PERSONAL FACTORS AND EFFICIENCY OF WEB SEARCHING

A DISSERTATION SUBMITTED TO THE GRADUATE DIVISION OF THE UNIVERSITY OF HAWAIʻI AT MĀNOA IN PARTIAL FUFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

DOCTOR OF PHILOSOPHY

IN

COMMUNICATION AND INFORMATION SCIENCES

DECEMBER 2011

By
Jeng-Her Chen

Dissertation Committee:

Rebecca Knuth, Chairperson
Edoardo Biagioni
Scott Robertson
Seongah Im
Shuqiang Zhang

Keywords: Web searching, information foraging, self-efficacy, problem space, Google, Austronesian

Acknowledgements

I would like to express my gratitude to my committee members. Without their support and advice, I could not have completed this dissertation. First of all, I am immensely grateful to my chair, Dr. Rebecca Knuth, who gives me full support both academically and emotionally. She redefined my definition of "good teacher"; she showed me what a real scholar is; she demonstrated what a good dissertation chair is. She is the moving target that I aspire to become someday.

I am thankful to my committee members: Dr. Edoardo Biagioni read my drafts carefully and gave me constructive advice on my research design and analyses; Dr. Scott Robertson helped me decide on issues that hindered my progress and accommodated my questions in a timely manner; Dr. Seongah Im gave me advice and help on analyses, especially the factor analysis; and finally but not least Dr. Shuqiang Zhang taught me so much on statistical methods over the years and inspired me on this dissertation topic and gave me tremendous help in a timely manner. I believe I had the best possible dissertation committee.

I owe so much gratitude to my parents who have been supporting me and encouraging me throughout this long process; I am grateful to my brothers and sisters who have been supporting me emotionally. And I would like to thank my son Shin-Wen who lights up my life and makes every day a new adventure.

Abstract

The study aimed to answer the compelling question: “What makes an efficient Web searcher?” Based on Bandura’s self-efficacy theory, Research Question No. 1 asks “How do self-efficacy, problem-solving confidence, and the use of Google’s Advanced Search affect timely successful Web searching?” Based on Newell and Simon’s problem space theory, Research Question No. 2 asks “Do efficient searchers share the same mental organization of keyword importance as the non-efficient searchers?” And Research Question No. 3 asks “Is a higher level of search performance characterized by increasingly consistent mental organizations of keyword importance?”

Participants searched the Web using Google. Each had up to 30 minutes to find the answer to the task: “How did Taiwan’s native (aboriginal) people communicate in writing from roughly 200 to 400 years ago?” Data analyses involved survival analysis for RQ1 with 86 subjects; TRICIR and t-test for RQ2 and Kendall’s concordance of coefficient for RQ3 with 88 subjects.

I tested five hypotheses. For RQ1, I found that Google’s Advanced Search hurts timely successful Web searching, that self-efficacy helps, and that confidence does not help. For RQ2, I found that there is a significant difference in mental organization of keyword importance in two levels of search performance. For RQ3, I found that the efficient searchers have higher consensus in the mental

organization of keyword importance than those of non-efficient searchers. In summary, I suggest what *not to do*—do not use Google's Advanced Search, and what *to do*—form a what I call "Decisive Problem Space" prior to searching with Google.

Table of Contents

List of Tables

List of Figures

Chapter 1: The Study

It is a generally accepted truism that we are living in an information age. The emergence of the Internet has played an important part in developing our dependence on information technology. The Internet has become an important medium of information and communication in our everyday life: people use the Internet for communication purposes such as sending or receiving emails, for information purposes such as retrieving news online or seeking information, for leisure use such as playing games or to pass time, and for transactions such as buying products online (Wayne & Alice, 2008). People use the Internet to do various kinds of things that used to happen in "real life" environments such as shopping in brick and mortar stores, learning inside classrooms, and searching for information in buildings we call libraries, to name a few. With its emergence, technological development, and popularity, the Internet now provides these "real life" experiences in cyberspace as a viable or even superior alternative when time and space limitations make traditional shopping, learning, and searching inconvenient.

Research has led to continued improvement of Internet use. A major area of study has been information seeking on the Web. There have been a multitude of studies on the growth and impact of the Internet. Studies have showed that information seeking is one of the major online activities people engage in everyday

life. Researchers have studied information-seeking in a variety of ways, asking how people access political information through the Web (Johnson & Kaye, 2003; Robertson, Vatrapu, & Medina, 2009; Robertson, Wania, & Park, 2007), why college students go online (Papacharissi & Rubin, 2000), and what is the importance of educational differences in accessing varying content on the Web (Robinson, DiMaggio, & Hargittai, 2003). With acceptance of the notion that achieving effective and efficient searches greatly improves our access to information and the quality of life, the quality of searches has become an important arena of study. I am interested in quality in information-seeking on the Web, particularly in how to make timely and successful searches.

Because the Web is so much part of daily life, it is important to do research on information seeking on the Web that corresponds to our everyday information needs and takes timeliness into consideration. Researchers have studied the relationship between self-efficacy and job performance (Compeau & Higgins, 1995b, 1999). Researchers have found that people's problem-solving confidence is related with study habit and semester grade point averages (GPA) among students (Elliott, Godshall, Shrout, & Witty, 1990). Bandura's "self-efficacy" is the situation-specific confidence in which a person believes he/she can do the task. Psychological confidence is general self-assurance while engaging in problem-solving activities. But how do self-efficacy and psychological confidence affect Web searching? Assume as part of a business day that you are about to present an

important business plan to your client in thirty minutes. It occurs to you that the presentation would be a lot better if it included a piece of information which you don't have at hand but which is probably available on the Web. You ask yourself whether you want to invest time on searching for the information on the Web or instead play safe, go over the slides, and practice in the remaining thirty minutes. In making this choice, is it your psychological confidence (general belief about yourself and ability) that most influences the decision, or is it your self-efficacy about searching the Web for the particular information needed, or is it your general level of search skills? What changes if your boss is with you and, just as a coach motivates athletes, keeps encouraging you by saying that it's an easy task and you will find the piece of information on the Web? Will that boost your self-efficacy and increase your chance of finding the information within limited time?

This kind of Web search task, a "production task" according to Marchionini (1995), and this kind of decision-making is happening every day. We only have a certain amount of time to look for information. When it is time-sensitive, there is only a narrow window of opportunity for finding relevant information and the searcher must decide whether it is worth the time and energy to initiate a search. Another example: a businessman working abroad is interested in knowing the score of a game in his home country. He only has thirty minutes of break time to look for the information on the Web. Will he decide to wait for tomorrow's newspaper and enjoy his break time or will he decide to satisfy his curiosity by immediately

searching for the information on the Web? How are the three factors (psychological confidence, self-efficacy, and search skill) involved in his decision to initiate a search and calculation about timeliness? How do these factors affect the search's successful completion?

These questions fall into the area of information seeking or information searching, which has long been a research topic in library and information science. There are two major approaches to understand information searching. One tradition is from the Library and Information Science field, the other is from the Computer and Information Science field. In library and information science field scholars traditionally studied how people search in a library environment, a purposeful effort to solve problems. This problem-solving perspective conceptualizes the process of information seeking as stages which are accomplished by human behavior, with different behaviors happening at different stages (Kuhlthau, 1993). Models of information behavior have been proposed with different perspectives. Kuhlthau's (1991) "Information Search Process" model is based on theories of learning which depicts a series of cognitive and affective stages people go through as they find and evaluate information. Donohew and Tipton's (1973) "flow model of information seeking" depicts sequences of events for designing information seeking investigations and excludes variables of task, demographics, and psychology. Marchionini's (1995) model is specifically for searching electronic information in databases or online library catalogs.

Other models that are more general and consider information needs and sources are those of Wilson (1981, 1999), Krikelas (1983), Leckie, Pettigrew and Sylvain (1996), to name a few. These models are defined in relation to theories but they are focused on more limited problems than theories because these models are tied more closely to the real world than theories. The above models each have their own focused problem area and thus help investigators develop clear explanatory predictors. The above models are purely descriptive. They differ from formal models which combine mathematical and pictorial logic. In this study I aim to develop a formal model using Cox proportional hazards regression (see Chapter 3 for details) that can explain the timely successful Web search from the three factors (self-efficacy, confidence, and search skills).

In computer and information science field another theory is being considered—information foraging theory (Pirolli, 2007; Pirolli & Card, 1999). We can think of information seekers as information foragers in analogy to animals foraging for food. Information foragers are information predators searching for information prey (relevant documents). The goal is to get the most nutritious prey at the least cost. The more useful and relevant information the information predator can achieve with the least cost , the more efficient that predator is, thus more suitable to the environment. In computer and information science, accessing the maximum amount of useful and relevant information is a primary goal.

People forage for information by using strategies to deal with unknown situations. Information seeking requires strategies because it is a purposeful search in order to bridge the gap between what is known and what is unknown. According to Chi and Glaser (1985), a problem is a situation in which you are trying to reach some goal, and must find a means for getting there. All problems have three things in common: initial state, goal state, and operations people have to perform on the initial state to achieve that goal. There are two classes of problems, well-defined and ill-defined problems. For example, a puzzle problem is a well-defined problem because a) the goal is clear, b) there is only one correct answer, and c) all the information needed to solve the problem is present. An algebra problem is a well-defined problem according to Chi and Glaser because all the aspects of the situation are well specified. In an ill-defined problem, for example composing a poem or designing a house, one or several aspects of the situation is not well specified. Most domains can be classified into either well- or ill-structured domains. In a well-structured domain (e.g. mathematics), most of the tasks are well defined; in an ill-structured domain (e.g. economics, education or law), most of the tasks are ill defined. Based on Chi and Glaser's problem definition, information seeking on the Web is an ill-defined problem-solving task due to the fact that, in searching on the Web, at least two of the three components (namely the path and goal state) are changing: many different routes can be taken and there is more than one right destination. The searcher may be satisfied by a variety of websites.

Some researchers focus on Web searching tactics and behavior, some researchers focus on the cognitive search strategies, and some focus on the relation between Web experience and cognitive search strategies. For example, Tabatabai & Shore (2005) found the following factors affect success in Web searching: using clear criteria to evaluate sites, avoiding excessive navigating, reflecting on strategies and monitoring progress, having background knowledge about information seeking, and approaching the search with a good attitude and enjoying the process. Tabatabai (2002) found the number of queries made is not related to a timely successful web search. Studies also show different how Web search tasks affect information searchers' strategies. Thatcher (2006) found that the choice of search strategy was dependent on the type of search task, and on whether the task was defined by the searcher himself/herself or not.

Marchionini defined three different information seeking tasks: a) production task which does not involve the information seeker in learning, such as retrieving or verifying a fact, b) a learning task which requires significant decision making and reflection during the search process, such as writing an assigned essay, and c) an accretional information seeking task which requires the information seeker to synthesize and analyze the information need (topic) and find information relevant to the topic (Marchionini, 1995). According to Marchionini, an information seeking task reveals the particular information problem at hand, and information seeking demands general cognitive facility and special knowledge and skills and is

influenced by attitudes and preferences such as motivation, confidence, etc. However, there are two related but confusing concepts about confidence: self-efficacy and confidence.

Self-efficacy has been drawn from social cognitive theory (Bandura, 1986). Compeau and Higgins (1995b, 1999) found computer self-efficacy had a positive effect on job performance and a mediating effect on outcome expectancy. Information system researchers including Debowski et al. (2001) and Wood et al. (2000) also model information behaviors using Bandura's social cognitive theory and self-efficacy. Bandura's social cognitive theory maintains that people operate on a model of triadic reciprocity in which behavior, environmental events, and personal factors in terms of cognitive, affective and biological events, all interact as determinants of each other. Other studies have shown, for example, that when confronted with a problem, those who doubt their capabilities usually reduce their efforts or give up, whereas those with a strong sense of efficacy tend to exert more effort. This will be discussed in greater detail in Chapter 2.

A psychological trait called confidence is often confused with self-efficacy. However self-efficacy is situation-specific whereas psychological confidence is general self-assurance while engaging in problem-solving activities; it is a general belief about oneself and one's abilities, and is developed based on countless real-world personal experiences (Heppner, 1988). Heppner developed the construct of problem-solving confidence as one of the three constructs in a problem-solving

inventory, a general appraisal of oneself in dealing with personal problems. Research shows that among students problem-solving confidence is significantly associated with adaptive study habits and effective attitudes toward studying, as well as higher semester grade point averages (Elliott et al., 1990).

As discussed above, web searching is an ill-defined problem-solving task based on Chi and Glaser's definition. Confidence is a self-assurance developed through life while engaging in problem-solving activities, according to Heppner. Self-efficacy is a situation-specific judgment of expected performance levels based on Bandura's Social Cognitive theory. What interests me is: how do confidence and self-efficacy affect timely successful Web searching? Obviously knowledge and skills improve performance. But how important are search skills compared to self-efficacy and confidence in dealing with an everyday web information-seeking challenge?

I believed that searchers placed a high value on timely and effective searching. According to both theories and common sense, it appears that confidence, self-efficacy and search skills are important factors in successful Web searches. To be more specific, I assumed a timely successful Web search on a production task corresponded to what most people expect to achieve every day. I disaggregated the seemingly related factors of confidence, self-efficacy and search skill on timely successful Web searching and found out how much explanatory power is due to which factor by using statistical analysis.

There are studies that relate to this area of research, but I expanded on them. Studies have shown that self-efficacy is a significant factor on Web-based experiments. For example, information seekers with low self-efficacy tend to vary their level of effort to seek different accuracy goals, while seekers with high self-efficacy usually don't change their effort (Kuo, Chu, Hsu, & Hsieh, 2004). Students with higher Internet self-efficacy showed better searching strategies and learned better in a web-based learning task (Tsai & Tsai, 2003). However, these studies did not consider other factors such as psychological confidence and search skills that may interact with self-efficacy in performance. These studies also did not answer how self-efficacy may affect the timeliness and success of Web searches in everyday situations.

A timely successful web searching model using survival analysis was studied from the perspectives of how experts differ from novices in terms of strategies and attributes (Tabatabai, 2002; Tabatabai & Shore, 2005). Tabatabai and Shore (2005) identified five specific actions that are associated with success in web searching, but their study did not look at how a timely successful web search might be related to self-efficacy. Compeau and Higgins (1995a, 1999) have shown evidence of the significance of self-efficacy in IT usage. They used the statistical method of Structural Equation Modeling. I think that the seemingly interrelated concepts of self-efficacy, confidence, and search skills are associated with timely success in Web searching.

I believed that the most appropriate way to answer this research question—"How do self-efficacy, problem-solving confidence, and search skills affect timely successful Web searching?"—was by using the statistical method, survival analysis. In everyday Web searching, people sometimes succeed and sometimes give up. This made the result a dichotomous variable as opposed to numerical which most studies were designed for. When the dependent variable is numerical and its distribution is normal, statistical methods such as ANOVA (Analysis of Variance) and regression (including Structural Equation Modeling), are appropriate. As opposed to ANOVA and regression, survival analysis is not based on normal distribution. It estimates the "hazard" of an event happening, instead of "whether or not" the event happens which is usually answered by statistical methods of ANOVA or regression (See "hazard" definition in Chapter 3).

I worked on the topic of timely successful Web searches because I wanted to find out which of the three factors (self-efficacy, problem-solving confidence, and search skill) is the most important. Once the answer was found, we can train web searchers more effectively. The Web, though disorganized, is considered the most complete encyclopedia or knowledge base on earth. When people are more efficient and effective searchers, they gain two crucial benefits: time and knowledge. When someone can access the needed information in a shorter time and form the needed knowledge with correct information, that person is more productive and suited to this fast-paced information age.

In addition, I was interested in searchers' selection of keywords as an indicator of divergent mindsets. Queries are important for Web search engines, either keyword based or question-based. Most Web search engines are keyword-based , including Google and Yahoo, which account for 95% of the market, according to the Nielsen Reports as of December, 2009 ("Nielsen Reports December U.S. Search Rankings," 2010). Many studies related to keyword expansion and keyword reformulation by the IR (Information Retrieval) community have shown that keywords aid users in effectively retrieving relevant documents. Studies indicated that information searchers have different priorities in terms of the importance of each query term.

Previous researchers that have used search engine logs have had some problems. First, most researchers analyze the logs of only one search engine out of a number of available search engines. For example Spink et al. (2001b), Lau and Horvitz (1999) and others used the Excite search engine to study queries. According to SearchEngineWatch.com (Sullivan, Jan 28, 2005) the Excite search engine was one of seven major search engines between 1995 and 1999. Second, in general, the more documents indexed by a search engine on the Web, the better the chance that the information seeker will find unusual or hard-to-find information. Search engines with a smaller number of indexed documents may not provide enough help for the searcher, thus a searcher may switch to different search engines during the search. Excite had roughly 55 million textual documents indexed as of

September 1997, next to the Inktomi search engine which had roughly 75 million indexed textual documents. By the mid 1999, Altavista and Northern Light both reached roughly 150 million indexed documents, Inktomi reached 110 million, and Google had some 80 million textual documents indexed while Excite remained at roughly the same 55 million, which made it number five in number of indexed documents (Sullivan, Jan 28, 2005). Third, the collection of logs and analysis was possible with the Excite engine and so it was used in studies using log analyses of Web activities. Log analysis studies have their advantages (for example, they are large-scale unobtrusive studies in real world situations, which makes their conclusions more generalizable), but the transaction logs do not contain uniquely identifiable information about the searchers and the session boundaries. This is the inherent disadvantage of most publicly available web-based search environments. They cannot exclude the possibilities that there are several searchers or computers sharing the same IP address, or that searchers relying on multiple windows do web queries in parallel (a common skill for advanced Web users). I did not want to be dependent on logs. My study had the advantage of observation of participants so that I could clearly identify their session boundary and queries.

In everyday life we prioritize tasks or choices all the time. We always need to decide whether we should do task A or task B first. When performing multiple tasks, it is the ability to prioritize tasks that makes us productive and efficient. People have preferences. For example, a child may choose a) ice cream over b)

chocolate cake over c) candy bars as his or her reward. Of course, inconsistency of choice may happen, as expressed in the instance, A is chosen over B, B is chosen over C, and C is chosen over A. When an inconsistent preference pattern occurs, it is a sign that the person may not be sure about his or her preferences.

Saracevic's (1997) stratified interaction model states that information seekers interact with Information Retrieval (IR) systems only at the surface level of the computer, which is an interface between user and system. The IR system does not know the user's cognitive structure and task, while the user has little or no knowledge of the IR system's processing and engineering characteristics. The system can at best "guess" a user's task based on the queries a user sends through the interface. For example, by taking user's cognitive factors into consideration, Web mining researchers Jimmy Liu and his colleagues came up with a solution (a computer simulating program) that can successfully predict a user's Web surfing behavior after validating with Web log data (Liu, Zhang, & Yang, 2004). Their goal is to develop a Web search tool running on the system side to "guess" a user's browsing strategy and facilitate a user's Web operation. On the other hand, users must enter queries through the interface and reformulate their queries if the returning results do not contain the expected content. This is what Information Foraging theory calls "patch activities": an information forager keeps refining queries or reformulates queries and moves between tabs (or windows) so that a search engine returns lists with higher proportions of potentially relevant

documents in which answers can be found. How often do users reformulate or refine their keyword queries? Not very often. According to studies on the Excite search engine, Spink et al. (2001b) found 52% of the users entered more than one unique query. Lau and Horvitz (1999) found that relatively few users refine their searches by means of specialization, generalization, or reformulation. With the inherent disadvantages of log-based studies, we can never be sure about the relationship between users' problem-solving tasks and their queries.

Information-processing theories (Greeno, 1978; Simon, 1979) shed light on this. Information-processing theorists maintain that problem solving involves three cognitive processes: a) construction of a problem representation or problem space, b) a solution process or problem-solving space that involves problem solvers' search within the problem space, and c) control processes to check the success or failure of the solution. In my study, I examined the first two cognitive processes in the field of Web search. When facing a problem-solving task, users should have the ability to construct the problem representation. First, in analogy to Web searching, information seekers should have the ability to construct the problem using queries— keyword queries to be specific. Each information seeker has his or her own problem representation which I call mental organization. Second, an information seeker should have a solution process that involves his/her search within his/her problem space (mental organization).

In the context of Saracevic's stratified interaction IR model, information-processing theory, and information foraging theory, information seekers keeps refining queries or reformulates queries and moves between tabs (or windows) (see Section 2.4). If a searcher's mental organization is not effective, he or she will refine keyword queries through the interface of the IR system. Thus it takes more time. The worst mental organization is probably the one without organization: the information seeker uses query terms randomly and it takes a long time because the searcher does not know keywords that represent the problem space, let alone the relative importance of keywords searching the problem space. On the other hand, when the initial mental organization is effective, the information seeker should take less time to find the answer.

What constitutes an effective mental organization and solution process in a Web search? There may not be an agreed-upon answer. I suspected it is like the unspoken consensus that experienced people have in any field. According to psychometric research in ESL (language acquisition of English as Second Language) which has shown that a tacit general consensus exists among native speakers regarding the psychological distances among vague quantifiers (Zhang, 1995), I used mental organization to refer to the relationship of importance among keywords as perceived by the information searchers of the study. I hypothesized that the reason that efficient searchers arrive at the correct answer faster than others is because they start off by having a clear mental organization of which keywords

are more important than the others. Efficient searchers could prioritize the importance of keywords as they begin a search task. Non-efficient searchers who lacked the discerning ability of prioritizing the keywords would spend more time on the task or would be timed-out. Slow or timed-out information seekers change their selection of keywords randomly, therefore they tended to spend more time on the search. In other words, they depended on luck rather than the clear mental concept of keyword importance. Through observation I wanted to test these assumptions about mental organization regarding the importance of being able to prioritize keywords. In this study, I tested whether the knowledge of importance of strategic keyword determination in forming initial queries positively affects searching.

Chapter 2: Literature Review

The literature which underlies this study is primarily from two fields: psychology and information science. The relevant concepts, terms and theories are self-efficacy, confidence, information processing and information foraging.

2.1 Self-efficacy

I based my first research question on concepts of self-efficacy and confidence. Much of the literature review on self-efficacy focuses on two major figures: Albert Bandura and, secondarily, James E. Maddux. In 1977, Albert Bandura first wrote the book " Social Learning Theory" (1977b) introducing the self-efficacy theory. Self-efficacy plays an important role in human behavior because the perception of efficacy determines how much effort people will expend, and how long they will persist when facing obstacles. Social learning theory views human behavior as a triadic, continuous, and reciprocal interaction between cognitive, behavioral, and environmental determinants. Within the framework of social learning theory, self-efficacy is seen as a person's assessment of their capability, formed by processing, weighing and integrating diverse sources of information, "… they regulate their choice behavior and effort expenditure accordingly (Bandura, 1977a, p. 212)."

