perform the assigned tasks.

__________________________________ __________________________________
Participant Signature Date

______________________________ ______________________________
Investigator Signature Date

If you have any concerns or require further information, please contact Yuelin Li (Principal Research Investigator) via e-mail at lynnlee@scils.rutgers.edu. You may also contact Dr. Nick Belkin at nick@belkin.rutgers.edu, who serves as Chair to this dissertation research.

If you have any questions about your rights as a research subject, you may contact:
Rutgers University Institutional Review Board for the Protection of Human Subjects
Office of Research and Sponsored Programs
3 Rutgers Plaza
New Brunswick, NJ 08901-8559
Tel: 732/932-0150 ext 2104
Email: humansubjects@orsp.rutgers.edu

Instructions (Study 2)

Today, you will be searching information for six simulated work task situations. You need to select information systems (e.g. databases in the university library, online catalogue, search engines, subject directories, or other web sites) which could provide useful information for the work task situation. Here are the procedures to complete this experiment:

- Step 1: Read and sign the consent form.
- Step 2: Fill out the Entry Questionnaire.
- Step 3: Read Task 1.
- Step 4: Imagine this is your real work task, and fill out a Simulated Work Task Evaluation Questionnaire.
- Step 5: Read the description of search task and fill out a Pre-Search Questionnaire.
- Step 6: Read the Think Aloud Guideline carefully.
- Step 7: Doing the search:
  - Select a system you feel appropriate for Task 1 and conduct the search.
  - You can decide how many systems you would like to search, but you have at most 15 minutes for the search.
  - You need to locate useful documents and select a way to keep them for your future use, such as save, bookmark, print, email, etc. You need to tell the way you choose.
- Step 8: During the search, you are required to think aloud following Think Aloud Guideline.
- Step 9: After you complete the search for Task 1, fill out a Post-search Questionnaire.
- Step 11: Repeat from Step 3 to Step 8 and complete the search for Task 2 to 6.
- Step 11: After completing all of the searches, you will be given an Exit Interview.

Do you have any questions about what you'll be doing today?

THANK YOU FOR YOUR PARTICIPATION!

Think Aloud Guideline

You are asked to tell your reasons when you take any actions during the search, for example:

- the reasons you select a specific system for a simulated work task situation
- the reasons you select to use basic search or advanced search or other search modes
- the reasons you select specific keywords to formulate your search query
- the reasons you submit a short or long query
- the reasons you follow any links for further information
- the reasons you select the methods to view the search results if the systems provide different ways to display search results, e.g. full-text or title and abstract only
- the reasons you need to go through several pages or only one pages for locating useful documents
- the criteria you select useful documents for a simulated work task situation
- the ways you keep these useful documents, i.e., save, print, bookmark, email, and so on
- the reasons you use any other features in the interface; for example, if you click "Help", tell the reasons you use this function.
- the reasons you stop the search and decide to move on to the next simulated work task situation
- …

Thank you for your hard working!

Entry Questionnaire

Background Information

1. You are ___________________at Rutgers University.

A: a doctoral student B: a master's student C: an undergraduate student

2. Your major ____________________

3. What is your gender?

____ Female ____ Male

4. What is your age?

___ 18 – 27 years
___ 28 – 37 years
___ 38 – 47 years
___ 48 + years

Computer Experience

Please circle the number that most closely describes your computer experience.

How much experience have you had…	None			Some			A great deal
1. using computers?	1	2	3	4	5	6	7
2. using World Wide Web browsers?	1	2	3	4	5	6	7

How often do you use a computer for…	Never	Once a year	Several times a year	Monthly	Several times a month	Weekly	Daily
1. work tasks?	1	2	3	4	5	6	7
2. personal tasks?	1	2	3	4	5	6	7
3. entertainment	1	2	3	4	5	6	7

Please indicate your level of expertise with computers:

Novice						Expert
1	2	3	4	5	6	7

Please list all programs, operating systems and/or programming languages that you typically use:

____

Searching Experience

Please indicate the number that most closely describes your searching experience.

How much experience have you had…	None			Some			A great deal
1. searching with WWW search engines?	1	2	3	4	5	6	7
2. searching with online library catalogs?	1	2	3	4	5	6	7
3. searching with indexing/abstracting service (INSPEC, MLA, etc.)?	1	2	3	4	5	6	7
4. searching with other systems, please specify the system: a. ____________________	1	2	3	4	5	6	7
b. ____________________	1	2	3	4	5	6	7
c. ____________________	1	2	3	4	5	6	7
d. ____________________	1	2	3	4	5	6	7

5. When I search the WWW, I can usually find what I am looking for.	Rarely			Some-times			Often
	1	2	3	4	5	6	7

How often do you conduct searching for information about…	Never	Once a year	Severa l times a year	Monthly	Severa l times a month	Weekly	Dail y
1. assignment/work related project?	1	2	3	4	5	6	7
2. shopping?	1	2	3	4	5	6	7
3. traveling?	1	2	3	4	5	6	7
4. medical/health?	1	2	3	4	5	6	7
5. government policy?	1	2	3	4	5	6	7
8. entertainment?	1	2	3	4	5	6	7
9. other information,	1	2	3	4	5	6	7

please specify: a.________________							
b.________________	1	2	3	4	5	6	7
c.________________	1	2	3	4	5	6	7
d.________________	1	2	3	4	5	6	7

Please indicate your level of expertise with searching:

Novice						Expert
1	2	3	4	5	6	7

Overall, for how many years have you been doing online searching? _______ years

Please list your favorite search engine(s): ___________________.