The belief in one's capabilities comes through integrating information from four primary sources (Bandura, 1977b, p. 80): Performance Accomplishments, Vicarious Experiences, Verbal Persuasion, and Emotional Arousal. *Performance Accomplishments* are the individual's mastery experience or enactive attainments. The most powerful source of self-efficacy information is our own attempts to control our environment. Successes raise our efficacy expectation, repeated failures lower them. The negative impact of failures will be reduced after strong self-efficacy is developed through repeated successes. Self-efficacy beliefs are influenced through *Vicarious Experiences*, observations of other people's behavior and consequences. People create expectations about themselves when they see other people performing threatening activities without bad results: They think that if others can do it, they should be able to do it with a similar level of performance, if not better. The concept, *Verbal Persuasion*, refers to how efficacy beliefs are influenced by what others say to us about what they believe we can or cannot do. Zeldin and Pajares (2006; 2000) built upon Bandura's ideas about Verbal Persuasion in a study that indicated that persuaders can be an important source in the development of a person's self-belief. In Maddux's (2005) chapter on self-efficacy, he suggested that the expertness, trustworthiness, and attractiveness of the source will influence the potency of verbal persuasion. This seems to fit with my story of "encouraging by the boss" in the Introduction. *Emotional Arousal* involves physiological states such as anxiety, stress, and mood that provide information

about self-efficacy beliefs: for example, people are more likely to expect success when they are not debilitated by agitation.

In the same year as his social learning theory book came out, Albert Bandura published a study on self-efficacy (Bandura, 1977a). He tested a hypothesis that there was a relationship involving the effects of each of these four sources above. The results confirmed that Performance Accomplishments, Vicarious Experiences, and Emotional Arousal influenced behavioral change, but Verbal Persuasion did not. In 2005 Maddux expanded the sources of self-efficacy from Bandura's four (Bandura, 1977b) to five, by adding Imaginal Experiences. Imaginal Experiences state that people can increase or decrease their self-efficacy by imaging themselves performing effectively or ineffectively in future situations. The images can be derived from actual experience, vicarious experience, or verbal persuasion, but imaginal experiences are not as likely to have as strong an influence on self-efficacy as actual experience. Bandura and other researchers then proceeded to research self-efficacy in a series of studies: Brown and Inougye (1978) found, in their anagram task, that the higher the subjects' expected efficacy, the longer they persisted regardless of treatment conditions. Using proximal goal setting as an effective mechanism for cultivating competencies, self-percepts of efficacy, and intrinsic interest, Bandura and Schunk (1981) found children's perceived self-efficacy was positively related to their accuracy in mathematical performance and to intrinsic interest in arithmetic activities. Through experiments on children with

low arithmetic achievement, Schunk (1981) found effort attribution had no significant effect either on perceived efficacy or on arithmetic performance, while perceived efficacy was an accurate predictor of arithmetic performance across levels of task difficulty and modes of treatment. When Bandura and Cervone (1983) studied subjects performing a strenuous activity with either goals and performance feedback, goals alone, feedback alone, or without either factor, they found that when both comparative factors were present, the evaluative and efficacy self-reactive influences predicted the magnitude of motivation enhancement. The higher the self-dissatisfaction with a substandard performance and the stronger the perceived self-efficacy of goal attainment, the greater was the subsequent intensification of effort.

1n 1986, Albert Bandura revised and expanded his social learning theory book and included the concept of self-efficacy (dealt with in his book's Chapter 9) into the larger Social Cognitive Theory (Bandura, 1986). There are four basic premises in Social Cognitive Theory: 1) people have powerful cognitive or symbolizing capabilities which allow them to create internal models of experience, develop innovative action, test their actions through the prediction of outcomes, and communicate ideas and experiences with others. For example, when children's understanding of language increases, so does their capacity for symbolic thought. 2) environmental events, inner personal factors, and behaviors are reciprocal influences. When we exercise control over our behavior through cognition, we then

influence the environment and personal factors (cognition, emotion, and biological events). 3) self and personality are socially embedded, they are created in our interactions with others and they change through these interactions. 4) people are capable of self-regulation. Through self-reflective activities such as engaging in self-observation and analyzing and evaluating their own behavior and thought, people choose goals and regulate their behavior in pursuit of goals. Besides the self-regulatory mechanism, there is another facet of a self system (i.e. self-efficacy). Bandura noted that Newell (Newell, 1978) perceived a lack of research on the processes governing the interrelationship between knowledge and action. Bandura (1986, p. 390) thinks that the social cognitive theory helps bridge the gap in terms of conception-matching processes whereby symbolic representations are translated into appropriate courses of action. For example, it is the self-referent thought (i.e. self-efficacy) that mediates people's behavior: people don't usually perform optimally even when they know full well what to do, but if they have a strong sense of self-efficacy, they persist longer and do better.

There have been some researchers who are more negative about self-efficacy. Some scholars think that self-efficacy belief is debilitating. Power's (1991) Perceptual Control Theory (PCT) assumes that behavior is a function of perception; this is in contrast to other theories of behavioral psychology. According to PCT, people and animals do not control their behavior. It is the perception and goal that drives the system or organism. To drive the system, there is a negative

feedback in the system. Taking the cruise control system in a car for an example: a sensor consistently comparing the difference between the “perceived speed” and the “preset goal speed,” the difference then determines the throttle setting. Building on Power’s (1991) perceptual control theory, Vancouver et al. (Vancouver, Thompson, Tischner, & Putka, 2002; 2001) claimed that the belief in one’s capabilities has no determinative function. Vancouver et al. (2002; 2001) believe that high perceived self-efficacy actually slackens performer’s effort. In an analogy to cruise control, higher perceived speed than preset goal speed will slow the car through the negative feedback loop. Bandura and Locke (2003) used studies from nine meta-analyses which evaluated the effect of self-efficacy (quantitatively), and argued against Vancouver et al.’s contradictory findings that belief in one’s capabilities and personal goal is self-debilitating.

As we have seen, Bandura has dominated the concept of self-efficacy, but other researchers have also contributed insights, including James Maddux, a social clinical psychologist. Maddux looked at self-efficacy in terms of Roger’s (1975) Protection Motivation Theory (PMT). PMT postulates that there are three crucial components of a fear appeal: a) the magnitude of noxiousness of a depicted event; b) the probability of that event's occurrence; and c) the efficacy of a protective response. Maddux found self-efficacy had a direct influence on intentions and that it interacted with variables of PMT when he tested a combined model of PMT and self-efficacy theory (Maddux & Rogers, 1983). In a book edited by Maddux in

1995 (Self-Efficacy, Adaptation, and Adjustment: Theory, Research, and Application) he wrote that social clinical psychologists have increasingly posited that effective adaptation and psychological adjustment require physical health and effective functioning for adult and children. Maddux thinks the heart of self-efficacy theory is a sense of self-control or mastery which is essential for psychological adjustment and behavioral effectiveness. When people seek professional help, they usually have a sense of reduced personal control or efficacy because of difficulties in life. Based on the principals of social cognitive theory, Maddux and Lewis (1995) argued that helping patients to raise or restore their self-efficacy is important in psychological adaptation and adjustment. Maddux and Meier (1995) did a comparison of self-efficacy theory with two major social cognitive theories (Beck's cognitive model and the helpless/hopeless model) of depression. They found that the self-efficacy theory is compatible with those two theories of depression and can be integrated with those models for greater clarity and precision. In the health field, psychologists have been studying why people do not always act in their best interest. For example, people smoke, drink, eat too much when they surely know these behaviors are not good for themselves. Maddux et al. (1995) explained how self-efficacy is important in each of the three types of health behaviors: prevention, promotion, and detection. They also pointed out that the self-efficacy has been incorporated into models and theories (e.g. the health behavior model, protection motivation theory, and theory of planned behavior) that

are used by health psychologists to explain or model human behavior in health related topics.

Maddux and Snyder (1997) used the self-efficacy theory developed by Bandura in combination with goal theory (goal determines the direction, intensity, and duration of action) to explain self-regulatory theory— a subfield of self-processes under social cognitive psychology. Maddux (1999) explained the differences and similarities between different types of self-efficacy proposed by Bandura (1977a) and Kirsch (1995). Kirsch uses two terms to describe self-efficacy: "task self-efficacy" and "coping self-efficacy." *Task self-efficacy* is defined by Kirsch (1995) as the perceived ability to perform a particular behavior, while *coping self-efficacy* is defined as the perceived ability to prevent, control, or cope with potential difficulties that might be encountered when performing. According to Maddux (1999), Kirsch's task self-efficacy is similar to Bandura's (1977a) original definition of self-efficacy expectancy as " the conviction that one can successfully execute the behavior required to produce the outcomes." Maddux (1995) noticed that the Kirsch's coping self-efficacy is similar to Bandura's (1995) later definition of self-efficacy when he tried to seek the common ground between the confusing definitions of self-efficacy by the two scholars. By using examples of "using a condom" and "swallowing a pill," Maddux clearly distinguished the confusing differences and established the common ground by drawing the distinction between task self-efficacy and coping self-efficacy. Maddux pointed out

that Kirsch's task self-efficacy, as Banduara referred to as "elemental act," can be detached from "complex adaptation" (coping self-efficacy). Most self-efficacy measurement focus on coping self-efficacy, not task self-efficacy. For example, when we ask people's self-efficacy on smoking, we are not asking the self-efficacy on lighting cigarettes (a simple motor act) but the coping self-efficacy of difficulties encountered when facing pressures and urges to smoke in different situations.

In this study, I used the definition of self-efficacy defined by Bandura which is similar to Kirsch's coping self-efficacy.

2.2 Confidence

Most of the literature on confidence is from the fields of counseling psychology although as seen in the study of Kim and Sin (2007) below, it has been applied to information-source selection. I found that Heppner's and his colleges in psychology had more to offer in terms of conceptual power and tested validity. Confidence is a construct that is considered to be similar conceptually to self-efficacy. Confidence has been widely studied and is a good predictor of performance. Heppner (1978), coming from the research perspective of counseling psychology, reviewed the literature of problem-solving in counseling and found only a few studies have explicitly attended to the problem-solving process. Heppner thought it was probably because of the lack of assessment instrument. He

later developed a problem-solving instrument and reported its reliability and validity through exploratory factor analysis (Heppner & Petersen, 1982). D'Zurilla and Goldfried's (1971) problem-solving model posited that there were five distinct stages: general orientation, problem definition and formulation, generating alternatives, decision making, and verification. Instead of confirming that the problem-solving process is five distinct stages as investigators before him postulated, Paul Heppner found that there were three dimensions underlying the perceived personal problem-solving process of college students: problem-solving confidence, approach-avoidance style, and personal control within student's perceptions of their real-life personal problem solving.

In 1987 Heppner and Krauskopf proposed an information-processing model of personal problem solving in which they maintained that practically any situation can be construed either objectively or subjectively as a problem that is to be remedied. They theorized that those who thought of themselves as effective problem solvers generate more adaptive, goal-directed solutions to problems than self-appraised ineffective problem-solvers. Building on Heppner and Krauskopf's (1987) model of personal problem solving which had looked at three dimensions, Elliot et al. (1990) found that of all of these problem-solving dimensions, problem-solving confidence was significantly predictive of study habits and GPA, while the other two (approach-avoidance style and personal control) were not. Problem-solving confidence is defined as self-assurance, beliefs, and trust in one's ability to

effectively cope with a wide range of problems (Heppner, 1988; Heppner, Witty, & Dixon, 2004). Problem-solving confidence is a significant factor in human adjustment research under counseling psychology. For example, Witty et al. (2001) and Heppner et al. (2002) found problem-solving confidence is associated with a person's tendency to avoid problems; avoidance is connected to psychological distress. Dixon et al. (1991; 1994) and Priester and Clum (1993) found problem-solving confidence has the strongest association with hopelessness and suicidal ideation among the three problem-solving dimensions. Williams and Kleinfelter (1989) found that the lack of problem-solving confidence together with tendency to avoid problems is related to the use of alcohol to control negative emotions and escape problems among undergraduate students.

Other researchers, though not using the same items developed by Heppner, were interested in how confidence was related to their field of research. In sport psychology, Vealey (1986) defines sport confidence as the belief or degree of certainty individuals possess about their ability to be successful in sport. Sport confidence is important because the winning athlete had higher confidence in the competition and a stronger belief that victory is achievable (Vealey, 1986, 1988). In the domain of behavior and information technology, Sen and Boe (1991) believed that confidence is an important and widely used indicator of the quality of decision making although the ultimate value of a decision is often difficult to know at the time the decision is made. Since information systems are increasingly used to assist

decision making, Sen and Boe (1991) looked at whether confidence is a good indicator of decision-making accuracy of computer displayed information. They found confidence is a poor correlate for accuracy in decision making. Besides, they pointed out that underconfidence may be more desirable than overconfidence because the effects of underconfidence are less harmful. In the library and information science domain, Kim and Sin (2007) used the same constructs developed by Heppner to study undergraduate students' perception and selection of information sources. They found that problem-solving confidence has a significant impact on perception of sources. Low-confidence users tend to have a negative perception of information sources in general. Low-confidence users perceived web search engines as less efficient than the high-confidence users.

The term problem-solving confidence is often used interchangeably with self-efficacy. While acknowledging the comprehensiveness of the problem-solving inventory and its evidence on reliability and validity, Margaretha Lucas (2004) treated problem-solving confidence interchangeably with self-efficacy. In the world of positive psychology, several constructs share similar theoretical underpinnings i.e. hope, self-efficacy, optimism, and explanatory style (Lopez & Janowski, 2004). Julian Rotter (1978) maintained that problem-solving attitude was the expectancy that one can affect, in part, what happens to oneself. Heppner and Petersen (1982, p. 72) found that their problem-solving confidence and personal control are related to what the expectancy notion identified by Rotter. Lopez and Janowski (2004)

urged researchers to do. They advocated for incremental validity studies on problem-solving confidence and personal control versus other positive cognitive constructs such as self-efficacy (Bandura, 1977a).

In the CIS field confidence has been studied and measured in the way Bandura defined self-efficacy because when CIS people measured confidence, it was task or situation specific. But my study looked at confidence as a psychological trait and this has been defined by Heppner and explored by psychologists. I treated confidence and self-efficacy as different and therefore covered them separately above.

2.3 Information Processing in Problem Solving

My Research Questions 2 and 3 involved information processing in problem solving. People face problems and try to solve problems every day, whether personal problems or non-personal problems. This begs the question: When people face challenges or problems, how do they respond psychologically? Bandura's self-efficacy theory helps us answer this question. Problem or challenges are usually situation- or task-specific. How people solve problems may be affected by their psychological trait of confidence, a general belief about themselves and their abilities, that is developed based on countless real-world personal experiences. The next level of question is: what exactly do people do when dealing with problem solving? Psychologists have been focusing on this question of process for

a long time. Some researchers focused on an individual's past experience as the most important variable in problem solving (Gagne, 1964; Skinner, 1974). Some researchers postulated that it is the individual's perception of the situation that's the most important (Kohler, 1925; Maier, 1970). Instead of advancing the constructivists' ideas about the human mind, some investigators looked at how to develop a mechanical model of the human mind when solving problems. Herbert A. Simon and his colleagues, Allen Newell and J. C. Shaw, first presented the idea of modeling human cognition as information processing to psychologists in 1958.

In 1972, Newell and Simon published a book, Human Problem Solving, a seminal publication in the field of artificial intelligence (AI). They introduced a theoretical framework that describes problem solving as it takes place in an external task environment with its associated objective search space. When facing a task, a problem solver generates a problem space, an internal representation of the situation, which is his way of viewing the task environment. Newell and Simon's framework of problem-solving behavior involves three components: the human information-processing system, task environment, and problem space.

1. The *human information-processing system* operates almost entirely serially, due to the narrowness of its momentary focus of attention. The inputs and outputs of these processes are held in a short-term memory and are executed in tens or hundreds of milliseconds. The system has access to essentially unlimited

long-term memory but it takes seconds or tens of seconds to retrieve information residing in that memory.

2. Simon and Newell pointed out that the structure of the *task environment* constrains a problem-solver's behavior in several ways. First, it defines legitimate moves; second, it defines the goal and the direction toward the goal; third, it interacts with the limits on short-term memory to make some solution paths easier to find.
3. The *problem space* is the way a particular subject represents a task in order to work on it. In other words, every problem solver has his or her own problem space that represents the omniscient observer's view of the problem. How easily a problem-solver can solve the problem depends on how successful he or she is in representing the crucial features of the task in his/her problem space.

I used Newell and Simon's assumptions about problem space in my study: efficient information searchers can identify the critical keywords of the task and prioritize them.

I based Research Question 2 on Newell and Simon's 1972 book and framework of information processing and problem solving discussed above and further on Simon Herbert's (1978) conclusion that effective problem solving

involves extracting information about the structure of the task environment and using that information for highly selective heuristic searches for solutions. I believed that is true in Web searching. When people search for information on the Web, they have to generate their own problem space that represents the search task. The efficient searchers can generate a problem space which extracts the crucial structure of the task. In my study I gave subjects all seven keywords that cover the possible range of the task environment and tested my belief that an efficient searcher, through heuristics, could identify the critical keywords to generate his problem space. I had thought that inefficient searchers could not pick the crucial keywords. The key difference lay in their mental organization which was a function of their search experience.

2.4 Information Foraging

Information foraging is a concept based on the idea that information seekers are analogous to animals foraging for food. Information foragers are information predators searching for information prey (relevant documents). In the natural world, food tends to be scarce. We live, on the other hand, a world where information abounds. Since 1992 the number of Internet hosts has been doubling about every year (Pirolli & Card, 1999). The number of scientific journals has been growing by about a factor of ten every fifty years since the 18th century (Price, 1963). People's ability obviously cannot keep up with the rapid growth of information. As Herbert

A. Simon points out, information consumes the attention of its recipients (as quoted in Varian, 1995). The problem now is not providing people with access to more information but rather how people allocate their attention to access useful information (Pirolli & Card, 1999). The problem of attention poverty becomes worse when there is little time to access potentially useful information and there is too much of it (Edmunds & Morris, 2000). The problem that information seekers face becomes information overload (Savolainen, 2006). Traditionally, the topic of information searching has been one of the important areas in library research (Given, 2002; Halttunen, 2003; Heinström, 2005; Kari & Savolainen, 2007; Savolainen, 1995; Sonnenwald & Iivonen, 1999). But recently theories such as information foraging theory originated from computer science (Pirolli & Card, 1999) and the optimal foraging theory originated from behavioral ecology (Stephens & Krebs, 1986). These theories provide different perspectives to address the complex empirical phenomena arising in the library sciences (Sandstrom, 1994).

The concept of information foraging or information searching in library sciences perspective can be used in either physical (libraries) or the virtual environment of the World Wide Webs. The goal is the same—to find the information needed in an efficient way. Information foraging theory was drawn heavily from optimal foraging theory which tries to explain how organisms adapt and behave in an environment where they must forage for food (Pirolli & Card,

1999; Smith & Winterhalder, 1992; Stephens & Krebs, 1986). Pirolli and Card (1999) suggested that we can think of information seekers as information foragers using an analogy to an animal foraging for food. The higher the rate of information the information predator can achieve, the more efficient the predator is, thus more suitable to the environment. As animal uses its scent to search for food, the information forager uses information scent to search for information. The information scent is an (imperfect) perception of the value, cost, etc. of information sources. The information predator uses proximal cues such as Web links and bibliographic citations to obtain the information sources but uses the information scent to judge the value and cost of these information sources, for example, government websites versus blogs, prestigious journals versus conference papers or e-journals (Pirolli & Card, 1999). Conceptually, the essence of the optimal foraging theory is that the optimal forager finds the best solution to the problem of net energy returned per effort expended (Pirolli & Card, 1999; Stephens & Krebs, 1986).

Often we search for information that will help us make a decision. In the past, decision science researchers found that decision makers tend to behave as if effort minimization was an important consideration where information is located in a large pool (Todd & Benbasat, 1992, 1999). While scholars were trying to consider the tradeoff between improving decision quality and conserving effort, the world changed storage of information from centralized computer environments to

the Web. Alan Dennis and Nolan Taylor argue that the cost of searching information in traditional settings was relatively uniform, but the costs changed, i.e. became non-uniform with searching the Web (Dennis & Taylor, 2006). As the cost changes, information forage theory has become popular as an explanation of information search behavior. Information foragers work in a "patchy" structure: piles of documents, file drawers, or on-line collections. An information forager is an information predator searching for information prey (relevant documents): The higher the rate of information gain the information predator can achieve, the more efficient the predator is, thus more suitable to the environment. Foraging information involves opportunity cost by choosing to exploit one resource over another where information prey is unevenly distributed, the information carnivore's strength is limited, and time is limited (Sandstrom, 1994).

Two mutually exclusive activities happen during information foraging: between-patches activity (inter) and within-patch activity (intra). A patch can be static online collections such as Web sites or temporary hyperlinks collected by a Web search engine which responds to user's queries. *Between-patches* activity means the information forager modifies the environment to reduce the average cost of moving from one information patch to another. *Within-patch* activity means the information forager modifies the information patch so that it will yield a better return of valuable information.

How was information foraging theory related to this study? Information searchers on the Web behave like information foragers. They work in an environment where acquiring data located on another page costs more than acquiring data on the current page (Dennis & Taylor, 2006, p. 813). This cost exists both in between and within-patch activities. A query can be used for two purposes: for between-patches activity by reformulating a different query or as modifying the current information by refining a query for within-patch activity. There are two kinds of searchers: 1) searchers who use only one tab (or window) when searching: they are the searchers who don't do between-patches activity because they always work on one information patch at a time; and 2) searchers who always use multiple tabs (or windows) when searching; when they use multiple tabs they might be doing between-patches searching. If a searcher uses multiple tabs or windows, each based on a different query, and he goes back and forth between the multiple tabs (or windows), he is doing between-patches activity. However, if the tabs (or windows) were created by similar queries or derived from previous queries and he never goes back to a previous tab, he is probably doing within-patch activity, even though he uses multiple tabs.

The boundary may be subtle sometimes and there are various combinations of situations. Within a search task, a searcher may start from operating within-patch then move to between-patches, or move from between-patches to within-patch, or do within-patch most of the time and rarely between-patches, or vice versa. For

simplicity of explanation, let's look at one situation: When a searcher starts with a query to form an information patch, he has to decide whether this patch is good or whether to dig further or not. If the patch is not good, he can destroy the patch by starting over on the same tab. If the patch is good and he decides to dig in, he starts to do within-patch searching (Patch A). If the patch is good but he thinks of another idea, he can keep with Patch A and, as well, start a new patch on a new tab (Patch B) by issuing another query to the search engine. As he starts to browse between Patch A and Patch B, he starts to do between-patches activity. Note that at any time, he has a choice whether to keep doing within-patch or between-patches for as long as he wants (until a computer runs out of memory). A searcher keeps doing the process until he finds the answer he wants. Every query result involves opportunity costs as the searcher chooses to exploit one information patch over another. Where relevant documents are unevenly distributed, a searcher's focus and time is limited. Every click on a hyperlink involves additional costs in terms of time, uncertainty, and risk. When an information searcher is not efficient—in (re)formulating and refining queries (keywords) on information patches—he takes longer in foraging for information, and sometimes runs out of time or energy.

I had to take into consideration the theory of information foraging because it explains why non-efficient information searchers may be timed out or may give up. I was dependent on the efficiency of patch activities because I believed this is what most people do in everyday information searching. According to the concept

of problem space of the information-processing theory, an information searcher first extracts components of the external task environment—the search task; second, according to the "patch activities" of the information foraging theory, he/she keeps refining queries or reformulates queries and moves between tabs (or windows) so that a search engine returns lists with higher proportions of potentially relevant documents in which he/she can find the answer. According to Simon (1978), an effective problem solver must be decisive when extracting components of the external task environment and conducting selective heuristic searches for solutions. I believed, similarly, that an efficient searcher must be decisive in extracting keywords from the search task. An efficient information searcher knows his/her preferences with little ambiguity. On the contrary, an inefficient information searcher is indecisive about his/her selection of keywords.

2.5 Mental Organization

The concept of mental organization in Research Questions 2 and then 3 was informed by Shuqiang Zhang's findings on the semantic differentiation in the acquisition of English as a Second Language study which I mentioned in the introduction (Zhang, 1995). Zhang found that native speakers of English share tacit understanding of intensifiers and quantifiers whereas non-native speakers have trouble differentiating those words. This is my Research Question 2: Do efficient searchers share the same mental organization of keyword importance as slow

searchers? I further hypothesized my third research question: Are successively higher levels of search performance characterized by increasingly consistent mental organizations of keyword importance?

It is important not to confuse mental organization with the term "mental model." Mental model is a term used in the research field of Human-Computer Interface (HCI) under Computer Science. The term is similar to but different from how I used "mental organization." Carroll and Olson (1988) define mental model as the mental representation that reflects the user's understanding of the system. Mental model is an important concept for system designers because it captures the way users understand or misunderstand the devices they design (Carroll, 2003). A good example of mental model research in HCI is Cockburn and Jones' (1996) study about users' models of the navigation facilities provided by Web browsers. The history list of visited pages in Internet browsers is implemented as a stack in which elements can be added or taken out only from the top. For this reason the "history list" in a browser does not represent users' mental model of history in which a complete record or time-line of visited pages is stored and can be retrieved forward or backward sequentially. When a user's mental model of a device is different from that of the designers, the device is not used efficiently. The interest in mental models in HCI is based on the idea that it is possible to design systems that support the acquisition of appropriate mental models and avoidance of performance errors (van der Veer & Puerta Melguizo, 2003).

Though the term “mental organization” sounds similar to the term “mental model,” they are different concepts. In HCI, mental model is a concept that designers explore and use to foster proficiency on a specific system they design. In contrast, mental organization in my study was not used for something I designed to foster users’ proficiency. I used mental organization to refer to how people organize the relative importance of keywords in Web searching. There are billions of search queries today on the Internet and each can be as unique. The mental organization of keyword importance can be understood as schema people come up with when facing searching tasks. The two terms are different in the way they are used. In HCI, system designers want to know people’s common understanding (mental model) of the device they design so that designers can design a device that captures most people’s intuition of the device and thus foster proficient use. In my study, I looked for individual’s mental organization of keyword importance so that I could capture different people’s ways of understanding the relative importance of keywords and to associate these ways with different levels of proficiency in information searching.

Though my mental organization was defined differently from the mental model defined by Carroll and Olson, my study relied on the initial-representation principle of mental model: people commence the interpretation process by constructing a minimal initial representation (Schroyens & Braem, 2011). Because humans have limited processing resources and a small working memory (or short-

term memory as defined by Newell and Simon (1972)), we cannot consider all possibilities at the beginning. However, it is crucial for people to actively engage in problem finding and formulating. That is, explicit problem analysis increases the quality of problem-solutions (Dorst & Cross, 2001). According to the finding of Zeng et al. (2011), those who actively and explicitly engaging in problem finding and formulating enhance the creativity of design solutions, compared with implicit, unstructured problem analysis where people directly begin problem solving.

Based on the initial-representation principle of mental models and the finding of Zeng et al. (2011), I asked participants to rank order seven sets of keywords—one set at a time—giving each set a ranking of between “1” and “3” based on how important they thought each of the three keywords in a set was to finding the correct answer (see Chapter 3); I did not ask them to rank all seven keywords at one time.

Chapter 3: Research Design

This study involved three research questions: 1) how do self-efficacy, problem-solving confidence, and search skill affect timely successful Web search?; 2) do efficient searchers share the same mental organization of keyword importance as slow searchers?; and 3) are successively higher levels of search performance characterized by increasingly consistent mental organizations of keyword importance? The first research question aimed to find out which of the three seemingly correlated factors (self-efficacy, problem-solving confidence, and search skill) had the most important effect on timely successful Web searches. The first research question involved three hypotheses (Hypotheses 1, 2, and 3) tested through survival analysis. The second and third research questions had to do with mental organization of keyword importance with Hypotheses 4 and 5 tested with the statistical program TRICIR (for circular triads), ANOVA (Analysis of Variance), and Kendall's coefficient of concordance.

3.1 Research Question 1

Research Question 1 is "How do self-efficacy, problem-solving confidence, and search skill affect timely successful Web searching?" This was an observational study about Web searching. It involved coordination between questionnaires and data collected from internet monitoring and surveillance

software. The research question was answered by observing subjects as they searched, and through questionnaires. I used the statistical method, survival analysis, to answer the research question. There was no treatment or control on how the participants interacted with the Web to find the answer to the task. All the participants used the same computer with the Internet Monitoring and Surveillance software Spector Pro installed. It was used to collect the variables: time and queries. There were several reasons why Spector Pro was chosen for data collection. First, it recorded the time to the second, while many other internet monitoring and surveillance software only record to the minute. Given the time limit of the task in the study and the nature of quantitative research, a time measurement unit specific to the second is more accurate. Second, Spector Pro recorded and could separate every web search query, either pure key strokes or easy-to-understand English words. This saved time in sorting through the data. Third, it provided a stealth mode for data collection which would not affect the participants' searches, though participants were notified before the study began that the monitor software was in place.

3.1.1 Hypotheses of Question 1

Hypothesis 1: According to Bandura's self-efficacy theory, I hypothesize that with considering search skill, and psychological confidence trait

included in the survival analysis, self-efficacy will be positively associated with timely successful Web search.

Hypothesis 2: Based on my literature review, the psychological confidence trait is a general appraisal of oneself, without reference to any particular problem or situation. I hypothesize that confidence will not be either positively or negatively associated with timely successful web search.

Hypothesis 3: Search skill will be positively associated with timely successful web search.

3.1.2 Sample

The sample consisted of 86 volunteer participants from various educational and occupational backgrounds in Hawaii. A snowballing method was used to locate participants in the study (this was changed, see Section 3.4). Snowballing involves approaching participants known to the researcher. These participants are then requested to suggest anyone suitable for this study. I specified that the proposed subjects should be able to search the Web. To minimize a possible confounding factor (i.e. the subject matter of this specific search task), the data excluded people who are from Taiwan and those who may read or speak Taiwanese or Mandarin.

This allowed me to minimize a potential bias in favor of participants who already know the answer to the task in the study.

3.1.3 Task

To simulate an everyday Web information search task, the task should be somewhat interesting to the searchers. The confounding factor can be minimized as much as possible. Edward Sapir, a well-known linguistic scholar, pointed out that the chronology of the dispersal of languages within a given language family can be traced from the greatest linguistic variety to that of the least (Sapir, 1968). Sapir's statement is generally accepted by linguistic scholars. Blust (1999) found the deepest divisions of Austronesian languages existed among the native Taiwanese aboriginals and suggested that the home of the Austronesian languages is the main island of Taiwan, also known as Formosa. Comrie (2001) noted that the internal diversity among the Taiwanese aboriginals is greater than that in all the rest of Austronesians put together and suggested that Formosan languages may well consist of several primary branches of the overall Austronesian family. The search task which was related to Taiwanese aboriginals and Austronesians was chosen because it is a topic most people in Hawaii are not familiar with, yet it should have been of interest to them because the background of the task is related to Hawaii which is part of Austronesia. I believed that some participants might not work as hard simply because they were not interested in the search task—this initial bias

could not be excluded. But it could be minimized by the choice of a topic of possible interest to local participants.

Task background statement: *"Members of the Austronesian race live in a vast area, roughly half the globe, extending from Madagascar in the west to Hawaii and Easter Island in the east, and from New Zealand in the south to Taiwan in the north. Austronesians are one of the indigenous or aboriginal people in the area which consists of many countries. The populations in these countries are diversified now. Some linguistic scholars suggest that Taiwan is the original homeland of all Austronesians, because the internal diversity among the Taiwanese native peoples' languages is greater than that of all the rest of Austronesia put together."*

Searching task: *Assume you are assigned to do homework by a professor. The homework question is "How did Taiwan's native (aboriginal) people communicate in writing from roughly 200 to 400 years ago?"*

3.1.4 Procedures

The participants were scheduled to participate in the study at their convenience. The participants met one-to-one with me on the designated day and filled out the confidence questionnaire (Appendix A) and search skill questionnaire (Appendix B). Participants then read the instructions of the study (Appendix C) and the description of the information seeking task (Appendix D). The task, as already

mentioned, was to search the Web in order to answer the question "How did Taiwan's native (aboriginal) people communicate in writing from roughly 200 to 400 years ago?" After the participant clearly understood the task and before he/she began the search, he/she filled out a questionnaire that measured his/her pre-task self-efficacy (Appendix E). Then the participants were allowed thirty minutes to find the answer on the Internet. During the task the internet monitoring and surveillance software recorded the data (time, queries, hyperlinks, keystrokes, etc.) needed for the study. After the task was done, the participants were given a questionnaire to measure their post-task self-efficacy. There were two forms of this questionnaire. If a participant finished the task in thirty minutes, the form in Appendix F was used. If a participant ran out of time, the form in Appendix G was used. Finally, a background questionnaire (Appendix H) was given to all participants, whether or not they had completed the task.

3.1.5 Instruments

This study involved three independent variables: confidence, self-efficacy, and search skill. Confidence was defined as self-assurance while engaging in problem-solving activities in general. It was measured by the confidence construct from the problem-solving inventory developed by Heppner (1988). The confidence construct consisted of eleven items measured on a six-point Likert scale. The possible range of confidence score was between 11 and 66 points (see Appendix

A). The second variable “self-efficacy” was defined as people’s judgments of their capability in executing actions necessary for specific designated types of performance (in this case, Web searching, i.e. finding the correct answer on the Internet). Self-efficacy was measured by a questionnaire of four items with a seven-point Likert scale that I developed. The self-efficacy scores could range from 4 to 28 points, because there were four items in this construct with “1” as the lowest possible rating and “7” as the highest possible rating a subject could self-report. (see Items 1, 3, 4 and 5 in Appendix E). The last variable, “search skill,” was a measurement of general search skill on the Web. It was arrived at by the subject completing a questionnaire that I developed consisting of five multiple choice items with five multiple choices on each question (see Appendix B). The reliability (Cronbach’s alpha) of the above independent variables was reported. The dependent variable was time-to-event. The event was defined as finding the correct answer within 30 minutes. The dependent variable consisted of two measurements: time and status. “Time” measured how much time, in seconds, a participant spent on the information seeking task. “Status” measured if participants found the correct answer or not, with “1” meaning the answer was correct, and “0” meaning either the answer was wrong or a participant gave up before time was up.

3.1.6 Data Analysis

This study used survival analysis (Allison, 1995). Survival analysis is a branch of statistics which involves the modeling of time-to-event data. Survival analysis attempts to answer questions such as “How do particular circumstances or characteristics increase or decrease the hazard ratio?” To answer such question, a well-defined event performed at a specific time is required. The best observation plan for survival analysis is prospective (direct observation data collected in a specific, concurrent time frame) instead of retrospective data collection in which people are asked to recall the dates of past events. Direct observation is preferred because there are two potential weaknesses of retrospective data: a) people may make substantial errors in recalling the times of events, and b) people respond in a biased fashion because they are embarrassed or put at risk, as when people are asked to recall their first sex, drug, or criminal experience (Allison, 1995). Survival analysis in this study was useful when time and status were used to compute the likelihood of an event happening or not (see Appendix J for an example using survival analysis).

I used survival analysis to test my proposed causal model in which being able to find the correct answer in thirty minutes depended on covariates (confidence, self-efficacy, and search skill). In my study, the participant who could not find the correct answer in the given time limit was considered censored,

whereas the event of interest was defined as finding the correct answer in the given time.

One of the most popular models for evaluating effects of predictors on survival is the Cox proportional hazards model. The hazard is a dimensional quantity that has the form of number of events per interval of time (Allison, 1995). The hazard at any point t corresponds to an intuitive notion of the risk of the event occurrence at time t. Therefore, to interpret hazard, you must know the units in which the time is measured. Using Cox proportional hazards regression gives you the log hazard function in terms of predictors in the formula below.

$$\ln h(t) = b_0 + b_1 x_1 + b_2 x_2$$

Exponentiation of the b_1 and b_2 gives you the hazard ratios for predictors x_1 and x_2.

If there are not interactions, the three hypotheses of the study (which will be tested without interaction in the model) will be validated. Interactions would indicate that the three main effects alone are not adequate to explain the model. In other words, to validate the three hypotheses, I checked the four interactions (three two-way interactions and one three-way interaction). If some of them turned out to be significant, I would keep them in the model and my hypotheses would be partly validated.

I used the PHREG procedure in SAS to analyze the data and test the above hypotheses. I used the option of ties equals to exact to deal with possible ties in the data. When two or more observations have the same exact event time, we call them

a “tie” in survival analysis. SAS provides several options in dealing with ties: breslow, efron, discrete, and exact. The “exact” option was used because it assumes that there is an unknown ordering for the tied event times which meets the assumption of this study. With ties= exact, the partial likelihood estimating method uses all possible orderings. For example, if there are three events occurring at the same point of time, there are 3! possible orderings ((1,2,3), (1,3,2), (2,1,3), (2, 3, 1), (3, 1, 2), (3, 2, 1)). The estimation method integrates information from the six possibilities. The “exact” option, though using the most computing time, provided the more accurate estimates in Cox proportional hazards regression when using SAS PHREG procedure.

3.2 Research Question 2

Research Question 2 is “Do efficient searchers share the same mental organization of keyword importance as slow searchers?” Research Questions 2 and 3 used the same sample and task as Research Question 1, however, the procedure, instrument, and data analysis of these two questions were different from that of Research Question 1.

3.2.1 Hypothesis of Question 2

Hypothesis 4: There is significant difference in mental organization of keyword importance among three levels of search performance.

3.2.2 Sample

Same as Question 1 except that the sample consisted of 88 volunteer participants.

3.2.3 Task

Same as Question 1.

3.2.4 Procedures

The participants were scheduled to participate in the study at their convenience. Participants then read the instructions of the study (Appendix C) and the description of the information seeking task (Appendix D). After the participant clearly understood the task and before he/she began the search, a questionnaire (Appendix I) was used to collect the searcher's mental organization of keyword importance. The participants were allowed thirty minutes to find the answer on the Internet. During the task the internet monitoring and surveillance software recorded the data (time, queries, hyperlinks, keystrokes, etc.) needed for the study. Finally, a background questionnaire (Appendix H) was given to all participants, whether or not they had completed the task.

3.2.5 Instruments

The information searcher's mental organization of keyword importance was obtained by asking participants to make pair-wise comparisons among the seven keywords in the task of this study: "How did Taiwan's native (aboriginal) people communicate in writing from roughly 200 to 400 years ago?" With adverbs and prepositions excluded, there were six terms that might be used by information searchers. Since the most important term in the background information of the task was the word "Austronesian," it was added to the six keywords, making a total of seven keywords that searchers may use during the task. Some people might not be able to come up with the seven keywords, but for measurement purposes it was necessary to give every participant the same information. I believed that people might not be able to discern the importance of the keywords they did not think of especially when they were asked to compare them three at a time for seven times, see below.

Instead of using 21 pair-wise comparisons of the seven keywords, the Youden Square of Balanced Incomplete Blocks was used to rank order three keywords at a time and collapse the comparisons to seven. The participants were asked to compare three keywords at a time and did it seven times, as shown below (see Appendix I for details).

Austronesian	How	Aboriginals
How	Taiwan	Communicate
Taiwan	Aboriginals	Writing
Aboriginals	Communicate	200 to 400 years ago
Communicate	Writing	Austronesian
Writing	200 to 400 years ago	How
200 to 400 years ago	Austronesian	Taiwan

3.2.6 Data analysis

After participants finished the comparisons above, the statistical program TRICIR (Dunn-Rankin, Knezek, Wallace, & Zhang, 2004) (for circular triads) was used to detect the inconsistencies of the information searchers' mental concepts of keyword importance. The more inconsistencies the searcher had on keyword importance, the less sure the searcher was about the keywords' importance in

finding the answer. He/she might change keyword queries randomly, thus it took longer time to finish the task. The mental organization of keyword importance was measured by the number of circular triads. The maximum number of circular triads of each judge is 14 ($\frac{k^3-k}{24}=\frac{7^3-7}{24}=\frac{343-7}{24}$) when there is odd number of k objects (in this example, k= 7 keywords), while the minimum is 0 (no confusion). I used ANOVA (Analysis of Variance) to determine the relationship between within-person consistency and three levels of search performance (efficient, slow and timed-out information searchers).

3.3 Research Question 3

Research Question 3 is "Are successively higher levels of search performance characterized by increasingly consistent mental organizations of keyword importance?"

3.3.1 Hypothesis of Question 3

Hypothesis 5: Successively higher levels of search performance (from timed-out to slow to efficient) are characterized by increasing stronger mental organization of keyword importance?

3.3.2 Sample

Same as Question 2.

3.3.3 Task

Same as Question 1 and 2.

3.3.4 Procedures

Same as Question 2.

3.3.5 Instruments

Same as Question 2.

3.3.6 Data analysis

I believed efficient searchers share unspoken understanding of keyword importance to the extent that they prioritized the keywords in more or less the same way. I calculated Kendall's coefficient of concordance to show the varying strength of consensus at different levels of search performance.

3.4 Changes Since the Proposal

To recapitulate, I had three research questions and five hypotheses tested. The first three hypotheses were subjected to survival analysis. The other two hypotheses were tested by TRICIR, ANOVA, and Kendall's concordance. Data was collected through observations and questions. Above was how I proposed my

study in April, 2010; however, two changes were made since the proposal defense. First, because of the limited resources in hardware and software, and limited time to finish the study, I changed the data collection method from recruiting by means of snowballing to recruiting subjects with motivational rewards. Second, to make the three research questions—from two separate but related studies using the same search task—comparable and coherent in this dissertation, I chose a performance measurement as the dependent variable throughout the study: a dichotomous variable, whether a subject found the correct answer or not. Thus, instead of three levels of performance in Hypotheses 4 and 5, the dependent variable was changed to a two-level (dichotomous) variable (see Section 4.5 and 4.6).

Chapter 4: Analyses and Results

This chapter presents the results and analyses performed for the study. First, the participants and the data collection processes are detailed. Next, the results of Research Question 1 are dealt with in two sections. Section 4.3 discusses the original Research Question 1 which treats Search Skill as a construct. Section 4.4 presents the modified Research Question 1 which treats advanced analysis of search skill based on observation. Finally, analyses for Research Questions 2 and 3 are covered by Sections 4.5 and 4.6 respectively.

4.1 Participants of Questions 1, 2, and 3

The voluntary participants of the study were selected from two sources: 1) the researcher's acquaintances, 2) six classes of undergraduate and graduate students enrolled in the University of Hawaii at Manoa. Participants were given either a gift card or extra credits. A total of 196 participants took part in the study in the period of August to December 2010. Ninety-five people participated in Research Question 1. One hundred-and-one people participated in Research Questions 2 and 3. However, the valid sample size for Research Question 1 is 86 because eight participants did not answer the correct version of the questionnaire and one participant did not understand the search task. The valid sample size for Research Questions 2 and 3 is 88 because the first twelve participants answered the

wrong versions of the questionnaires and one participant experienced computer failure during the search task.

4.2 Data Collection

Participants were scheduled one person at a time, worked in the researcher's office, and each was given about one hour to participate in the study. The voluntary participants met two basic requirements: 1) ability to use Google as a search engine, and 2) comfort with the Windows Vista operating system and Internet Explorer 8 as the browser. After reading the instructions and signing the Human Subject Research consent form, participants first answered the questionnaires, then worked on the search task on the Internet for up to 30 minutes, and finally answered the questionnaire that provided demographics. Every participant was told to add the website onto the "My Answer" folder under My Favorites if he or she thought the website had the correct answer. The whole study was conducted on Morae 3.2 with Morae Recorder running on the participant's computer and Morae Observer running on the researcher's computer. The researcher used Morae Observer to control the process of the study, tag and log particular behaviors of participants that interested the researcher, and send the pre-defined questionnaires to the Morae Recorder which the participants worked on. Every computer operation, search behavior, keystroke, etc. on the participant's computer was recorded by the Morae Recorder. In addition, a spyware Spector Pro was running

on stealth mode to collect users' search queries. At the end of the study the researcher reminded each participant not to reveal the search task to others and not to continue working on the search task on his own computers—this was important as a means of ensuring the consistency, fairness, and accuracy of the study. After a participant finished the study the computer he/she worked on was immediately reset to erase the answer website, helpful websites, temporary Internet files, history, cookies, recently typed URLs, Index.dat files, etc. and thus to ensure that the next participant's performance was not affected by the previous participants' performance. After the study Morae Manager was used to collect information recorded by both the Morae Recorder and Observer.

4.3 Research Question 1: Constructs Based on Questionnaires

A valid dataset of 86 people is included in the analysis of Research Question one. Among the 86 participants 49 were females and 37 were males. Three constructs are assumed in order to answer the research question: "How do self-efficacy, problem-solving confidence, and search skill affect timely successful Web searching?" The Self-Efficacy construct consists of four items. The Problem-Solving Confidence construct consists of 11 items. The Search Skill construct has 16 items, but six of them were deleted because they were found to be inappropriate. The remaining ten items in the Search Skill construct ask "how frequent"-questions about the use of the functions in Google's Advanced Search and the advanced

search behavior that helps accelerate Web search. Section 4.3.2 shows how the two factors represent the Search Skill after factor analysis; four constructs are needed to answer the research question instead of three constructs. The dependent variable is the product of two variables: 1) time spent on searching the answer on the Web and 2) performance of the web-information search.