Please indicate whether you accepted any professional training in information search, for example, taking courses, participating in workshop, and so on.

Yes_________ No___________

Simulated Work Task Situation Evaluation Questionnaire

1. Please indicate the most appropriate statement which describes this **work task**:
    a. This is the first time I conduct this type of work task.
    b. I did this type of work task before, but not very frequently.
    c. I frequently engage in this type of work task.

2. Imagine this is a real and important work task for you, do you think how long it will take you to complete this **work task**?
    a. ≤ 1 day
    b. > 1 day but ≤ 1 week
    c. > 1 week but ≤ 2 weeks
    d. > 2 weeks but ≤ 3 weeks
    e. > 3 weeks but ≤ 4 weeks
    f. > 1 month

3. Imagine this is a real and important work task for you, how will you engage in this **work task**?
    a. I don't need to do it back and forth during engaging in it.
    b. I have to do it or part of it back and forth during engaging in it.

4. This **work task** is mentally demanding.

Totally disagree	Mostly disagree	Somewhat disagree	Neutral	Somewhat agree	Mostly agree	Totally agree
1	2	3	4	5	6	7

5. I expect this to be a challenging **work task**.

Totally disagree	Mostly disagree	Somewhat disagree	Neutral	Somewhat agree	Mostly agree	Totally agree
1	2	3	4	5	6	7

6. Please indicate how difficult do you think this **work task** is:

Extremely easy	Easy	Somewhat easy	Neutral	Somewhat difficult	Difficult	Extremely difficult
1	2	3	4	5	6	7

7. I am familiar with the topic of this **work task**.

Totally disagree	Mostly disagree	Somewhat disagree	Neutral	Somewhat agree	Mostly agree	Totally agree
1	2	3	4	5	6	7

8. Please indicate how knowledgeable you are with the topic of this **work task**:

Extremely unknow-ledgeable	Unknow-ledgeable	Somewhat unknow-ledgeable	Neutral	Somewhat know-ledgeable	Know-ledgeable	Extremely Know-ledgeable
1	2	3	4	5	6	7

9. Please indicate how knowledgeable you are with the procedure to complete this **work task**:

Extremely unknow-ledgeable	Unknow-ledgeable	Somewhat unknow-ledgeable	Neutral	Somewhat know-ledgeable	Know-ledgeable	Extremely Know-ledgeable
1	2	3	4	5	6	7

10. This **work task** requires a lot of thought and problem-solving.

Totally disagree	Mostly disagree	Somewhat disagree	Neutral	Somewhat agree	Mostly agree	Totally agree
1	2	3	4	5	6	7

11. This **work task** involves a lot of sub-tasks, activities, or steps.

Totally disagree	Mostly disagree	Somewhat disagree	Neutral	Somewhat agree	Mostly agree	Totally agree
1	2	3	4	5	6	7

12. Please indicate how complex this **work task** is:

Extremely simple	Simple	Somewhat simple	Neutral	Somewhat complex	Complex	Extremely complex
1	2	3	4	5	6	7

Pre-search Questionnaire

What information would you like to search for in order to complete the work task? Give a brief description.

____

____

1. Please indicate the most appropriate statement which describes this **search task**:

   b. This is the first time I conduct this type of search task.
   c. I did this type of search task before, but not very frequently.
   d. I frequently engage in this type of search task.

2. I expect this to be a challenging **search task**.

Totally disagree	Mostly disagree	Somewhat disagree	Neutral	Somewhat agree	Mostly agree	Totally agree
1	2	3	4	5	6	7

3. Please indicate how difficult do you think this **search task** is:

Extremely easy	Easy	Somewhat easy	Neutral	Somewhat difficult	Difficult	Extremely difficult
1	2	3	4	5	6	7

4. I am familiar with the topic of this **search task**.

Totally disagree	Mostly disagree	Somewhat disagree	Neutral	Somewhat agree	Mostly agree	Totally agree
1	2	3	4	5	6	7

5. Please indicate how knowledgeable you are with the topic of this **search task**:

Extremely unknow-ledgeable	Mostly Unknow-ledgeable	Somewhat unknow-ledgeable	Neutral	Somewhat know-ledgeable	Mostly Know-ledgeable	Extremely Know-ledgeable
1	2	3	4	5	6	7