4.3.1 Demographic Data of Question 1

Of the 86 participants whose data were used in the analysis for Research Question 1, 57% were female and 43% male. Additional demographic variables of highest educational degree obtained, current status, and academic major were obtained. More than half of the participants had at least a high school diploma (53.5%), about 29% of respondents had obtained a college degree, and 15% of them had a graduate degree. The majority of the participants were students (87.2%). The participants come from a diverse academic background across 34 majors. The communication majors (19.8%) and the computer science majors (18.6%) were the two biggest populations. Table 4.1 shows the frequency on academic majors of participants.

Table 4.1 Academic Major of Participants in Research Question 1

Academic Major of Participants in Research Question 1					
Academic Major	**Frequency**	**Percent**	**Academic Major**	**Frequency**	**Percent**
Astrophysics	1	1.2	Human Resource Management	1	1.2
Biology	2	2.3	Japanese	1	1.2
Book keeping	1	1.2	Korean	1	1.2
Business	2	2.3	Labor-art	1	1.2
Chemistry	2	2.3	Library & Information Science	5	5.8
Civil Engineering	3	3.5	Mechanical Engineering	1	1.2
Communication	17	19.8	Music	1	1.2
Communication & Information Sciences	2	2.3	Natural Resource & Environmental Management	1	1.2
Computer Science	16	18.6	Nursing and Public Health	1	1.2
Creative Media	1	1.2	Physical Education	1	1.2
East Asian Languages and Civilizations	1	1.2	Pre-Communication	1	1.2
Economics	1	1.2	Pre-Education	1	1.2
Educational Psychology	3	3.5	Pre-nursing	1	1.2
Electronic engineering	1	1.2	Psychology	2	2.3
English	2	2.3	Social work	2	2.3
Family Resources	1	1.2	ESL	2	2.3
Geography	1	1.2	Undecided	4	4.7
History	2	2.3	Total	86	100.0

4.3.2 Factor Analysis of Search Skill

Factor analysis was used to examine the discriminate validity of the scales to ensure that the measures of different concepts are distinct. Each factor is a combination of variables whose shared correlations explain a significant amount of

the total variance. Of the three constructs in Research Question 1 only the Search Skill construct needed to be validated by factor analysis because Self-Efficacy and Confidence constructs are theory-driven one-dimensional constructs. The Search Skill consists of 10 “how often” questionnaire items. The 10 items fall into two areas: one is the functions in Google’s Advanced Search, and the other is not. Five of the 10 items asked how often people used the functions in Google’s Advanced Search webpage. The other five questions that are not related to Google asked other advanced search skills that help accelerate the search speed. Thus, a two-factor analysis was selected in factor analysis. There is reason to believe that people who use the functions in Google’s Advanced Search tend to use other advanced skills to help their Web search. The possible two factors identified may be correlated. Thus the oblique rotation, Promax, in factor analysis was used because oblique rotation derives factor loadings based on the assumption that the factors are correlated. The other rotation method, Varimax, assumes factors are not correlated with each other, which is not applicable in this case. Oblique rotation in factor analysis produces two important matrices: a factor structure matrix and a rotated factor pattern matrix (Tabachnick & Fidell, 2007). A factor structure matrix presents the correlations between factors and variables after rotation while a rotated factor pattern matrix indicates the uncontaminated (before rotation) relationship between each factor and variable. About 40% of the variance is explained by the two factors. The inter-factors correlation is low, 0.08, which shows the two factors are minimally

correlated. Here I report two matrices, the Rotated Factor Pattern and the Factor Structure, because the correlation matrix can be reproduced by multiplying the structure matrix (Factor Structure) with the transposition of the pattern matrix (Rotated Factor Pattern). Table 4.2 shows the Rotated Factor Pattern. Table 4.3 presents the Factor Structure. The items that are not related to the functions in Google's Advanced Search ask about people's use of advanced skill and short-cut keys that help accelerate the search, thus they are named Advanced Search Behavior. The Search Skill construct is further divided by two factors: Google's Advanced Search (GAS) and Advanced Search Behavior (ASB).

Table 4.2 Rotated Factor Pattern

Rotated Factor Pattern (Standardized Regression Coefficients)		
	Factor 1	**Factor 2**
ASB2	0.80	0.08
ASB4	0.72	-0.05
ASB5	0.48	-0.04
ASB6	0.46	-0.00
ASB7	0.66	0.02
GAS12	0.17	0.69
GAS13	-0.04	0.74
GAS14	-0.04	0.49
GAS15	0.14	0.38
GAS16	-0.17	0.70

Note. Principal Component Analysis with Promax Rotation, 2 factors selected.

Table 4.3 Factor Structure

Factor Structure (Correlations)		
Item	**Factor 1**	**Factor 2**
ASB2	0.81	0.14
ASB4	0.71	0.01
ASB5	0.48	-0.00
ASB6	0.46	0.04
ASB7	0.66	0.08
GAS12	0.23	0.70
GAS13	0.02	0.73
GAS14	0.00	0.49
GAS15	0.17	0.39
GAS16	-0.11	0.68

Note. Principal Component Analysis with Promax Rotation, 2 factors selected.

4.3.3 Independent Variables: Constructs

Search Skill is further divided into two factors: Google's Advanced Search (GAS) and Advanced Search Behavior (ASB) as discussed in the last section. Four constructs are used as the predictors. The Confidence construct was borrowed from the Confidence factor, one of the three factors in the Heppner's Problem Solving Inventory (PSI). Confidence is general self-assurance while engaging in problem-solving activities. Self-efficacy is a situation-specific judgment of expected performance levels. GAS is the measurement of use of the functions in Google's Advanced Search (five items). ASB is the measurement of search behavior using advanced skills and short-cut keys (five items). Table 4.4 shows the means, medians, and the standard deviations of the four constructs.

Table 4.4 Means, Medians, and Standard Deviations of Subjects for the Four Key Constructs

Means, Medians, and Standard Deviations of Subjects for Four Key Constructs			
	Mean	**Median**	**Standard Deviation**
Confidence	50.73	51.00	6.95
Self-Efficacy	19.30	20.00	4.36
GAS	1.01	0.75	0.76
ASB	1.97	1.75	1.04

Table 4.4 shows the Confidence construct has the biggest standard deviation indicating there is much dispersion from the mean. That is, respondents' answers in Confidence construct varied a lot. Compared to Confidence and Self-Efficacy constructs, the answers in GAS and ASB constructs varied very little.

4.3.3.1 Confidence (CON)

Confidence is an eleven-item-construct measured on a six-point Likert scale. It is extracted from Heppner's Problem-Solving Inventory (PSI) (1988). To make the interpretation easier to understand and correspond to most people's perception of numbers, my confidence measurement uses a smaller number in the scale to represent lower confidence and a bigger number to represent higher confidence, as opposed to denoting lower confidence with bigger numbers and higher confidence with smaller numbers in the original confidence construct of Heppner's PSI. Table 4.5 shows the eleven items that consist of the Confidence

construct. Basic descriptive statistics of each item – means, medians, and standard deviations—are listed.

Table 4.5 Means, Medians, and Standard Deviations of Subjects for the Confidence Construct

Means, Medians, and Standard Deviations of Subjects for the Confidence Construct			
Item	**Mean**	**Median**	**Std Dev**
CON1	4.49	5.00	1.10
CON2	4.42	5.00	0.99
CON3	4.50	5.00	1.06
CON4	4.76	5.00	0.92
CON5	4.57	5.00	1.10
CON6	5.19	5.00	0.90
CON7	4.57	5.00	0.91
CON8	4.59	5.00	1.04
CON9	4.26	5.00	0.86
CON10	4.22	5.00	1.26
CON11	5.17	5.00	1.06

CON10 has the lowest mean [4.22 out of 6] but biggest standard deviation among the 11 items. This item asks the question "When confronted with a problem, I am unsure of whether I can handle situation." It is a reverse coding question. The low mean implies that some respondents had relative low evaluations on CON10.

4.3.3.2 Self-Efficacy (SE)

Self-Efficacy is a self-developed four-item construct measured on a seven-point Likert scale. As opposed to the Confidence construct which does not include a neutral scale, Self-Efficacy includes a neutral scale number 4, with scale number

1 and 7 as the two extreme anchor points. The higher on the scale, the higher the degree of Self-Efficacy. Table 4.6 shows the four items that compose the Self-Efficacy construct. Basic descriptive statistics of each item— means, medians, and standard deviations—are listed.

Table 4.6 Means, Medians, and Standard Deviations of Subjects for the Self-Efficacy Construct

Means, Medians, and Standard Deviations of Subjects for Self-Efficacy Construct			
Item	**Mean**	**Median**	**Std Dev**
SE1	4.66	5.00	1.39
SE3	5.00	5.00	1.24
SE4	4.85	5.00	1.49
SE5	4.79	5.00	1.35

The SE1 has the lowest mean [4.66 out of 7] among the four items. It asks the question "How confident do you think you are that you can find the answer in 30 minutes?" Compared to the other three items, the SE4 has the biggest standard deviation indicating most variation in the answers. SE4 asks "How likely do you think it is that you can NOT find the answer in 30 minutes?" It is a reverse coding question.

4.3.3.3 Google's Advanced Search (GAS)

The functions in Google's Advanced Search (GAS) construct borrows the advanced search functions provided by Google as the question items. It consists of

five items measured by a five-point Likert scale. The participants answered these items by choosing one of the following frequency terms: never, occasionally, sometimes, often, and always. The answers were then coded as 0, 0.25, 0.5, 0.75 and 1, respectively. Table 4.7 shows the five GAS items. Basic descriptive statistics of each item—means, medians, and standard deviations— are listed.

Table 4.7 Means, Medians, and Standard Deviations of Subjects for the Google's Advanced Search Construct

Means, Medians, and Standard Deviations of Subjects for the GAS Construct			
Variable	**Mean**	**Median**	**Std Dev**
GAS12	0.26	0.25	0.23
GAS13	0.15	0.00	0.23
GAS14	0.31	0.25	0.32
GAS15	0.06	0.00	0.14
GAS16	0.23	0.00	0.30

GAS 13, GAS15, and GAS 16 have value 0 on the 50th percentile, the median score, indicating at least half of the respondents never use these the functions in Google's Advanced Search. GAS 13 asks how often the OR Boolean function is used while GAS15 asks how often the NOT function is used. GAS 16 asks how often the language selection function is used. Of the five items, GAS14 has the most variation in answers among the five items. GAS14 asks "When you use Google or other search engines, do you use the "phrase search" which tells the search engine to search the exact words you type in that exact order without any change?"

4.3.3.4 Advanced Search Behavior (ASB)

Advanced Search Behavior (ASB) is a five-item construct. It asks how frequently people use the advanced skills and short-cut keys when searching information on the Web. In the same way as the items that ask people's frequent use of the functions in Google's Advanced Search above, the participants answered these items by choosing one of the following frequency terms: never, occasionally, sometimes, often, and always. The answers were then coded as 0, 0.25, 0.5, 0.75 and 1, respectively. Table 4.8 shows the five items that make up ASB. Basic descriptive statistics of each item—means, medians, and standard deviations—are listed.

Table 4.8 Means, Medians, and Standard Deviations of Subjects for the Advanced Search Behavior Construct

Mean, Medians, and Standard Deviations of Subjects for ASB Construct			
Item	**Mean**	**Median**	**Std Dev**
ASB2	0.31	0.13	0.36
ASB4	0.22	0.00	0.36
ASB5	0.48	0.50	0.32
ASB6	0.19	0.00	0.23
ASB7	0.78	1.00	0.34

ASB6 has the lowest mean, median, and standard deviation values indicating most respondents rarely use this feature. ASB6 asks "When you search the Internet, do you use the "cached" function provided by search engines?" Of the

five items, ASB2 asks “How often do you use “Ctrl+F?” which has the most variation in answers [ASB2 Std Dev= 0.3590724; ASB4 Std Dev= 0.3552061].

4.3.4 Reliability of Constructs

This section reports the Cronbach’s alpha results for the constructs used in the study. Cronbach’s alpha measures the internal consistency of the scales used to measure these constructs. The two psychological constructs Confidence and Self-Efficacy have relatively high reliability. However, the constructs of Google’s Advanced Search (GAS) and Advanced Search Behavior (ASB) have relatively low reliability. I suspect that it may be natural for the construct asking about “skills” (in this case the GAS and ASB) to have lower internal reliability than the psychological constructs. Psychological constructs ask people’s opinions or feelings. I argue that people almost always have some feelings or opinions about something even if they have never actually experienced it. Thus, the reliability of a psychological construct tends to be high if the right questions are asked. The “skills” construct asks about people’s use of certain specific skills. I believe that most people pick and choose some set of the skills they like and never use the rest. Different people use different sets of skills, thus the reliability of the “skill” construct tends to be low even if the right questions are asked. Table 4.9 shows the reliability of the four constructs.

Table 4.9 Reliability of the Four Constructs in Research Question 1

Reliability of the Four Constructs	
Construct	**Cronbach's Alpha**
Confidence (11 items)	0.84
Self-Efficacy (4 items)	0.81
GAS (5 items)	0.56
ASB (5 items)	0.64

The Confidence and Self-Efficacy constructs have very good reliabilities. The GAS and ASB constructs have unacceptable and undesirable reliability, respectively, according to Devellis's (2003) suggestion that reliability between 0.60 and 0.65 is undesirable, and below 0.60 is unacceptable.

4.3.5 Dependent Variable: "1" or "0"

The dependent variable of Research Question 1 is "1" or "0." Participants can be divided into three groups based on performance in the study: those who found the correct answer, those who found the wrong answer, and those who got timed out because they couldn't find an answer in 30 minutes. No participants quit in this study. Of the 86 participants for Research Question 1, 24 of them found the correct answer, 40 found the wrong answer, and 22 could not find an answer within the time limit. For the purposes of survival analysis the three performance groups are coded with "1" or "0." The research question asks the participant to demonstrate their ability to do a timely successful Web search. Participants who found the correct answer within 30 minutes will be coded "1" while the rest of the participants will be coded "0." In this research question, 24 participants' status was

coded as “1”; 66 people’s status was coded as “0.” There are two types of time, the time of the event (finding the correct answer within the time limit) and the time of the censored event that did not happen. The time of the event is used in survival analysis to calculate the hazard (potential) of the event happening. The censoring times are considered in the calculation but ignored as a dependent variable.

4.3.6 Results of Hypotheses 1, 2, and 3 for Research Question 1 When Treating Search Skill as Two Constructs

The Research Question 1 asks: “How do self-efficacy, problem-solving confidence, and search skill affect timely successful Web searching?” The question asks three things that may affect a person’s timely successful Web search. However, the “three things” in the question should be treated as four constructs because “Search Skill” should be treated as 2 factors (constructs) [refer to Section 4.3.2]. So Research Question 1 was rephrased: “How do self-efficacy, problem-solving confidence, Google’s advanced search, and advanced search behavior affect timely successful Web searching?” The rephrased research question lead to revisions in Hypothesis 1 and Hypothesis 3. Hypothesis 1 became: “According to Bandura’s self-efficacy theory, I hypothesize that with considering the functions in Google’s Advanced Search, advanced search behavior and psychological confidence in the survival analysis, self-efficacy will be positively associated with timely successful Web search.” Hypothesis 3 is replaced by two different

hypotheses, Hypothesis 3A and Hypothesis 3B. Hypothesis 3A: "The functions in Google's Advanced Search will be positively associated with timely successful web search." Hypothesis 3B: "Advanced Search Behavior will be positively associated with timely successful web search." Since on the question items, the units of measurement of the four constructs differ, I standardized the scale scores and made the four constructs presented in standard scores. Standard scores make different scores comparable with their means equal to zero and standard deviations equal to one. From here on, the Confidence, Self-Efficacy, GAS, and ASB constructs are presented as in ZCON, ZSE, ZGAS, and ZASB, respectively, in statistical analyses.

4.3.6.1 Significance Testing of the Overall Model

Instead of testing one factor at a time in the survival analysis model, I included all four factors in the model to be tested. In addition, I checked the eleven interactions (six two-way interactions and four three-way interactions, and one four-way interaction), one by one, with the four main effects in the model. No interaction effect was found to be statistically significant, hence I fell back to the model with four main effects. Table 4.10 shows the results of testing the overall model with four main effects.

Table 4.10 Result of Testing the Overall Model with Four Main Effects

Result of Testing the Overall Model with Four Main Effects			
Test	**Chi-Square**	**DF**	**Pr>ChiSq**
Likelihood Ratio	8.67	4	0.07
Score	7.23	4	0.12
Wald	6.73	4	0.15

Note. Testing Global Null Hypothesis: BETA=0

Table 4.10 shows the model with four effects is not significant based on Likelihood Ratio test statistics. I did not assume the four predictors should change over time, as they are not time-dependent variables. The Likelihood Ratio test is the appropriate test to refer to because it assumes the proportional hazard is satisfied (Allison, 1995). The survival analysis used in the study is the Cox's Regression which is based on proportional hazards model (to be explained below) when the co-variates (predictors, or the 4 factors in this study) are not time-dependent.

4.3.6.2 Significance Testing of Hypotheses 1, 2, and 3

Table 4.11 shows the results of testing Hypotheses 1, 2, and 3. To test the hypotheses dealing with the timely successful Web search, the survival analysis based on Cox's regression is used. The basic form of Cox's regression is $\ln h(t) = a + b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4$. The dependent variable in Cox's regression is a log hazard. It is not directly available from the data; it's available through the partial likelihood estimation method and the proportional hazards model, two innovations by Cox in 1972. The statistical software SAS calculates the dependent

variable of log hazard using the procedure PHREG which stands for Proportional Hazard Regression. Once the log hazard is calculated through iterations of maximum partial likelihood estimation requiring intensive computation, the hazard function can be obtained by exponentiation. The hazard function is defined as $h(t) = \lim_{\Delta t \to 0} \frac{P_r\{t \leq T < t+\Delta t | T \geq t\}}{\Delta t}$. The hazard is not probability, but it can be understood through the instantaneous probability concept, as shown in the formula. The possible range of hazard is from 0 to infinity. Since hazard cannot be interpreted as probability with the range of 0 to 1, it's a bit tricky to interpret it. One way to interpret the hazard number is with the number of events that happened within the time interval. We can inverse the hazard to help interpretation. The bigger the hazard, the smaller the inverse of hazard ($\frac{1}{h(t)}$), hence the quicker the event will happen. For example, if the hazard of catching a cold for Person A is 0.05 while for Person B is 0.1 per month, we know Person B will catch a cold faster than Person A because it takes about 10 months for B to catch cold the next time, while it takes 20 months for A to catch the next cold ($\frac{1}{0.1}$ versus $\frac{1}{0.05}$). Another way to interpret this is that the hazard is the "potential" for the event to happen. The bigger the hazard, the higher the potential the event will happen. If the hazard is close to 0, the potential of the event to happen is very low. For example, if Person A has a hazard of 3 per year in terms of death while Person B has a hazard of 0.01, we know that the potential of death happening for Person A is very high,

but very low for Person B. The hazard is assumed to be constant across time. When we say the hazard of catching a cold is 0.1 per month, we are actually saying if the person maintains his living style, diet habit, and nutrition taking (if these are the predictors in a survival analysis model) constantly for a full period of one month, he would catch the next cold after 10 months. This assumption of the hazard being constant is called proportional hazard. People have different hazards for the same event, as mentioned in the examples above. When we compare two persons' hazard functions in the form of ratio format, we can know whether one person's potential (hazard) of an event happening is bigger or smaller than the other person. If the ratio is 1, the two persons have same hazard (potential) of the event happening. For example, in the event of death if the ratio of Person A over Person B is 1.5, we know that the hazard of the event (death) happening for Person A is 1.5 times that of Person B. In other words, the hazard of Person A to die is 50% more than that of Person B. Another example, if the ratio is 0.2 of Person A over Person B in the event of car accident, we know the hazard of Person A in terms of having a car accident is 80% less than that of Person B. To interpret the results of survival analysis, we can imagine that two persons have the exact same scores in living style and diet habit, but a different nutrition taking score. If the hazard ratio of Person A over B in terms of catching a cold is 0.8 and is statistically significant, we can say that nutrition taking score is increased by one on Person A, the hazard (potential) of catching a cold for Person A is decreased by 20% compared to Person B. The

Parameter Estimate indicates how the predictor (variable) is positively or negatively related to the hazard (potential) of an event happening and with how much magnitude. When the hazard ratio is lower than 1, the Parameter Estimate indicates the low potential with a negative sign (-). The 95% Hazard Ratio Confidence Limits show the possible range of the hazard ratio SAS reports with 95% confidence.

Table 4.11 Results of Hypotheses 1, 2, and 3 for Research Question 1When Treating Search Skill as Two Constructs (GAS and ASB)

Results of Hypotheses 1, 2, and 3 for Research Question 1								
Var.	**DF**	**Prm. Est.**	**Std Error**	**Chi-Sq**	**Pr>ChiSq**	**Hazard Ratio**	**95% Hazard Ratio Confidence Limits**	
ZCON	1	-0.01	0.02	0.06	0.80	0.99	0.95	1.04
ZSE	1	0.06	0.09	0.52	0.47	1.07	0.90	1.27
ZGAS	1	-0.19	0.10	3.75	0.05	0.82	0.68	1.00
ZASB	1	0.11	0.08	1.79	0.18	1.12	0.95	1.31

Note. Analysis of Partial Likelihood Estimates; Var.=Variable; Prm. Est.= Parameter Estimate; DF= Degrees of Freedom; Std= Standard; Sq= Square

Hypothesis 1 states “According to Bandura’s self-efficacy theory, I hypothesize that with considering search skill, and psychological confidence trait included in the survival analysis, self-efficacy will be positively associated with timely successful Web search.” Table 4.11 shows the Self-Efficacy (ZSE) level does not have a statistically significant effect on the timely successful Web search. The hypothesis was not confirmed.

Based on the literature review, the psychological confidence trait is a general appraisal of oneself, without reference to any particular problem or situation. Hypothesis 2 posits that confidence will not be either positively or negatively associated with timely successful web search. Table 4.11 indicates that the person's general confidence level (ZCON) does not have a statistically significant effect on a timely successful Web search, though it shows a negative relationship. The hypothesis was confirmed.

Hypothesis 3A hypothesizes that the functions in Google's Advanced Search will be positively associated with timely successful web search. Table 4.11 shows that the functions in Google's Advanced Search score (ZGAS) does not have a statistically significant effect on timely successful Web searching. The hypothesis was not confirmed.

Hypothesis 3B states "The advanced search behavior will be positively associated with timely successful web search." Table 4.11 shows that the advanced search behavior (ZASB) does not have a statistically significant effect on timely successful Web searching. The hypothesis was not confirmed.

4.4 Modification of Research Question 1: Analysis of Search Skill Based on Observations

In Research Question No. 1, all four constructs were not statistically significant. However, the two constructs, GAS and ASB, do not have good

reliabilities. Including any construct with low reliability makes results questionable and difficult to defend. To deal with the questionable result, I dropped one construct and replaced another. As reported above, the Google's Advanced Search (GAS) construct had a low reliability (0.56). Since the study was video-recorded by Morae Recorder, it was possible to observe participants' actual use of the functions in Google's Advanced Search. The actual measurement obtained from observation was more accurate than the construct. Since the spyware Spector Pro was running on stealth mode during data collection, participants' queries in the simple Google query box were recorded. That made the judgment of actual use of Boolean operators (AND, OR, NOT, etc.) possible. These operators such as AND, OR, NOT, etc. are equivalent to the functions in Google's Advanced Search on the webpage. The Google's Advanced Search construct was replaced by an observational variable, Use of Google's Advanced Search (UGAS).

The second construct, Advanced Search Behavior (ASB) construct, was dropped based on the 0.64 Cronbach's alpha. When I was collecting data, some participants told me that they were having trouble answering the ASB items because some of the question items were designed for Windows users, but the participants were Mac users. I had no way of identifying how many of the participants were non-Windows users trying to answer those questions designed for Windows users.

The nature of the study is to find the factors that may affect timely successful Web searching in real life situations. It is a field study. Each of the 86 participants physically experienced the search task and their performances were measured by their hands-on effort. From the field study perspective, an accurate measure from observation, is always better than a construct measure. Furthermore, two constructs (GAS and ASB) in the model of original research question do not have good enough reliabilities. Thus, the modified Research Question No. 1 is: "How do self-efficacy, problem-solving confidence, and the use of Google's Advanced Search affect timely successful Web searching?" I argue that the modified research question is more appropriate than the original one in terms of the nature of the study. The modified research question leads to the change of Hypotheses 1 and 3. Hypothesis 1 became: "According to Bandura's self-efficacy theory, I hypothesize that with use of the functions in Google's Advanced Search and psychological confidence in the survival analysis, self-efficacy will be positively associated with timely successful Web search." Hypothesis 3 became: "The use of the functions in Google's Advanced Search will be positively associated with timely successful web search."

4.4.1 Data Collection for New Research Question

To answer the modified question, I used the information that can identify the participants that did use the functions in Google's Advanced Search during the

search task of the study. Luckily, the software was in place during data collection, though getting information required intensive labor. First, I watched the video recordings of Morae Recorder to see who used the Google's advanced search webpage during the search. Next, I read through all the queries recorded by the Spector Pro spyware in order to identify which participants actually used Boolean operators during the search task. Finally, I combined the information obtained from the two pieces of software and coded the participant as "1" if, during the search, he or she ever used the functions in Google's Advanced Search webpage or composed a query in the simple Google query box with Boolean operator(s). If the participant did neither of the two, he was coded as "0." The coding variable is named UGAS (Use of Google's Advanced Search), which is a binary variable.

4.4.2 Significance Testing of the Overall Model

As stated in Chapter 1, I assume a timely successful Web search on a production task corresponds to what most people expect to achieve every day. I wanted to disaggregate the seemingly related factors of confidence and self-efficacy as well as the use of the functions in Google's Advanced Search on timely successful Web seeking and use statistical analysis to find out the relative explanatory power of each factor. Instead of testing one factor at a time in the survival analysis model, I tested all three factors at once as that helped in comparing their influence. In addition, I checked the four interactions (three two-

way interactions and one three-way interaction), one by one, with the three main effects in the model. No interaction effect was found to be statistically significant; hence I fell back to the model with three main effects. Table 4.12 shows the result of testing this model in survival analysis.

Table 4.12 Result of Testing the Overall Model with Three Main Effects

Result of Testing the Overall Model with Three Main Effects			
Test	**Chi-Square**	**DF**	**Pr>ChiSq**
Likelihood Ratio	10.92	3	0.01*
Score	9.45	3	0.02*
Wald	8.41	3	0.04*

Note. Testing Global Null Hypothesis: BETA=0; * $p < .05$

Table 4.12 shows that the model is significant based on the Likelihood Ratio test.

4.4.3 Significance Testing of Hypotheses 1, 2, and 3

Table 4.13 shows the results of testing Hypotheses 1, 2, and 3 for the modified Research Question 1. It shows the data necessary for interpretation including: the parameter estimates, the significance levels (Pr), hazard ratios and the confidence limits. Section 4.3.6.2 has the explanation of these statistical terms in survival analysis.

Table 4.13 Results of Hypotheses 1, 2, and 3 for Modified Research Question 1 [Advanced Analysis of Search Skill Based on Observations]

Results of Hypotheses 1, 2, and 3 for Modified Research Question 1								
Var.	**DF**	**Prm. Est.**	**Std Error**	**Chi-Sq**	**Pr>ChiSq**	**Hazard Ratio**	**95% Hazard Ratio Confidence Limits**	
ZCON	1	-0.05	0.03	2.51	0.11	0.96	0.90	1.01
ZSE	1	0.156	0.08	4.26	0.04*	1.17	1.01	1.36
UGAS	1	-1.62	0.71	5.22	0.02*	0.20	0.05	0.79

Note. Analysis of Partial Likelihood Estimates; * p < .05; Var.=Variable; Prm. Est.= Parameter Estimate; DF= Degrees of Freedom; Std= Standard; Sq= Square

Hypothesis 1 states "According to Bandura's self-efficacy theory, I hypothesize that with use of the functions in Google's Advanced Search and psychological confidence in the survival analysis, self-efficacy will be positively associated with timely successful Web search." Table 4.13 shows if the Self-Efficacy (ZSE) score goes up by one standardized score, the hazard of finding the correct answer will increase by somewhere between 1% and 36%. The hypothesis was confirmed.

Based on the literature review, the psychological Confidence (ZCON) trait is a general appraisal of oneself, without reference to any particular problem or situation. Hypothesis 2 states that confidence will not be either positively or negatively associated with timely successful web search. Table 4.13 indicates that a person's general confidence level does not have a statistically significant effect on the timely successful Web search, though it shows a negative relationship (-0.05). The hypothesis was confirmed.

Hypothesis 3 states “The use of the functions in Google’s Advanced Search will be positively associated with timely successful web search.” Table 4.13 shows that compared to people who don’t use the functions in Google’s Advanced Search (UGAS), people who do use these search functions have the hazard of finding the correct answer in 30 minutes decreased by between 21% to 95%. Or compared to those who don’t use the functions in Google’s Advanced Search, people who do use these search functions have only 20% hazard of finding the answer. The result contradicts my hypothesis and is an interesting finding. The result shows that after considering psychological confidence and self-efficacy, the use of the functions in Google’s Advanced Search during the search hurts people’s timely successful Web search.

4.5 Research Question 2

A total of 101 people participated in the study of Research Questions 2 and 3. However, the first twelve participants did not answer the correct version of the questionnaire. The computer crashed when one participant was working on the search task. Thus, the data of 88 participants were used to answer the research questions. To make the definition of performance correspondent to that of Research Question 1, the Research Questions 2 and 3 were slightly changed. Instead of analyzing the differences involving 3 levels of performance, I looked into the differences between 2 levels of performance— the correct answer found or not-

found—as defined in the survival analysis for Research Question 1. This part of my study involves one categorical independent variable [performance] and one continuous dependent variable [number of circular triads] to answer the question: "Do efficient searchers share the same mental organization of keyword importance as the non-efficient searchers?"

4.5.1 Demographic Data of Question 2

Of the 88 participants whose data were analyzed for Research Question 1, 56.8% (50) were female and 43.2% (38) were male. Additional demographic variables of highest educational degree obtained, current status, and academic major were obtained. More than half of the participants had at least a high school diploma (56.8%), about 33% of respondents had obtained a college degree, and 7.9% of them had earned a graduate degree. The majority of the participants were students (94.3%), only 5.7% of them were not students. The participants come from a diverse academic background across 32 majors. The computer science majors (17%) and the library & information science majors (12.5%) are the two biggest populations. Table 4.14 shows the frequency table on academic major of participants.

Table 4.14 Academic Major of Participants in Research Questions 2 and 3

Academic Major of Participants in Research Question 2 and 3					
Academic Major	**Frequency**	**Percent**	**Academic Major**	**Frequency**	**Percent**
Animal Science	1	1.1	Japanese	2	2.3
Asian Studies	1	1.1	Kinesiology	4	4.5
Biology	3	3.4	Library & Information Science	11	12.5
Broadcast Journalism	1	1.1	Nursing	2	2.3
Business	5	5.7	Philosophy	1	1.1
Civil Engineering	3	3.4	Political Science	1	1.1
Communication	7	8.0	Pre-business	3	3.4
Computer Science	15	17.0	Pre-nursing	2	2.3
Educational Foundations	1	1.1	Pre-psychology	2	2.3
Educational Psychology	7	8.0	Psychology	2	2.3
Electrical Engineering	1	1.1	Second Language Studies	1	1.1
Environmental Studies	1	1.1	Sociology	1	1.1
Finance	1	1.1	Statistics	1	2.3
Fine Arts	1	1.1	Undecided	2	2.3
Food Science & Human Nutrition	2	2.3	Unavailable	1	1.1
French	1	1.1	Total	88	100
History	1	1.1			

4.5.2 Independent Variable: Performance Groups

The independent variable, status, of the study is a binary variable of performance: those who found the correct answer within the time limit and those who could not find the correct answer in the 30 minutes limit. Of the 88 participants, 21 got the correct answer within the time limit, 41 got the wrong

answer, and 26 people were timed out. The status variable is the same as the status variable used in the survival analysis in previous research questions. Since this research question asks whether there is a difference in mental organization of keyword importance between efficient and non-efficient searchers, participants who found the correct answer within 30 minutes are coded "1" while the rest of the participants are coded "0." In this research question, 21 people's status is coded as "1," while 67 people's status is coded as "0."

4.5.3 Dependent Variable: Number of Circular Triads

The dependent variable, number of circular triads, is the information searcher's mental organization of keyword importance which is obtained by asking participants to make pair-wise comparisons among the seven keywords in the task. I use the number of circular triads to detect the inconsistencies of the information searchers' mental concepts of keyword importance. The more inconsistencies a searcher has on keyword importance, the less sure the searcher is about the keywords' importance in finding the answer.

4.5.4 Results of Hypothesis 4 for Research Question 2

I used Newell and Simon's problem space theory in my study and assumed that efficient information searchers can identify the critical keywords of the task and prioritize them. When people search for information on the Web, they have to generate their own problem space that represents the search task. The efficient

searchers can generate a problem space which extracts the crucial structure of the task. To test my belief that an efficient searcher, through heuristics, can identify the critical keywords to generate his problem space, I look for the individual's mental organization of keyword importance so that I can capture different people's ways of understanding the relative importance of keyword and to associate these ways with different levels of proficiency in information searching. My dependent variable was the number of circular triads in searcher's mental organization of keyword importance to capture people's ways of understanding the relative importance of keywords. The status variable is used as the independent variable to indicate the different levels of proficiency in information searching. A t-test is used to test the research question "Do efficient searchers share the same mental organization of keyword importance as the non-efficient searchers?" Section 4.5.4.1 reports the folded F test for testing the equality of variances in t-test. Section 4.5.4.2 reports the comparison between two groups to test the hypothesis 4: "There is significant difference in mental organization of keyword importance between two levels of search performance."

4.5.4.1 Testing Equality of Variances

T-tests assume that independent samples are drawn from different populations. In other words, the two performance groups, efficient searchers versus non-efficient searchers in the study, are not linked with unknown parameters. The

null hypothesis of the independent sample t-test is the mean difference of the two groups is zero. If the statistical test shows non-significant, the two groups appears to have equal variances, thus the assumption of equal variances in t-test is met. Table 4.15 shows the result of testing equality of variance using the folded form F-test.

Table 4.15 Result of Testing Equality of Variances

Result of Testing Equality of Variances					
Variable	**Method**	**Num DF**	**Den DF**	**F Value**	**Pr>F**
triads	Folded F	66	20	1.63	0.22

Note. Num= Numerator; DF= Degree of Freedom; Den= Denominator

Table 4.15 shows small F statistic 1.63 and does not reject the null hypothesis of equal variances ($p < .22$). It means the equal variance of the two populations is probable, so the choice of t-test is acceptable.

4.5.4.2 Significance Testing of Hypothesis 4

Since the equality of variances testing in previous sections suggests the two populations have more or less equal variances to start with, the "pooled" method for computing the standard error of difference of the means as a part of t-test is the appropriate method to refer to (Park, 2009; SAS, 2008). Table 4.16 shows the significance testing of Hypothesis 4.

Table 4.16 Result of Testing Hypothesis 4

Result of Testing Hypothesis 4					
Variable	**Method**	**Variances**	**DF**	**t Value**	**Pr>|t|**
triads	Pooled	Equal	86	2.24	0.03*

Note. * $p < .05$

Table 4.16 shows the large t 2.24 and its p-value 0.03 reject the null hypothesis that there is no significant difference in mental organization of keyword importance between two levels of performance. The result confirms my hypothesis that there is significant difference in mental organization of keyword importance in two levels of search performance.

Table 4.17 presents summary statistics and confidence limits of hypothesis 4. The last row shows the lower bound and upper bound of confidence intervals for the mean difference of number of circular triads between the two groups, status “0” and status “1.” Status “0” indicates the people who could not find the correct answer or got timed-out. Status “1” indicates the people who found the correct answer within the time limit.

Table 4.17 Summary Statistics and Confidence Limits of Hypothesis 4

Summary Statistics and Confidence Limits of Hypothesis 4									
Var	**Status**	**N**	**Lower CL Mean**	**Mean**	**Upper CL Mean**	**Lower CL Std Dev**	**Std Dev**	**Upper CL Std Dev**	**Std Err**
triads	0	67	1.50	2	2.50	1.75	2.05	2.47	0.25
triads	1	21	0.17	0.90	1.64	1.23	1.61	2.32	0.35
triads	Diff (1-2)		0.12	1.10	2.07	1.70	1.96	2.30	0.49

Note. Var= Variable; CL=confidence limit; Std Dev= Standard Deviation; Err= Error

Table 4.17 shows the people who could not find the correct answer or got timed-out had at least 0.12 at most 2.07 more circular triads in mental organization of keyword importance than the group of people who found the correct answer. In other words, the efficient searchers had less circular triads of mental organization of keyword importance. The result corresponds to my expectation based on the problem space theory that efficient searchers can identify the critical keywords of the task, thus they have less circular triads in their mental organizations of keyword importance.

4.5.4.3 Further Analysis of Circular Triads

Further analysis found that the total number of circular triads in the correct-answer group (with 21 participants) is 19 triads; the timed-out group (26 participants) came up with 41 triads; the wrong-answer group (41 participants) came up with 93 triads. In other words, there are on average 0.90 circular triads per person in the correct-answer group; 1.61 circular triads in the timed-out group; and

2.27 circular triads per person in the wrong-answer group. Thus, successful searchers use less triads on average. A good example is shown in Table 4.18, which compares the two most common triads used by the two least successful groups.

Table 4.18 Comparison of Most Common Circular Triads

Comparison of Most Common Circular Triads			
	Wrong-Answer Group N=41 Triads=93	**Correct-Answer Group N=21 Triads=19**	**Timed-out Group N=26 Triads=41**
The Two Circular Triads Favored by the Wrong-Answer Group			
Writing-200 to 400 Years ago-Austronesian	9	2	
Taiwan-Communicate-Writing	7	0	
The Two Circular Triads Favored by the Timed-out Group			
Communicate-Writing-200 to 400 Years ago		1	5
Native(Aboriginal)-Communicate-Writing		2	5

The wrong-answer group most commonly used the "Writing-200 to 400 Years Ago-Austronesian" and "Taiwan-Communicate-Writing" –an aggregate of sixteen times. If you then look at how often these particular triads were used by the correct-answer group, you see that they were used only two times. The most commonly used triads by the timed-out group were "Communicate-Writing-200 to 400 Years Ago" and "Native (Aboriginal)-Communicate-Writing." The timed-out group used them an aggregate of ten times. These two triads were only used by the correct-answer group a total of three times.

4.6 Research Question 3

As stated in Section 4.3.2, the sample size of this part of the study is 88 people. And as stated in Section 4.5, Research Questions 3 was lightly changed. Instead of analyzing the differences involving 3 levels of performance, I looked into the differences between 2 levels of performance—found the correct answer or not-found—as defined in survival analysis in Research Question 1. The question: "Is a higher level of search performance characterized by increasingly consistent mental organizations of keyword importance?" is answered by obtaining two numbers: 1) the participants' performances, and 2) the strength of consensus at different levels of search performance.

4.6.1 Demographic Data of Question 3

Same as in 4.5.1

4.6.2 Independent Variable: Performance Groups

Same as in 4.5.2

4.6.3 Dependent Variable: Kendall's Coefficient of Concordance

Kendall's coefficient of concordance is a measurement of consensus strength which is obtained by the TRICIR statistical program. The higher the coefficient, the higher the consensus exists within the group. On the contrary, the

lower coefficient indicates more discriminate opinion existing within the group. For any group of ranked data, we can have two numbers. One is the number that shows how much the ranking is different from the null hypothesis that there is no significant difference in ranking objects among all judges. The other is the theoretically maximum possible difference in ranking when all the judges have perfect agreement. Kendall's coefficient of concordance is the proportion of the two numbers which are measured by sum of squares. Kendall's coefficient of concordance ranges between 0 and 1. If the coefficient is equal to 1, it means the sum of squares observed from real data is as much as perfect agreement will give you. It means the judges have perfect agreement. If it is closer to 0, it means the judges disagree more with each other.

4.6.4 Results of Hypothesis 5

As opposed to Research Question 2 which uses the within-person consistency concept (through the measure of circular triads) to answer the question, Research Question 3 uses the concept of within-group consistency. Based on the problem space theory of Newell and Simon, I believe efficient searchers are like efficient problem-solvers who can identify the crucial features of the task. Since the efficient searchers can identify the crucial keywords, their within-group consistency in organizing the keyword importance should be higher than those who are not efficient searchers. Hence I hypothesize "Successively higher levels of search

performance are characterized by increasingly stronger mental organization of keyword importance." I use the Kendall's coefficient of concordance (ω) to measure the within group consistency between the group of efficient searchers and non-efficient searchers. Kendall's coefficient of concordance is used for assessing agreement among raters. Table 4.19 shows the within-group consistency in the two performance groups.

Table 4.19 Result of Hypothesis 5

Result of Hypothesis 5		
Performance group	**Number of people**	**Kendall's coefficient of concordance**
Found the correct answer within time limit	21	0.66
Could not find the correct answer within time limit, or timed-out	67	0.43

Table 4.19 shows that the group of efficient searchers has a higher within-group consistency (ω =0.66) in the organization of keyword importance than the group of non-efficient searchers does (ω =0.43). That is, the result confirms the hypothesis that the efficient searchers have higher consensus in the mental organization of keyword importance than those of non-efficient searchers.

I further analyzed the rankings of keyword importance by the three performance groups (the correct-answer, the wrong answer, and the timed-out group). An interesting finding is that: all three performance groups have a similar pattern of rankings of the relative keyword importance. Table 4.20 (below) shows

all groups ranked “Austronesian”> “Taiwan”> “Native (Aboriginal) as the most important keywords in that order and “How” as the least important.

Table 4.20 Comparisons of Keyword Rankings by the Three Groups

Comparisons of Keyword Rankings by the Three Groups			
Keyword	**Correct-answer group**	**Wrong-answer group**	**Timed-out group**
Austronesian	1	1	1
Taiwan	2	2	2
Native (Aboriginal)	3	3	3
Writing	4	5	6
200 to 400 years ago	5	4	4
Communicate	6	6	5
How	7	7	7

Note. Ranking 1-7 with 1 the most important

Table 4.20 shows the only differences in rankings between the three groups lie in the keywords “Writing,” “200 to 400 years ago,” and “Communicate.” The relative importance of these keywords is debatable among the three groups. The correct-answer group ranked them as “Writing”> “200 to 400 years ago”> “Communicate.” The wrong-answer group ranked them as “200 to 400 years ago”> “Writing”> “Communicate.” The timed-out group ranked differently: “200 to 400 years ago”> “Communicate”> “Writing.” Are these differences obvious? The answer is “No.” Table 4.21, 4.22, and 4.23 show that these 3 keywords (“Writing,” “200 to 400 years ago,” and “Communicate”) are weighted similarly by the number of votes they got.

Table 4.21 Correct-answer Group's Votes and Rankings of the Keywords

Correct-answer Group's Votes and Rankings of the Keywords (N=21)							
Kw	**Austronesian**	**Taiwan**	**Native (Aboriginal)**	**Writing**	**200 to 400 years ago**	**Communicate**	**How**
Votes	110	96	78	54	53	50	0
Rankings	1	2	3	4	5	6	7

Note. Kw= Keywords

Table 4.22 Wrong-answer Group's Votes and Rankings of the Keywords

Wrong-answer Group's Votes and Rankings of the Keywords (N=41)							
Kw	**Austronesian**	**Taiwan**	**Native (Aboriginal)**	**200 to 400 years ago**	**Writing**	**Communicate**	**How**
Votes	182	174	147	124	104	97	33
Rankings	1	2	3	4	5	6	7

Note. Kw= Keywords

Table 4.23 Timed-out Group's Votes and Rankings of the Keywords

Timed-out Group's Votes and Rankings of the Keywords (N=26)							
Kw	**Austronesian**	**Taiwan**	**Native (Aboriginal)**	**200 to 400 years ago**	**Communicate**	**Writing**	**How**
Votes	128	114	98	75	62	57	12
Rankings	1	2	3	4	5	6	7

Note. Kw= Keywords

Tables 4.21, 4.22, and 4.23 above show that all three groups consistently rated three keywords most important: "Austronesian"> "Taiwan" "Native (Aboriginal)." The keyword "How" was voted as the least important consistently across the groups. On the other hand, the rankings of keywords "Writing," "200 to

400 years ago," and "Communicate" are not very distinguishable, except in the timed-out group. Considering the number of votes on these keywords and the number of the people in the three groups, these three keywords in general do not show as clear differences in rankings as the other four keywords ("Austronesian," "Taiwan," "Native (Aboriginal)," and "How").

In other words, all searchers agreed on the relative importance of the three most important keywords and the one least important keyword. A clear pattern of rankings of keyword importance exists among the three performance groups: "Austronesian" is the most important, "Taiwan" the second, "Native (Aboriginal) the third, and "How" the least. It is not the rankings of keyword importance that suggest the differences in performance. However, based on the finding on Hypothesis 4 shown on Table 4.17, it is the number of circular triads in the mental organizations of keyword importance that suggests the difference. The efficient searchers had less circular triads (more decisive) in their rankings of keyword importance than their counter-part, non-efficient searchers.