6. Please indicate how knowledgeable you are with the procedure to complete this **search task**:

Extremely unknow-ledgeable	Mostly Unknow-ledgeable	Somewhat unknow-ledgeable	Neutral	Somewhat know-ledgeable	Mostly Know-ledgeable	Extremely Know-ledgeable
1	2	3	4	5	6	7

7. Please indicate how complex do you think this **search task** is:

Extremely simple	Simple	Somewhat simple	Neutral	Somewhat complex	Complex	Extremely complex
1	2	3	4	5	6	7

Post-search Questionnaire

1. Do you think you had enough time to do this **search task**?
   Yes________ No_________

2a. Do you think you got enough information to support your **work task**?
   Yes________ No_________

(if "No" in Q2a) 2b_1. Please indicate how many more searches of this sort you will use to gather enough information to support your **work task**:

0	1	2	3	4	5	6 or more

(if "No" in Q2a) 2b_2. You would do more searches in

e. the system I just searched.
f. other systems, please specify ___________________________________

3. During the search, I decided to select a document or web page for the **work task** if I felt it was

A little bit helpful			Somewhat			Extremely helpful
1	2	3	4	5	6	7

4. For the documents or web pages I selected,

a. I am sure that all of them are useful for this **work task**.
b. I am sure that most of them are useful for this **work task**; the others may or may not be useful.
c. I am sure that about half of them are useful for this **work task**; the other half may or may not be useful.
d. I am sure that only a small part of them are useful for this **work task**; most of them may or may not be useful.
e. I am not sure whether all of them are useful or not for this **work task.**

5. The display of search result list is helpful for me to make selection of the documents (if you searched several systems, please indicate your answer for each system)

	Totally disagree	Mostly disagree	Somewh at disagree	Neutral	Somewhat agree	Mostly agree	Totally agree
System 1	1	2	3	4	5	6	7

System 2	1	2	3	4	5	6	7
System 3	1	2	3	4	5	6	7
System 4	1	2	3	4	5	6	7

6. This **search task** was too vaguely specified to allow me to proceed with the search.

Totally disagree	Mostly disagree	Somewhat disagree	Neutral	Somewhat agree	Mostly agree	Totally agree
1	2	3	4	5	6	7

7. It was hard to specify a search query to submit to the system.

Totally disagree	Mostly disagree	Somewhat disagree	Neutral	Somewhat agree	Mostly agree	Totally agree
1	2	3	4	5	6	7

8. It was hard for me to decide whether a document contains useful information for this **work task**.

Totally disagree	Mostly disagree	Somewhat disagree	Neutral	Somewhat agree	Mostly agree	Totally agree
1	2	3	4	5	6	7

9. This **search task** was mentally demanding.

Totally disagree	Mostly disagree	Somewhat disagree	Neutral	Somewhat agree	Mostly agree	Totally agree
1	2	3	4	5	6	7

10. Based on the search you just did, please indicate how difficult do you think this **search task** was:

Extremely easy	Easy	Somewhat easy	Neutral	Somewhat difficult	Difficult	Extremely difficult
1	2	3	4	5	6	7

11. This **search task** required a lot of thought and problem-solving.

Totally disagree	Mostly disagree	Somewhat disagree	Neutral	Somewhat agree	Mostly agree	Totally agree
1	2	3	4	5	6	7

12. This **search task** required searching several systems.

Totally disagree	Mostly disagree	Somewhat disagree	Neutral	Somewhat agree	Mostly agree	Totally agree
1	2	3	4	5	6	7

13. This **search task** involved a lot of activities and steps before locating useful information.

Totally disagree	Mostly disagree	Somewhat disagree	Neutral	Somewhat agree	Mostly agree	Totally agree
1	2	3	4	5	6	7

14. Based on the search you just did, please indicate how complex this **search task** was:

Extremel y simple	Simple	Somewhat simple	Neutral	Somewhat complex	Complex	Extremely complex
1	2	3	4	5	6	7

15. I believe I was successful in searching information for this work task.

Totally disagree	Mostly disagree	Somewhat disagree	Neutral	Somewhat agree	Mostly agree	Totally agree
1	2	3	4	5	6	7

16. I did not feel frustration during searching the system(s).

Totally disagree	Mostly disagree	Somewhat disagree	Neutral	Somewhat agree	Mostly agree	Totally agree
1	2	3	4	5	6	7

17. Please indicate how satisfied are you with your search process of this **search task**:

Extremely dis-satisfied	Dis-satisfied	Somewhat dis-satisfied	Neutral	Somewhat satisfied	Satisfied	Extremely satisfied
1	2	3	4	5	6	7

Exit Interview

1. How do you think different work task situations affected your searches? Why?
2. What different actions do you think you took when searching for information for the six work task situations? Why?
3. Any questions from the observations of the experiment.

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