Chapter 5: Conclusions and Discussion

This chapter has five parts: the conclusions involving for Research Questions 1, 2, and 3; a discussion of contributions, again organized around the research questions; a discussion of the research design and confounding variables; limitations of the study; and implications for future research.

5.1 Conclusions

Conclusions were derived from analysis of the data, observations, and statistical processes that determined the significance or non-significance of the hypotheses.

5.1.1 Conclusions from Testing Research Question 1 Hypotheses

Research Question 1 involved the factors behind timely successfully Web searching, an important area of inquiry with implications in optimizing performance for 2,000 million searchers. The world is increasingly dominated by iPhone, iPad, and mobile devices with built-in wireless Internet connections and search abilities. Of the dominant web parent companies, Google is the leading search engine ("Top 10 Global Web Parent Companies, Home & Work," 2011). It has 86.3 % worldwide market share in 2010, and a 63.2% market share in the United States. According to Neilsen ratings in April 2011, on average American

spends over two and a quarter hours on Google per month—that is, on average, about 4.5 minutes on Google everyday.

The question of what makes a timely successful Web search is an important question in an age where search engines are ubiquitous and we expect our searches to be effective and efficient. My study looked at various constructs in the context of "Google's Advanced Search" designed to facilitate people's search performance, and whether this "Google's Advanced Search" was helpful to effective searching. Because Google is the dominant Web search engine, I focused on people's performance on Google. I disaggregated the seemingly related factors, self-efficacy, confidence, and the use of Google's Advance Search. I asked "How do self-efficacy, problem-solving confidence, and the use of Google's Advanced Search affect timely successful Web searching?"

My findings shed light on the relative effect on searching of the various constructs including self-efficacy and problem-solving confidence. While previous research findings (in studies where the constructs were tested individually) had revealed that self-efficacy and problem-solving confidence had a significant effect on performance, my study introduced nuances. Unlike previous studies, I looked at both constructs simultaneously (in the context of searching) and found that problem-solving confidence does not help to make web searches timely and successful. Also, surprisingly, the use of Google's Advanced Search does not help and can even hurt in completing a search in a timely manner. Confidence by

definition is a non-task specific measurement and therefore I had hypothesized that confidence does not help with the specific task of web searching. My hypothesis was driven by theory derived from previous studies. But contrary to the findings of previous researchers who found confidence to be significant to college students' GPA (Elliott et al., 1990), my finding extends the understanding of confidence (to the context of Web searching) and shows that confidence does not help. Statistically, it is not a significant factor in an effective search. Compared to the other two factors (self-efficacy and use of the functions in Google's Advanced Search), in a survival analysis model, confidence does not have a statistically significant effect.

Self-efficacy, on the other hand, is positively related to timely successful Web searching. That is perhaps related to the fact that it is by definition task specific. If the Self-Efficacy (the construct) score goes up by one standardized score, the hazard of finding the correct answer will increase by 1% to 36%. The research suggests that the higher the self-efficacy before the search task, the higher the potential to find the correct answer on the Web. My findings are congruent with the body of self-efficacy literature, however my finding extends the understanding of self-efficacy to the context of a specific Web searching task. The finding may not be applicable in studies where boosting self-efficacy of the subject is implemented during the task or process, for example by coaching or teaching. A

study with a different design in which you boost and measure self-efficacy throughout the information search task would be desirable.

My findings on confidence and self-efficacy help in differentiating between the two seemingly identical concepts. Some researchers use the two terms interchangeably (Lucas, 2004) but some researchers have promoted the need to differentiate between the two similar terms (Lopez & Janowski, 2004). My study responded to this call for differentiation and used a new context. According to my findings, confidence and self-efficacy are two different concepts and affect performance differently in the context of searching. Confidence is negatively related to timely successful searches, though not in a statistically significant way. Self-efficacy, on the other hand, is shown by statistical evidenced to be positively related to timely successful searches.

The most important finding in Research Question 1 is that the use Google's Advanced Search hurts search performance (in terms of timeliness and correctness), contrary to most people's assumption that the functions in Google's Advanced Search are helpful to Web searching. Compared to people who don't use the functions in Google's Advanced Search (UGAS), people who do use them have the hazard of finding the correct answer in 30 minutes decreased by between 21% and 95%. Section 5.2 covers more details about this finding. This is the first finding, from empirical data, that Google's Advanced Search hurts searchers' performance.

5.1.2 Conclusions from Testing Research Question 2 Hypothesis

Research Question 2 asks "Do efficient searchers share the same mental organization of keyword importance as the non-efficient searchers?" Simon's (1978) conclusion about problem space states that "effective problem-solving involves extracting information about the structure of the task environment and using that information for highly selective heuristic searches for solutions." I believe that when people search for information on the Web, they have to generate their own problem space, one that represents the search task. Efficient searchers can generate a problem space which extracts the crucial structure of the task. I looked at the individual's mental organization of keyword importance so that I could capture different people's ways of understanding the relative importance of keywords; I associated these with different levels of proficiency in information searching. Research Question 2 asked participants to rank order three keywords at a time seven times which resulted in circular triads (for example: Writing>200 to 400 Years ago>Austronesian>Writing). My results show that there is statistical significant in the difference in mental organization of keyword importance between two levels of performance: Group A (status=1) those who found the correct answer in time versus Group B (status=0) those who could not find the correct answer.

In further analysis Group B was broken down into two groups, the wrong-answer group and the time-out group; thus making a total of three groups by performance. Despite three different levels of performance, each group had circular

triads in their organizations of keyword importance. However, some sets of keywords elicited more circular triads in the wrong-answer group and timed-out group than in the correct-answer group. Section 4.5.4.3 shows examples of those. As shown in Table 4.18, in a comparison of the two circular triads favored by the wrong-answer and timed-out groups with those in the correct-answer group, the wrong-answer group used a total of 16 circular triads while the correct-answer group used only two; the timed-out group used a total of ten circular triads whereas the correct-answer group used only three. The correct-answer group uses less circular triads and are more effective searchers. The finding supports the application of the problem space theory invented by the founders of Artificial Intelligence Newell and Simon (1972) to the context of Web searches. My finding shows the group of people who could not find the correct answer or got timed-out has at least 0.12 and at most 2.07 more circular triads in mental organization of keyword importance than the group of people who found the correct answer.

5.1.3 Conclusions from Testing Research Question 3 Hypothesis

Research Question 2 looked at individual's mental organizations of keyword importance. Research Question 3 looked at the consensus of mental organization within groups that perform the same. It probes whether efficient searchers have higher within-group consistency in their mental organizations of keyword importance than non-efficient searchers. The result shows a higher level

of search performance can be characterized by increasingly consistent mental organizations of keyword importance. In addition, further analysis shows that when forced to think through the relative keyword importance prior to searches, efficient searchers and non-efficient searchers share a clear pattern of ranking the keywords. There is no obvious difference in the rankings of keywords among all searchers. The obvious difference is in the number of circular triads of keyword importance, and this is related to the search performance.

5.2 Contributions

5.2.1 Contributions and Discussions Involving Research Question 1

The contributions to be discussed were generated after discussions involving Research Question 1. The most important contribution from testing Research Question1 hypotheses is that my study bridged the gap between two approaches favored by information retrieval (IR) researchers: 1) information retrieval (IR) approaching from the human-computer interaction perspective, and 2) the approach of using search engine logs. Both approaches took on added importance as the Internet expanded. Information retrieval researchers looked at searches on computer systems in terms of the interaction between human and computer. For example, some researchers developed a user-centered approach to studying the effectiveness and usability of a Web search engine. Fort et al. (2001)

tried to decipher individual differences in Internet searching and assessed people's cognitive styles, prior experiences, Internet perceptions, study approaches, etc. On the other hand, scholars using search engine logs found information retrieval on the Web to be a different kind of information retrieval (Jansen, Spink, & Saracevic, 2000): web users differ significantly from the users in standard IR literature. For example, Silverstein and his colleagues (1999), using one billion search queries, found that users type in short queries and seldom modify queries. Jansen et al. (2000), using 51 thousand queries, found that Boolean operators were seldom used by searchers who used a particular search engine. Similar results were reported in a study by Amada Spink and others (2001a) who studied one million queries: people use few queries and few modify their queries; they view few web pages and rarely use advanced search features. Search engine log studies have their inherent disadvantages, for example, they cannot answer some interesting questions about performance. Without studying search engine logs, researchers Lucas and Topi (2005; 2002) also looked at the effect of Boolean operators on search performance and found that the use of Boolean operation does not always guarantee successful performance. Unlike the studies just mentioned, my study looks at psychological factors in the context of "Google's Advanced Search." Previously, those who looked at individual factors do not look at advanced search functions; those who looked at search engines and Boolean operations did not look at individual differences, especially psychological factors. Above all neither group looks at

performance on search tasks. This study bridges the gap between the two schools of researches by asking "How do self-efficacy, problem-solving confidence, and the use of Google's Advanced Search affect timely successful Web searching?"

People tend to assume that they need a more "advanced" tool for more difficult tasks. Thus when people cannot find the answer from the basic Google search engine, they often turn to what they perceive to be a more powerful search tool, advanced search functions, to help with their searches. However, my empirical study found that not only does the Use of Google's Advanced Search not help (even slightly as Google implies in its information), it hurts timely successful Web searching. My research has implications for the assumption that people "think" they need "Google's Advanced Search" for more difficult searching tasks. My finding should be of interest to the general public because it contradicts a common assumption.

Performance using Google's Advanced Search is hindered by the fact that most people don't read instructions or manuals until they get stuck, so they often don't read the instructions for "Google's Advanced Search." Caroline Eastman and Bernard Jansen (2003) have found that most query (advanced) operators have no significant effect on coverage, relative precision, or ranking, although the effect varies depending on the search engine. In their study, they noticed that in general the three search engines, AOL, MSN, and Google, indicate that the use of advanced operators can be expected to improve search results. Eastman and Jansen noted the

wordings of Google's advice on its Advanced Search, I noticed changes of wording and the interface of "Google's Advanced Search" since 2010. Indeed, Google is making changes that suggest additional support for my finding. Google has changed at least two factors related to advanced searching in its interface since around 2011 summer. Web searchers aren't shown the "Advanced Search" link shown on Google's homepage anymore. This change is universal across countries (for example:"Google Japan Homepage," 2011; "Google Taiwan Homepage," 2011; "Google UK Homepage," 2011). Only after a searcher places a simple query onto the new Google homepage can he see the Advanced Search link. In other words, the Advanced Search link is available only on the second try of searching, not on the first as of before. Figure 5.1 shows Google's 2010 home page where Advanced Search was available next to the query box. Figure 5.2 shows Google's 2011 (July) home page where the Advanced Search link is not available ("Google US Homepage," 2011). Figure 5.3 shows that an advanced search link becomes available on the second search. Note, now the link is "Advanced search" instead of "Advanced Search" in 2010. For consistency, I use "Advanced Search" through the paper, when talking about the Google search engine.

Figure 5.1 Google's 2010 Home Page

Figure 5.2 Google's 2011 (July) Home Page

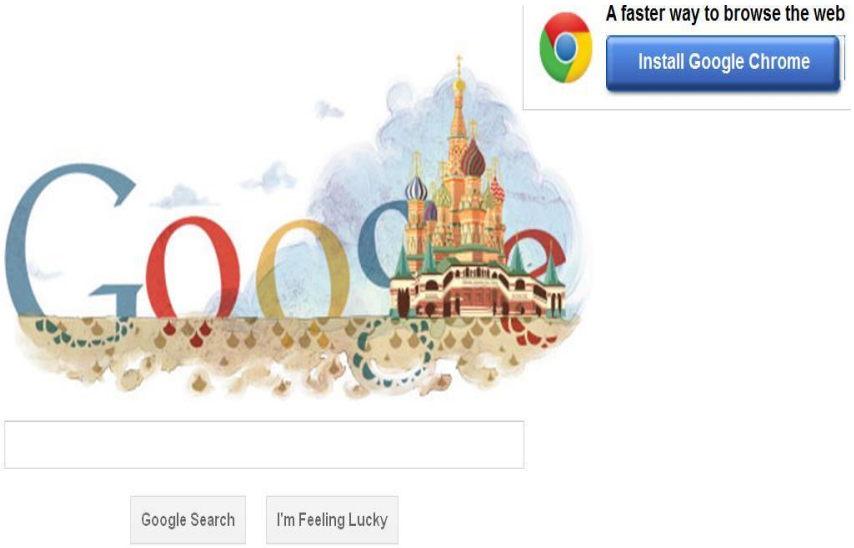
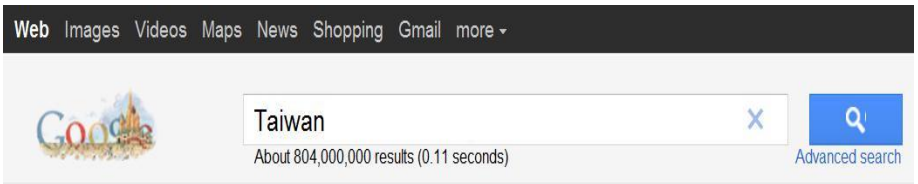


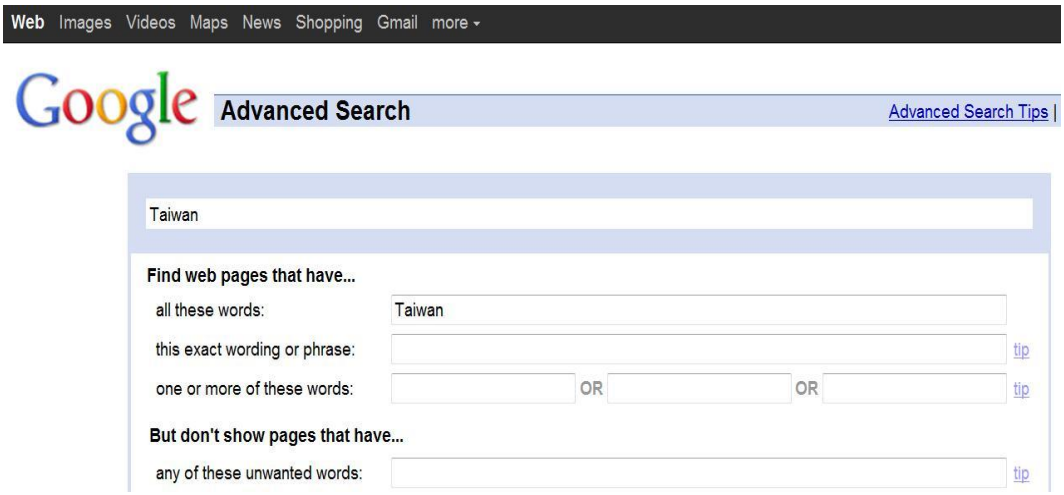
Figure 5.3 Advanced Search Becomes Available on the Second Search



Once on the Advanced Search page, searchers have option to look for further tips ("Advanced Search Tips") on that page. Figure 5.4 shows Google's 2010 Advanced Search page; Figure 5.5 shows Google's 2011 Advanced Search page.

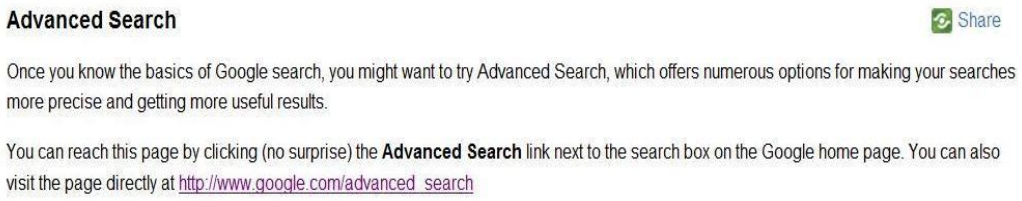
Figure 5.4 Advanced Search 2010

Figure 5.5 Advanced Search 2011



On the Advanced Search Tips webpage back in 2010, Google suggested: "Once you know the basics of Google search, you might want to try Advanced Search, which offers numerous options for making your searches more precise and getting more useful results."(see Figure 5.6 below)

Figure 5.6 Advanced Search Tips (2010)



Also, compared to 2010 (when this study was conducted), Google has renamed its "Advanced Search", calling it "More search help," and as mentioned

above, does not seem to be advocating the use of its "Advanced Search" as strongly. And, as of July 2011, Google is directing users to a new webpage linked to the Advanced Search link—it is called "More search help." It uses a toned-down voice in advocating its Advanced Search, stating "… sometimes you need a little bit more power. This document will highlight the more advanced features of Google Web Search. Have in mind though that even very advanced searchers, such as the members of the search group at Google, use these features less than 5% of the time. Basic simple search is often enough." (see Figure 5.7 below)

Figure 5.7 More Search Help (2011)

More search help

The Basic search help article covers all the most common issues, but sometimes you need a little bit more power. This document will highlight the more advanced features of Google Web Search. Have in mind though that even very advanced searchers, such as the members of the search group at Google, use these features less than 5% of the time. Basic simple search is often enough. As always, we use square brackets [ ] to denote queries, so [`to be or not to be`] is an example of a query; [`to be`] or [`not to be`] are two examples of queries.

It is interesting that Google has made these changes recently. Has Google made its Advanced Search unavailable on the homepage because Google realized that most people don't use the functions in Google's Advanced Search or because its Advanced Search did not work as well as expected? Did Google make the Advanced Search unavailable from its homepage in the interest of efficiency because most people didn't use it anyway? Is it because of its relative inefficiency that Google toned down its advocacy of the functions in Google's Advanced

Search—because it promised more than it was delivering? And was the language "More search help" more useful and less intimidating? If most people don't use Google's Advanced Search, should it even be on the webpage and touted as offering "numerous options for making your searches more precise and getting more useful results?" Only Google can answer these questions. However, I suspect that Google has recently found similar findings to mine and has made these two changes correspondingly.

It is helpful to discuss my conclusions, in terms of a study by Eastman and Jansen (2003), in order to contrast my study with a previous one and lay bare the contribution my study makes to advancing thinking on searching. My research finding is consistent with Eastman and Jansen's conclusion: in general query operators in search engines (AOL, Google, and MSN) provide little or no benefit and these search engines are counter productive in some cases. However, their data cannot be used to argue that the advanced search functions have a negative effect on timely successful Web searches. In their research design they assumed that the search was completed once the search engine returned documents that had good scores as manually evaluated by four reviewers. Their study ignored the individual differences in Web searching and did not consider that people may find the wrong answer which they mistake for a correct one; some people may not choose the correct answer from good returns of documents but the wrong answer among the bad returns; some people find the correct answer faster than others; and some

people may quit or get timed-out. These possible issues in everyday Web searching were considered in my research design and analyzed by survival analysis.

Though Eastman and Jansen's work in 2003 is consistent to my finding on Hypothesis 3 in Research Question 1—that the use of Google's Advanced Search hurts timely successful Web searching—they did not look at the actual performance of human participants as my study did. They used four reviewers to judge the coverage, relevance, and ranking differences between no-(Boolean) operator-queries and with-(Boolean) operator-queries across three real life search engines. They did not look at queries with more than one operator. Based on previous research conclusions, they only scored the top 10 documents obtained from each search engine. Their research settings did not reflect real-life Web searching. In contrast to Eastman and Jansen's study, I tried to simulate a true-to-life Google environment as much as possible. My participants were given the same search task. They were allowed to use as many queries as they liked, use as many keyword terms and operators and in any number of combinations of the two, and view as many documents as the search engine retrieved for any query, etc. Web searching involves human behavior and interaction with the search engine. While Eastman and Jansen's study captured what they called the "multivariable complexity of information seeking" on the Web [Dumais, 2002], my study not only captured multivariable complexity from the system perspective but also factors in human behavior and psychological constructs—self-efficacy and problem-solving

confidence. With the obvious differences mentioned above, my finding extends previous research and finds that the use of the functions in Google's Advanced Search can actually hurt people's timely successful searches.

Eastman and Jansen focused on the performance of search engines. Because Web searching involves interactions between humans and computers, it is important to look over users' shoulders and observe their performance. Studies using search engine logs cannot fill this need. Eastman and Jansen found the query operators in search engines provide little or no benefit through a study that did not involved observations of actual performances by human participants. My study shows a statistically significant negative effect on the use of these query operators through field research involving measuring human participants' performance. It suggests that the effect of using query operators magnifies when humans interact with search engines.

Surprisingly, my finding, at least in the perspective of timeliness and success, contradicts previous conclusions that Boolean operations in search engines should be promoted and notions like those of Topi and Lucas (2005) who promote training and interface to further help people utilize the power of search engines. Their conclusions are based on neither a direct nor complete test of the real life search tasks because Topi and Lucas limit users from reading the links—search results. This violates what people do on search engines.

On the basis of empirical data and survival analyses techniques, after considering the seemingly related factors of self-efficacy and problem-solving confidence, I have argued that the use of the functions in Google's Advanced Search hurts people's performance on timely successful searches. However, there may be factors that may also be relevant to this poor performance: one is that the functions in Google's Advanced Search involve the use of Boolean operators. I think that when under time pressure, the use of Boolean operators in search engines involves an extra cognitive load that does not render better results. People might as well spend the same cognitive effort on more efficient and effective queries, simple queries without Boolean operations. Two, the search task in my study is a difficult one. The successful rate was only about 25 % in both samples; roughly 50% got the wrong answers. The task's difficulty probably lead people, non-efficient searchers, to turn to "Google's Advanced Search" for help under the pressure of time and being monitored. Also, non-efficient searchers might have been miscued by the Search Skill questionnaire which I had them answer before beginning the search task (see Appendix B). It may have lead to an impression that the search task requires the use of Boolean operations to find the correct answer. When participants could not find the answer, they might have recalled the questionnaire items regarding the "the functions in Google's Advanced Search" and tried the functions. Three, those who could not find the correct answer may be those who don't know how to correctly use the Boolean operators in Web search engines.

Thus, they used Google's Advanced Search badly. After all, research has shown that many people have difficulty in using Boolean operators to correctly compose queries for searches (Jansen et al., 2000; Spink et al., 2001a). Four, the Boolean operations in Google may not work well in difficult search tasks such as the task set used in the study. Efficient Web searchers, through experience, know when it is appropriate to apply Boolean operations and when it is not. Efficient searchers may use Boolean operators to facilitate the search processes of simpler tasks, but not of difficult tasks. Future research may look at the relationship between search performances, different difficulty levels of search tasks, and the uses of Boolean operations in search engine.

5.2.2 Contributions and Discussions Involving Research Questions 2 and 3

The first contribution of Research Questions 2 and 3 is that it expands Newell and Simon's problem space theory into the context of Web searching. Problem space theory helped guide my study, but I designed my research to introduce an additional concept related to ranking keywords (known as "objects" in scaling methods): circular triads. In the study, I ran two analyses regarding keyword importance: one on circular triads and one on rankings of keyword importance. The circular triads analysis, run on the TRICIR statistical program, was to test Hypotheses 4 and 5. I used the TRICIR statistical method to look at the circular triads in terms of the searcher's mental organization of the keywords'

importance. Second, rankings of keyword importance were studied as a further analysis of Hypothesis 5. Indirectly TRICIR generated rankings of keyword importance when I asked students (or "judges") to rank order seven sets of keywords, giving each set a ranking of between one and three based on how important they think each of the three keywords in a set was to finding the correct answer. Each keyword has "votes" (a numerical value)—obtained from TRICIR—based on its relative position within a triad. I calculated the total number of votes every keyword got. A sequential sorting of the votes produced rankings of keyword importance.

I used rankings of keyword importance as a further/alternative analysis to verify problem space theory (see Tables 4.20, 4.21, 4.22, 4.23 in Section 4.6.4). Problem space theory indicates that efficient problem-solvers can extract crucial information from the task and non-efficient problem solvers cannot. I began my study with this assumption, that in terms of Web searching, efficient searchers can extract crucial information and non-efficient searchers cannot. Based on problem space theory I believed that when a searcher is not clear about which keywords to choose, he/she is most likely to fail to extract the crucial information of the task and thus not find the correct answer in time. I thought that if information searchers could extract the crucial keywords, they could find the correct answer. In other words, the rankings of keyword importance between successful and non-successful people would be very different. But when I looked at the rankings (see Tables 4.20,

4.21, 4.22, 4.23 in Section 4.6.4), I realized that my findings contradicted this assumption. My findings show that a clear pattern of ranking the keywords' importance exists across different levels of performance. Information searchers all ranked "Austronesian"> "Taiwan"> "Native (Aboriginal)" as the most important keywords, and "how" as the least important. In other words, efficient or non-efficient searchers accorded similar relative importance to keywords—a conflict with what the problem space theory implies. My study expanded upon problem space theory by using the TRICIR statistical method and I was able to find out that it is not the rankings of keyword importance that makes the difference in performance but decisiveness. There is no obvious difference between the relative importance of keywords ranked by the correct-answer, wrong-answer, and timed-out groups—they all came up with the same patterns. Differences in performance are instead related to decisiveness as measured by the number of circular triads in the mental organizations of keyword importance. The efficient searchers had less circular triads and thus were more decisive in their rankings of keyword importance than their counter-part, non-efficient searchers. The more decisive the searcher is (the less circular triads you have), the more likely one is to find the correct answer. Table 4.17 (see Chapter 4) shows a statistically significant difference in the number of circular triads between the successful and non-successful groups.

Some may argue that this may not be true, because in this study I forced participants to think before they search. In real life, people may not spend as much

time in thinking and in selection of keywords prior to their searches. When people don't think before they search, they may have different rankings of keyword importance as Newell and Simon's problem space theory suggested. Therefore, some may argue that I did not strengthen this problem space theory. It is true that my study did not reflect how most people behave in everyday Web searching, especially in their mental effort of choosing keywords. However, I believe it is difficult, if not impossible, to implement a study probing information searchers' ranking of keywords while simultaneously simulating the everyday situation where most people don't think much prior to their searches. The studies using search engine logs are not adequate because there is no way to know information searchers' mental rankings of all keywords. To ascertain the different rankings of keyword importance as the problem space theory suggests, you must probe their rankings before the search task. If you ask people to rank after the search, their answers may be biased by their search experiences. Once you give people enough time to rank all the keywords, you force them to think through keywords, which is exactly what I did in the study. You may limit the time for people to rank the keywords to try to "simulate" the everyday situation that people only get "enough time" to rank but "not enough time" to think through the keywords. But it's difficult to know the "time" for everyone anyway because everyone's reading speed is different.

I argue that within the universe of the Internet where search process and result are instantaneous, Newell and Simon's problem space theory deserves a closer examination through using the TRICIR statistical method. I further argue that indecisiveness in extracting crucial information has a greater effect in Web searching than in traditional problem-solving activities. When you are ambivalent about keyword importance, even though your selection is as good as the efficient searcher's, you tend to make mistakes. The fact you have the freedom to change your keywords instantly in the search engine may not be a good thing—you are more prone to make mistakes because of your ambivalence. In traditional problem-solving activities which Newell and Simon studied, the ability to extract the crucial information from the exterior task and apply it to the interior problem space is critical. Perhaps in traditional problem-solving activities such as the Tower of Hanoi, people manually solve the problem which is generally a slow process. Within the realm of slow problem-solving activities, you lose the luxury of changing your solutions instantly, and it may be a good thing. As long as you can extract the crucial information from the task and apply it to your interior problem space, even with ambivalence, you may still be able to solve the problem because you stick with your solution to the end. In other words, the effect of indecisiveness magnifies in the context of Web searching and may lead to bad performance.

Problem space theory has been shown to have much to offer to researchers. I extended it to the context of Web searching, with one slightly modification—

through a different methodology. If I had only used ordinary ranking methods instead of the TRICIR method, I might not have been able to determine the relationship between the performance and rankings of keywords, because all searchers identify a similar pattern of rankings (see Table 4.20 in Chapter 4). Only through the TRICIR method can you see the different levels of performance associated with the circular triads of keyword importance. Given enough time for searchers to think through the keywords in the study, all searchers came up with the similar pattern of the ranking. There is no obvious difference in ranking of keywords in relation to performance. It is the "how sure" you are in your ranking of the keywords, which is obtained by TRICIR. This finding suggests new directions for future research.

My findings from Research Questions 2 and 3 have practical applications for successful Web searching. To make a successful search, one must form a what I call "Decisive Problem Space" before searching. A Decisive Problem Space refers to a problem space a searcher forms by making a conclusive mental organization of keywords' importance before Web searching begins. To form a Decisive Problem Space, a searcher must: 1) first think through the relative keyword importance before the search and then 2) stick with the selected keywords even if one is ambivalent about their selection. Better searchers tend to be more decisive and they stick with the keywords they select. Indecisive searchers get distracted by other information and lost in the ocean of the Internet. To be successful, one must not be

ambivalent because ambivalence allows one to become distracted and lose the focus attained through the thoughtful selection of keywords. Once distracted, it is easier to go in the wrong direction. My study suggests that after thinking through the keywords' importance, searchers' rankings will be more or less similar to the one successful searchers would choose. But searchers who follow my two-step advice will improve their chance of finding the answer. Both steps are crucial.

The second contribution uncovered in looking at Research Question 3 is a confirmation of James Greeno's (1977) process of understanding in problem-solving and its extension to the context of Web searching. Table 4.20 (see Chapter 4) shows that all groups (correct-answer, wrong-answer, timed-out) ranked in this order "Austronesian"> "Taiwan"> "Native (Aboriginal) as the most important keywords and "How" as the least important. The keyword "Austronesian" was not stated in the search task: "How did Taiwan's native (aboriginal) people communicate in writing from roughly 200 to 400 years ago?"; but it was stated in the task background statement. However, all searchers ranked "Austronesian" as the most important among the seven keywords. Greeno (1978) maintains that the process of understanding in problem solving can be analyzed in a way comparable to the analysis of understanding language. In a chapter on problem-solving abilities, Greeno states that understanding in problem solving often depends on a global theme that may be provided as contextual information. By choosing Austronesian as a significant keyword, searchers in my study demonstrated an understanding of

the contextual theme behind the search task. Thus my findings support Greeno's idea that problem solvers understand the relationships between the components of the solution and relating meaningfully to general concepts.

I adapted problem space theory, invented by the founders of Artificial Intelligence Newell and Simon, to studying subjects engaged in Web searching. My subjects searched using Google (the world's dominant search engine) whose developers, surprisingly, have been working toward the goal of an "ultimate" search engine—a version with artificial intelligence. Artificial intelligence is generally considered to be a machine-based or design issue as well as having a mechanistic element. I believe that it is important to study artificial intelligence in terms of human factors. In Research Questions 2 and 3, I link the (machine and human sides) of the goal—a search engine with artificial intelligence—and apply Simon's conclusions about problem space theory. The findings of Research Questions 2 and 3 suggest what searchers should do on keyword selections on Google, a keyword-based search engine. Also, the findings of Research Question 1 may cue Google developers to problems with its Advanced Search feature.

Search engines have become human's external memory; it has become our go-to guy, as in a recent article in *Science*, maintains: "We have become dependent on them [computer tools] to the same degree we are dependent on all the knowledge we gain from our friends and co-workers—and lose if they are out of touch (Sparrow, Liu, & Wegner, 2011)." That Google is becoming our transactive

memory is crucial to addressing the next question—what makes an efficient searcher?—which this study has addressed. I believe that this is a compelling question because when someone can use correct information to access needed information in a shorter time, that person is more productive and suited to our fast-paced information age. By using survival analysis, the findings in Research Question 1 show what NOT TO DO in web searching—do not use Google's Advanced Search. By looking at how a searcher's problem space, represented in our short-term memory, plays a role in searching, my findings in Research Questions 2 and 3 suggest what TO DO: to become an efficient searcher, think through prior searching and then stick with your decision.

5.3 Discussion of the Research Design and Confounding Variables

In every study, it is important to control for confounding factors. The researcher must ensure that his/her conclusions are not thrown off by design errors and that conscious choice-making lays the platform for solid data collection and, then, for discussing a study's limitations. I was very careful in controlling the conditions of searching on my end. As part of the process of making a Web searching platform that was fair for every subject, I sought advice. Before data collection, I posted this question on Google's Help Forum: "How do I stop Google's indexing?" Thomas P., a top contributor in Google's Web Search Forum, replied:

Simply clear all cookies between "sessions" & don't sign in to your account - that will eliminate all possibility that anything on your end changes conditions for the participants. You cannot however prevent Google from changing results over time in response to changes on websites, but as long as the participants don't span several days or weeks - you're likely fine.

Following that advice, I did the following between sessions: 1) I deleted my Google profile and made sure I did not login to my gmail account during the data collection; 2) I deleted all tracking cookies, Internet histories, etc. by using a freeware, “CCleaner;” 3) I deleted any “My favorites” created by previous subjects, and 4) I turned off Google Suggestion (Google Instant) which predicts queries and makes recommendations for you as you type in queries. In addition, as a second security door to delete cookies and browsing histories in case CCleaner was not conducted, I set the Internet Explorer (the only web browser allowed in data collection) to delete browsing history on exit. With the above procedures enforced during data collection and a research design that allowed each participant only 30 minutes to work on the search task, I sought to eliminate any possibility that something on my end could change conditions for the participants.

Though Thomas did not advise me to turn off Google Suggestion, I did it anyway because I suspected it would provide my subjects with biased recommendations. If Google Suggestion had not been turned off and kept giving query suggestions to my subjects, they could have been misled by the

recommendations which worked either in favor of or biased against the searchers. This could have hurt the study especially as regards to Research Questions 2 and 3 which looked at the relationship between how searchers selected and ranked keywords, and their search performance. Google (the company) teaches its search engine how to "learn" from users' clickings and then direct the search results to what has been referred to as a "happy zone" of "long clicks" (Levy, 2011, p. 50) (in the original text Levy used "short clicks" which is a mistake confirmed by the author, in personal communication July 25th, 2011). As Steven Levy explained in In The Plex: How Google Thinks, Works, and Shapes Our Lives (2011, p. 47), long clicks indicate that the user was satisfied (happy) about the search because he/she found a webpage that provided an answer that satisfied them, and thus ended the search; short clicks, on the other hand, indicate the user is unhappy about a particular search result and has come back for another try. Google Suggestion (now called "Google Instant") facilitates the process by providing suggestions based on the user's specific clicks. Google's direction of users to sites based on their clicking patterns deserves further examination and warrants care on the part of researchers. Take my study as an example: about 50% got wrong answers and 25% got timed out. The effect of Google Suggestion (now called Google Instant) on my study could have been disastrous: my subjects would have performed worse and worse over the 5 months of data collection if Google had updated its indexing based on its search logs and the strategy of finding "long clicks." My on-going data collection

relied on the fact that I had turned off Google Suggestion. On September 12th 2010, which luckily fell on a Sunday, I found out that Google had changed Google Suggestion (which could be turned off) to Google Instant (which did not have this option then). This sudden change which meant that I did not have the option of turning off Google Suggestion could have compromised my study. I found a solution on Google's Web Search Help forum and was able to continue my research the second day [I might add that I found the solution on Google, as I always do]. Others were also concerned about how to turn off Google Suggestion then or Google Instant now, as evidenced by queries that first appeared on September 8th 2010; this is now ranked as the ninth most popular query with 732 replies on the "How Do I…Using Google Search?" subsection of the Google's Web Search forum. Google's search engine (with the enhancement Google Instant) is far from the "ultimate version of artificial intelligence" that its designers aspire it to be. Google believes that Google Instant helps searchers but I and others are not so sure. We want the choice of being able to turn it off and have posted complaints, requests and solutions to turn this option back on. Google did respond to the complaints and gave back the option to turn Google Instant off. But only the prediction and results appear while typing, not the autocomplete (which gives you recommendations) unless you use other techniques which Google does not provide. The autocomplete does not affect your queries, but it distracts your attention and thus might affect your judgment of keyword selection.

Google incrementally updates its indexing of World Wide Web documents (Levy, 2011, p. 56), which is something I could not control as Thomas advised. The performance results, however, suggest that the study has achieved its basic goal: providing a fair and consistent search platform for all participants. Both of my samples had similar successful and unsuccessful rates in a period of five months: 28% correct in Sample A (Research Question 1) versus 24% correct in Sample B (Research Questions 2 and 3); 47% wrong in Sample A versus 47% wrong in Sample B; 26% timed-out in Sample A versus 30% timed-out Sample B. Sample A data were collected from August 6th until November 4th and Sample B data were collected between November 5th and Dec. 13th 2010. Had Google somehow, without the help of cookies and browsing histories on my computer (which I had deleted for the purpose of this study), realized the "happy" and "unhappy" queries and responded quickly, the successful and unsuccessful pattern would have been very different between the two samples. If I had not enforced the above procedures throughout the study, if I had not turned off Google Suggestion, and if Google had somehow figured out my search task and changed its search returns, the confounding variables would have made my data invalid.

5.4 Limitations

There are several limitations to this study. First, the sample was mainly university students. Of the 174 participants in both Sample A and Sample B,

there were 86 for Research Question 1 and 88 for Research Questions 2 and 3; about 90% (158) of them were undergraduate or graduate students. These student participants may or may not be representative of the larger population. At best, the findings can be generalized to the student population at University of Hawaii at Manoa.

A second limitation may be that that only one task was studied. Based on the theories and literature situating Web searching as an everyday problem-solving task, I probed three research questions using the same task. The study of more tasks might have produced different results, but using one task made it possible to make comparisons because the research questions were related. There are, of course, limitations around the task itself: for example, the difficulty of the task. I set a task difficult enough to be appropriate to the research questions. I asked how Taiwan's native (aboriginal) people communicated in writing from roughly 200 to 400 years ago. About half of the participants got the wrong answer; one quarter got timed-out; and one quarter got the correct answer. To simulate everyday Web searching, the task had to be interesting enough for searchers to engage in a search process, but not a task whose answer is already known. The task was chosen because its background is related to, but not about, Hawaii. Given the time limit of the research design, the limited knowledge I had about American culture, and the knowledge I had about Taiwan, I chose this particular task because of the likelihood that participants would not know the answer. Choosing an appropriate research task

involving Web searching will always be difficult. There are millions, perhaps billions, of queries each day on Google; it is impossible to find one search task that can be representative of all possible queries. Theoretically, many other search tasks would have qualified for the study, but they may not have had a similar level of difficulty. I believe that my chosen task as well as the use of one task for all three questions, rather than more tasks at varying levels of difficulty, was effective for this study.

A third possible limitation was that the controlled environment may have encouraged participants to act in abnormal ways and may have produced artificial results. Participants were closely monitored and they were under time pressure. This may not reflect the real-life situation where searchers perform search tasks without being monitored. Performance may be changed in a monitored environment. Unfortunately, this is an inevitable tradeoff when web searching research is observational rather than reliant on the study of search logs. Search log studies have their inherent problems (see Section 5.2) which this study was designed to avoid. Second, limitations were introduced because each participant worked on the search task on a computer which was configured to minimize factors that could affect performance. For fairness and accuracy reasons, I turned off Google Instant (then Google Suggestion). Google Suggestion predicts and recommends queries before you finish typing a query. Google Instant not only offers what Google Suggestion did but shows you the results on the fly as you

change your query. This search enhancement is a default setting on Google, and thus is a prevalent feature in everyday searching. I made the situation artificial by turning off this enhancement because its effects of performance—especially the selection of keywords. But setting up a controlled environment is a necessary part of studying behavior in ways that make comparison and generalization possible. Some limitations induced by this are an inevitable factor in most research.

5.5 Future Research

The results of this study have several implications for future research. This section will detail recommendations for research in the following areas: 1) the relationship between search performance and changes of confidence before and after the search task; 2) the relationship between query terms (keyword) selection and effective Web searching; 3) exploration of importance of mental organization of sets of keywords ; 4) the relationship between search performance and individual differences in engaging in evaluation; 5) the relationship between under-confident and over-confident searchers, and timely successful Web searches; 6) exploration of differences in the understanding of keyword search engine across levels of search performance; 7) inquiries into why efficient searchers visit more correct websites than non-efficient searchers and why some non-efficient searchers almost got the correct answer but did not; and 8) investigation into the relationship of

searchers' clicking behavior in an environment where "Net Neutrality" (see below) is not valued.

First, the study found that problem-solving confidence and self-efficacy are different concepts in Web searching and they affect performance differently. The two concepts were measured before the search task and the searchers were not told whether they had found the correct answer. If after the task we know how confident the searchers are that their answers are correct, we can answer this question "Did searchers subconsciously know their answers are correct or not?" Are there changes in searchers' confidence about finding the correct answer before and after the search task? If there are, are the changes related to their performance? Are the changes the same between the correct-answer group and the wrong-answer group? Finding the answers to the above questions can help us to further understand the "gut" feeling of successful searches through the changes of confidence before and after the search task.

Second, through the findings of Research Question 1 we knew what *not* to do to achieve successful searches in a timely manner—do not use Google's Advanced Search—and what helps to achieve that goal—task-specific self-efficacy. I believe future research might be helpful finding out exactly what to do to achieve that goal. Some researchers suggest that the query terms are the most important factor in Web searching. But what makes a good search query? Is there an approach to selecting keywords that we may learn from efficient searchers? If

we know what to do (from future research) and what not to do (by applying lessons from this study), we may be able to provide specific guidance in how to achieve a timely successful search—an important goal in an age where search engines are ubiquitous and we want our searches to be effective and efficient.

Third, this study found that the mental organization of keyword importance is related to search performance by asking subjects to rank individual keywords. However, in real life people query in one set of keywords at a time. They usually try different sets of keywords on search engines until they find the answer they want. Future research might probe whether there is a clear mental organization of the importance of sets of keywords. If there is, which kind of mental organization—perhaps the choice to use individual keywords versus sets of keywords—is associated with stronger search performance? In other words, if the mental organization of sets of keywords is associated with stronger search performance than that of individual keywords, we should advocate that people think through the relative importance between different sets of keywords rather than between individual keywords as suggested in this study.

Fourth, since the mental organization of (individual) keyword importance is related to search performance, I suggest in this study that searchers think through the keywords before they search and stick with their decision throughout the process of search task (see Section 5.2.2). This suggestion is based on the problem space theory of Newell and Simon and my findings. However, it would be

interesting to explore what makes efficient searchers more decisive in choosing keywords and sticking to their choices. Is it something that can be trained? Some research suggests that people are different in the extent to which they engage in chronic evaluating. That is, some people always evaluate things around them while some people seldom do that except when they are forced to. If we can find a theory that can explain why some people are more decisive and also be applied to train people, we will contribute greatly to effective Web searching.

Fifth, this study found self-efficacy helps Web searches to be timely and successful. However, other concepts related to self-efficacy may be worthy of future research, such as over- and under-confidence. Is it always true that the higher the self-efficacy the better in terms of performance? Some researchers argue that over-confidence may work against you while others argue the opposite: under-confidence works against performance. Can we take and test this argument in a Web searching situation by asking: Does under/over-confidence affect timely successful Web searching?

Sixth, I think it would be valuable to do qualitative research around the issue of whether there is a difference in understanding the use of keywords in search engines between searchers of different performance? With the keyword-based search engines such as Google and Yahoo dominating the Internet, this is a fundamental question. Keyword-based search engines, as implied by the name, rely on the keywords users enter to search. Do efficient searchers have a better

understanding of using keywords than inefficient searchers? If the answer is yes, what is the basis of mistakes in misunderstandings concerning the use of keywords on (keyword-based) search engines? The answer to these questions would be helpful in forging practical pedagogical lessons for Web searchers.

Seventh, I have some other observations. In this study I found that efficient searchers visited more correct websites than non-efficient searchers. Was it because the efficient searchers tend to seek multiple sources of the same answer before they selected their final answer? Was it because they are more careful or less confident in themselves? Besides, through observation, I found some people were close to finding the correct answer, and actually in the websites where other people had found the correct answer, however, they jumped away. Was it because they were careless, impatient in reading through the text, or were they distracted by other clues? These questions need study. The generation of these research questions seems to indicate the value of empirical studies with human participation; finding the answers would be more difficult if one studied search logs. The questions posted above form the basis of future research that I am interested in undertaking. If we can identify the sources of how some people "almost got" the correct answer but did not, we can probably improve the speed and rate of success.

Eighth, I am interested in investigating searchers' clicking patterns in the context of Net Neutrality. Net Neutrality refers to an idea that a maximally useful public information network aspires to treat all content, sites, and platforms equally

(Wu, 2003). In discussing the importance of Net Neutrality, Sir Tim Berners-Lee, the father of the Web, commented on his blog:

> *The Internet is increasingly becoming the dominant medium binding us. The neutral communications medium is essential to our society. It is the basis of a fair competitive market economy. It is the basis of democracy, by which a community should decide what to do. It is the basis of science, by which humankind should decide what is true.* (Berners-Lee, 2006)

Net Neutrality is thus a key issue and it can be affected by Google's use of a "long clicks" (staying on website for a longer period of time) algorithm to identify whether a webpage satisfies a searcher or not. Short clicks (moving onto other web sites fairly quickly), on the other hand, indicate the user is unhappy about a particular search result and coming back for another try, another query or another hyperlink. The implication is that successful searchers should spend more time on reading or browsing websites than the unsuccessful searchers. In this study, data were collected in an environment in which all content was treated equally. I found that on average each searcher in the correct-answer group spent 38.43 seconds on reading (browsing) one webpage; wrong-answer group, 36.32 seconds; timed-out group, 34.64 seconds. While not statistically significant, this shows the pattern that successful searchers may spend more time on reading or browsing web pages than unsuccessful. This trend fits the basic idea of Google's "long clicks" algorithm.

What interests me is how this “long clicks” algorithm works in an environment where Net Neutrality is not valued—say in an authoritarian environment.

In summary, this study has spoken to Betsy Sparrow et al.’s conclusion in *Science* (2011) : “The experience of losing our Internet connection becomes more and more like losing a friend. We must remain plugged in to know what Google knows.” This study suggests what *not to do* and what *to do* when searching with Google; the above future research opens up research avenues which I aspire to explore.

Appendix A: Confidence Questionnaire

Directions [1]
People respond to personal problems in different ways. The statements on this inventory deal with how people react to personal difficulties and problems in their day-to-day life. The term "problems" refers to personal problems that everyone experiences at times, such as depression, inability to get along with others, choosing a vocation, or deciding whether to get a divorce. Please respond to the items as honestly as possible so as to most accurately portray how you handle such personal problems. Your responses should reflect what you actually do to solve problems, not how you think you should solve them. When you read an item, ask yourself: Do I ever behave this way? Please answer every item.

Your responses will be kept confidential and only used for research. Read each statement and indicate the extent to which you agree or disagree with that statement, using the scale provided. Mark your responses by circling the number to the right of each statement.

1	2	3	4	5	6
Strongly Disagree	Moderately Disagree	Slightly Disagree	Slightly Agree	Moderately Agree	Strongly Agree

1. I am usually able to think of creative and effective alternatives to my problems.

   1 2 3 4 5 6

2. I have the ability to solve most problems even though initially no solution is immediately apparent.

   1 2 3 4 5 6

3. Many of the problems I face are too complex for me to solve.

   1 2 3 4 5 6

4. When solving a problem, I make decisions that I am happy with later.

[1] This questionnaire is developed by Heppner (1988).

1 2 3 4 5 6

5. When I make plans to solve a problem, I am almost certain that I can make them work.

1 2 3 4 5 6

6. Given enough time and effort, I believe I can solve most problems that confront me.

1 2 3 4 5 6

7. When faced with a novel situation, I have confidence that I can handle problems that may arise.

1 2 3 4 5 6

8. I trust my ability to solve new and difficult problems.

1 2 3 4 5 6

9. After making a decision, the actual outcome is usually similar to what I had anticipated.

1 2 3 4 5 6

10. When confronted with a problem, I am unsure of whether I can handle the situation.

1 2 3 4 5 6

11. When I become aware of a problem, one of the first things I do is try to find out exactly what the problem is.

1 2 3 4 5 6

Appendix B: Search Skill Questionnaire

Please answer each of the following questions by clicking only one of choices.

1. What does pressing "Ctrl+F" (press both Ctrl and F at the same time) do when you are viewing a page in Internet Explorer (the Internet browser)?

A. Don't know
B. It brings up the File Menu
C. It brings up the Find function, normally found under menu Edit > Find
D. It maximizes the screen (makes the window/page as large as the screen)
E. It closes the window/page (normally found under File > Close)

2. How often do you use "Ctrl+F"?

   A. Never
   B. Occasionally
   C. Sometimes
   D. Very often
   E. Always

3. What happens when you press "Alt+Tab" (both Alt and Tab at the same time)?

   A. Don't know
   B. It switches between windows
   C. It selects the next link on the page.
   D. It selects the previous link on the page
   E. It works in Microsoft Word as Tab key inside a table

4. How often do you use "Alt+Tab"?
   A. Never
   B. Occasionally
   C. Sometimes
   D. Often
   E. Always

5. When you browse the Internet, do you use the right button on the mouse to bring up a short cut menu?

A. Never
B. Occasionally
C. Sometimes
D. Often
E. Always

6. When you search the Internet, do you use the “cached” function/link provided by search engines?

   A. Never
   B. Occasionally
   C. Sometimes
   D. Often
   E. Always

7. When you browse the Internet, do you use the “tabbed browsing” (load Web pages in separate tabs of a single browser window)?

   A. Never
   B. Occasionally
   C. Sometimes
   D. Often
   E. Always

8. What does "URL" mean?

   A. Universal Registry Locator
   B. Uniform Reference Link
   C. Unbound Reference Link
   D. Uniform/ Universal Resource Locator
   E. Don't know

9. What does "http" stand for?

A. hypertext twisted pair
B. hyperlink transfer protocol
C. hyperlink transfer placard
D. hypertext transfer protocol
E. Don't know

10. What does "https" stand for?

A. http secure
B. http system
C. http socket
D. http simplified
E. Don't know

11. How often do you encounter “https” on the Internet?

A. Never
B. Occasionally
C. Sometimes
D. Often
E. Always

12. When you use Google or other search engines, do you use its advanced search function?

A. Never
B. Occasionally
C. Sometimes
D. Often
E. Always

13. When you use Google or other search engines, do you use the “or” operator which specifically allow the search engine to search either one of several words you type in a search query?

A. Never
B. Occasionally
C. Sometimes
D. Often
E. Always

14. When you use Google or other search engines, do you use the “phrase search” which tells the search engine to search the exact words you type in that exact order without any change?

A. Never
B. Occasionally
C. Sometimes
D. Often
E. Always

15. When you use Google or other search engines, do you use the “exclude” function which tells the search engine to do a webpage search that do not contain the word(s) you type?

A. Never
B. Occasionally
C. Sometimes
D. Often
E. Always

16. When you use Google or other search engines, do you use the language selection function which tells the search engine to search only for pages written in the specific language you specify?

A. Never
B. Occasionally
C. Sometimes
D. Often
E. Always

Appendix C: Instructions for the Study (Dos and Donts)

You are asked to do a "search task" on the Internet. You have 30 minutes to work on it. The followings are what you can and can't do during the experiment.

Dos:

1. For consistency reason of this study please ONLY use Google as your search engine.

2. When you think a website may be helpful during the search, you may add the webpage onto "Helpful webpages" folder under the "favorites" of Internet Explorer (Note, it's optional. You can add as few as none to as many as you want onto "Helpful webpages" folder.).

3. When you find the answer that you think it is correct, add the webpage that contains the answer onto "**My answer**" folder under the "favorites" of Internet Explorer (Note, please do so ONLY when you are sure. You should add only **one** answer onto "My answer" folder.).

4. Please fill out the survey questions after the task.

5. Except the "don't" below, please feel free to do anything you like to do the search task.

Don't:

1. When you work on this computer for the search task, please do NOT change any Windows and Internet Explorer browser's Internet options settings or install any program.

2. Please do NOT turn off any programs except your browser.

3. Do NOT use other search engines at any time in this study, except Google.

4. For consistency and fairness reason please do NOT turn the Google query suggestion back on during your search.

5. Please do not ask the monitor for assistance. The monitor would not be able to provide you assistance.

Appendix D: Task

Task background statement: "Members of the Austronesian race live in a vast area, roughly half the globe, extending from Madagascar in the west to Hawaii and Easter Island in the east, and from New Zealand in the south to Taiwan in the north. Austronesians are one of the indigenous or aboriginal people in the area which consists of many countries. The populations in these countries are diversified now. Some linguistic scholars suggest that Taiwan is the original homeland of all Austronesians, because the internal diversity among the Taiwanese native peoples' languages is greater than that of all the rest of Austronesia put together."

Searching task: Assume you are assigned to do homework by a professor. The homework question is "How did Taiwan's native (aboriginal) people communicate in writing from roughly 200 to 400 years ago?"

Appendix E: Self-Efficacy Questionnaire

Before you start the task

1. How confident do you think you are that you can find the answer in 30 minutes? (check one only)

□1	□2	□3	□4	□5	□6	□7
Not at all confident			Neutral			Very confident

2. How much time, in minutes, do you think you need to find the answer? (Please answer it with the narrowest time period possible. For instance, with range of 2-3 minutes.)
   Answer:

3. How confident do you think your answer is correct if you find the answer? (check one only)

□1	□2	□3	□4	□5	□6	□7
Not at all confident			Neutral			Very confident

4. How likely do you think it is that you can *NOT* find the answer in 30 minutes? (check one only)

□1	□2	□3	□4	□5	□6	□7
Not at all likely			Neutral			Very likely

5. How do you rate your ability on Web information seeking? (check one only)

□1	□2	□3	□4	□5	□6	□7
Poor			Neutral			Excellent

6. What do you estimate as the difficulty level of this task? (check one only)

□1	□2	□3	□4	□5	□6	□7
Not at all difficult			Neutral			Very difficult

Appendix F: Post-Task Questionnaire-Form A

1. Without looking at a watch, how long do you think you have spent on the task? (Please answer it with specific number as possible, or with a range of 2-3 minutes.)
   Answer:

2. What is your answer to the question "How did Taiwan's native (aboriginal) people communicate in writing from roughly 200 to 400 years ago? (Please give only one answer)
   Answer:

3. How confident are you that your answer is correct? (check one only)

□1	□2	□3	□4	□5	□6	□7
Not at all confident			Neutral			Very confident

4. How do you rate your ability on Web information seeking now? (check one only)

□1	□2	□3	□4	□5	□6	□7
Poor			Neutral			Excellent

5. How do you rate the difficulty level of the task now? (check one only)

□1	□2	□3	□4	□5	□6	□7
Not at all difficult			Neutral			Very difficult

6. Why do you think you were able to finish the task in the allotted time?

_____
_____
_____
_____
_____
_____
_____
_____

Appendix G: Post-Task Questionnaire-Form B

1. Given enough time, how confident do you think you could find the answer?

□1	□2	□3	□4	□5	□6	□7
Not at all confident			Neutral			Very confident

2. Approximately how much time (in minutes) in total do you think you may need to be able to find the answer?

   Answer:
   _____ minutes

3. How do you rate your ability on Web information seeking now? (check one only)

□1	□2	□3	□4	□5	□6	□7
Poor			Neutral			Excellent

4. How do you rate the difficulty level of the task now? (check one only)

□1	□2	□3	□4	□5	□6	□7
Not at all difficult			Neutral			Very difficult

5. Why do you think you were unable to finish the task in the allotted time?

_____
_____
_____
_____
_____
_____

Appendix H: Background Questionnaire

1. Age:

2. Circle Gender: M F

3. Check the category which best describe your status now
_____College undergraduate student
_____Graduate student
_____Doctoral student
_____Working
_____Retired
_____Other

4. What is/was your major/department? _____

5. Which of the following best describe the field you are studying now or you graduated from? (circle one only)

Natural Science	Engineering	Business School
Law School	Medical School	Social Science
Education	Music/ Fine Arts	Other _____
		please specify

6. Highest degree level attained: _____

7. What is your nationality:_____

8. How do you think the keywords affected your performance on this task?
_____
_____
_____
_____
_____
_____
_____

Please rate the following questions, from 1 to 7. (check only one)

9. What is your **general** feeling about yourself and ability?

□1	□2	□3	□4	□5	□6	□7
Not at all good			Neutral			Very good

10. How confident did you feel doing this **particular** task?

□1	□2	□3	□4	□5	□6	□7
Not at all confident			Neutral			Very confident

11. How do you evaluate your search skill on Web information search?

□1	□2	□3	□4	□5	□6	□7
Not at all good			Neutral			Very good

Thank you so very much for your participation. I really appreciate your help! For consistency, fairness, and accuracy reason, please DO NOT reveal the search task to other people and I would prefer you NOT to continue the search task at home. If you are interested to know the answer, please contact me later. I will be more than happy to share my findings when I finish my doctoral dissertation (hopefully in one year!).

Appendix I: Mental Organization of Keyword Importance Questionnaire

Example:
Someone ranked the following three items in order of their importance:

Item A	*Item B*	*Item C*
2	*1*	*3*

In this comparison item B is more important than item A, and item A is more important than item C.

You are going to rank order each of the following combinations of keywords (I to VII), according to their importance in finding the answer. 1 meaning the most important keyword, 2 the second, and 3 the least important keyword. (Only use 1, 2, and 3 to rank order **each** comparison.)

I.	Austronesian _____	How ___	Native (Aboriginal) _____
II.	How ___	Taiwan _____	Communicate _____
III.	Taiwan _____	Native (Aboriginal) _____	Writing _____
IV.	Native (Aboriginal) _____	Communicate _____	200 to 400 years ago _____
V.	Communicate _____	Writing _____	Austronesian _____
VI.	Writing _____	200 to 400 years ago _____	How _____
VII.	200 to 400 years ago _____	Austronesian _____	Taiwan _____

Appendix J: An Example Using Survival Analysis

An example of how survival analysis has been used is a study by Rossi et al. (1980) in which 432 inmates released from Maryland state prisons were followed to see if they were rearrested within a one-year period. The researchers were interested in recidivism (a tendency to relapse into a previous condition or mode of behavior; especially: relapse into criminal behavior). They did not use traditional logistical regression analysis because they wanted to factor in the time of re-arrest (i.e. whether the released prisoner was rearrested in a week or later). The event of interest in that study was the first arrest after release from jail. The aim was to determine how the occurrence and timing of arrests depended on several predictor variables. One possibility was to perform a logit (logistic regression) analysis with a dichotomous dependent variable: "arrested" or "not arrested." But this analysis ignores information on the timing of arrests. Ignoring such information would have reduced the precision of the estimates. One solution to this problem would be to make the dependent variable the length of time between release and first arrest and then estimate a conventional linear regression model. But what do you do with the persons who were not arrested during the one-year follow-up? Such cases are referred to as censored. A biased estimate occurs either if you discard the censored cases or you set the time of arrest at one year for all those who were not arrested. "Censored cases are those for whom the time of the event being studies (dropout, death, failure, graduation) is unknown" (Tabachnick & Fidell, 2007). To deal with censored data, survival analysis is more accurate than other statistical analyses.

Appendix K: Agreement to Participate in Research

Title of Study
Personal factors and the efficiency of Web information searching.

Investigator: Jeng-Her (Alex) Chen PhD Candidate.

Faculty Supervisor: Rebecca Knuth
Library & Information Science Program
Information & Computer Sciences Department
Hamilton Library 3D
2550 McCarthy Mall
Honolulu, HI 96822
Phone: (808) 956-5810

Purpose of Research Study
To investigate the relationship between personal factors and the Web information searching.

If you agree to participate in this research, you will be asked to do the following things:

1. Provide information on the questionnaires provided by the investigator.
2. The questionnaires ask you your confidence levels, search skills and keywords preferences in Web information search, and your general background information (answer in anonymous way).
3. Perform a Web information search task on the computer provided by the investigator.
4. Your Web search behavior will be recorded the internet monitoring and surveillance software.
5. The study will take approximately 30 to 60 minutes in total.
6. The research will involve approximately 160 participants.

Your Rights To Confidentiality
Your anonymity will be preserved. You will not provide your identity on either the questionnaire or the answer sheet. Individual results will neither be reported, nor provided to anyone outside of the investigators and their University of Hawaii-Manoa faculty advisors.

To Ask Questions at Any Time
You may ask questions about the research at any time. Call the investigator at (808) 955-2596 Jeng-Her (Alex) Chen. If the investigator cannot answer your questions,

contact the faculty supervisor at (808) 956-5810 Dr. Rebecca Knuth.

To Withdraw at Any Time
You may withdraw from the study at any time, and you may require that your data be destroyed, without any consequences or loss of compensation.

Compensation
I will provide you with feedback on your performance (in the form of whether your search answer is correct or not, and the time (in second) you spend on the search task).

Possible Risks
None.

Signature
I certify that I have read and understand the above, that I have been given satisfactory answers to any questions about the research, and that I have been advised that I am free to withdraw my consent and to discontinue participation in the research at any time, without any prejudice or loss of compensation.

I agree to be a part of this study with the understanding that such permission does not take away any of my rights, nor does it release the investigator or the institution (or any agent or employee thereof) from liability for negligence.

If I cannot obtain satisfactory answers to my questions, or have comments or complaints about my participation in this study, I may contact: Committee on Human Studies (CHS), University of Hawaii, 2540 Maile Way, Honolulu, HI 96822. Phone: (808) 956-5007.

(print your name) (date)

--- ---

(signature)

References

Advanced Search Tips. Retrieved July 8, 2011, from http://www.google.com/support/websearch/bin/answer.py?answer=35890

Allison, P. D. (1995). *Survival analysis using SAS: A practical guide.* Cary, NC: SAS Institute.

Bandura, A. (1977a). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review, 84*(2), 191-215.

Bandura, A. (1977b). *Social learning theory*. Englewood Cliffs, NJ: Prentice-Hall.

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory.* Englewood Cliffs, NJ: Prentice-Hall.

Bandura, A. (1995). On rectifying conceptual ecumemism. In J. E. Maddux (Ed.), *Self- efficacy, adaptation, and adjustment: Theory, research, and application* (pp. 347- 375). New York, NY: Plenum.

Bandura, A., & Cervone, D. (1983). Self-evaluative and self-efficacy mechanisms governing the motivational effects of goal systems. *Journal of Personality and Social Psychology, 45*(5), 1017-1028.

Bandura, A., & Locke, E. A. (2003). Negative self-efficacy and goal effects revisited. *Journal of Applied Psychology, 88*(1), 87-99.

Bandura, A., & Schunk, D. H. (1981). Cultivating competence, self-efficacy, and intrinsic interest through proximal self-motivation. *Journal of Personality and Social Psychology*, *41*(3), 586-598.

Berners-Lee, S. T. (2006). Neutrality of the Net. Retrieved from http://dig.csail.mit.edu/breadcrumbs/blog/4

Blust, R. (1999). Subgrouping, circularity and extinction: Some issues in Austronesian comparative linguistics. In E. Zeitoun & P. J.-k. Li (Eds.), *Selected papers from the Eighth International Conference on Austronesian Linguistics* (pp. 31-94). Taipei: Academia Sinica.

Brown, I., & Inouye, D. K. (1978). Learned helplessness through modeling: The role of perceived similarity in competence. *Journal of Personality and Social Psychology*, *36*(8), 900-908.

Carroll, J. M. (Ed.). (2003). *HCI models, theories, and frameworks: Toward a multidisciplinary science*. San Francisco, CA: Morgan Kaufmann Publishers.

Chi, M. T. H., & Glaser, R. (1985). Problem solving ability. In R. J. Sternberg (Ed.), *Human abilities: An information processing approach* (pp. 227-250). New York, NY: Freeman.

Cockburn, A., & Jones, S. (1996). Which way now? Analysing and easing inadequacies in WWW navigation. *International Journal of Human-Computer Studies*, *45*(1), 105-129.

Compeau, D. R., & Higgins, C. A. (1995a). Application of social cognitive theory to training for computer skills. *Information Systems Research, 6*(2), 118-143.

Compeau, D. R., & Higgins, C. A. (1995b). Computer self-efficacy: Development of a measure and initial test. *MIS Quarterly, 19*(2), 189.

Compeau, D. R., & Higgins, C. A. (1999). Social cognitive theory and individual reactions to computing technology: A longitudinal study. *MIS Quarterly, 23*(2).

Comrie, B. (2001). Languages of the world. In M. Aronoff & J. Rees-Miller (Eds.), *The handbook of linquistics* (pp. 19-42). Oxford: Blackwell.

D'Zurilla, T. J., & Goldfried, M. R. (1971). Problem solving and behavior modification. *Journal of Abnormal Psychology, 78*(1), 107-126.

Debowski, S., Wood, R. E., & Bandura, A. (2001). Impact of guided exploration and enactive exploration on self-regulatory mechanisms and information acquisition through electronic search. *Journal of Applied Psychology, 86*(6), 1129-1141.

Dennis, A. R., & Taylor, N. J. (2006). Information foraging on the web: The effects of "acceptable" Internet delays on multi-page information search behavior. *Decision Support Systems, 42*(2), 810-824. doi: 10.1016/j.dss.2005.05.032

DeVellis, R. F. (2003). *Scale development: Theory and applications* (2nd ed.). Thousand Oaks, CA: Sage Publications.

Dixon, W. A., Heppner, P. P., & Anderson, W. P. (1991). Problem-solving appraisal, stress, hopelessness, and suicide ideation in a college population. *Journal of Counseling Psychology, 38*(1), 51-56.

Dixon, W. A., Heppner, P. P., & Rudd, M. D. (1994). Problem-solving appraisal, hopelessness, and suicide ideation: Evidence for a mediational model. *Journal of Counseling Psychology, 41*(1), 91-98.

Donohew, L., & Tipton., L. (1973). A conceptual model of information seeking, avoiding and processing. In P. Clark (Ed.), *New models of communication research.* Newbury Park, CA: Sage Publications.

Dorst, K., & Cross, N. (2001). Creativity in the design process: co-evolution of problem-solution. *Design Studies, 22*(5), 425-437. doi: 10.1016/s0142-694x(01)00009-6

Dumais, S. (2002). *Web experiments and test collections.* Paper presented at the 11th International World Wide Web Conference, Honolulu, HI. http://www2002.org/presentations/dumais.pdf

Dunn-Rankin, P., Knezek, G. A., Wallace, S., & Zhang, S. (2004). *Scaling methods.* (2nd ed.). Mahwah, NJ: Lawrence Erlbaum Associates.

Eastman, C. M., & Jansen, B. J. (2003). Coverage, relevance, and ranking: The impact of query operators on Web search engine results. *ACM Trans. Inf. Syst., 21*(4), 383-411. doi: 10.1145/944012.944015

Edmunds, A., & Morris, A. (2000). The problem of information overload in business organisations: A review of the literature. *International Journal of Information Management, 20*(1), 17-28.

Elliott, T. R., Godshall, F., Shrout, J. R., & Witty, T. E. (1990). Problem-solving appraisal, self-reported study habits, and performance of academically at-risk college students. *Journal of Counseling Psychology, 37*(2), 203-207.

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

Gagne, R. M. (1964). Problem solving. In A. W. Melton (Ed.), *Categories of human learning*. New York, NY: Academic Press.

Given, L. M. (2002). The academic and the everyday: Investigating the overlap in mature undergraduates' information-seeking behaviors. *Library & Information Science Research, 24*(1), 17-29.

Google Japan Homepage. Retrieved July 12, 2011, from http://www.google.co.jp/

Google Taiwan Homepage. Retrieved July 12, 2011, from http://www.google.com.tw/

Google UK Homepage. Retrieved July 12, 2011, from http://www.google.co.uk/

Google US Homepage. Retrieved July 12, 2011, from www.google.com

Greeno, J. G. (1978). Natures of problem-solving abilities. In W. Estes (Ed.), *Handbook of learning and cognitive processes.* (Vol. 5 Human Information Processing, pp. 239-270). Hillsdale, NJ: Lawrence Erlbaum Associates.

Halttunen, K. (2003). Students' conceptions of information retrieval – Implications for the design of learning environments. *Library & Information Science Research*, *25*(3), 307-332.

Heinström, J. (2005). Fast surfing, broad scanning and deep diving: The influence of personality and study approach on students' information-seeking behavior. *Journal of Documentation 61*(2), 228 - 247

Heppner, P. P. (1978). A review of the problem-solving literature and its relationship to the counseling process. *Journal of Counseling Psychology*, *25*(5).

Heppner, P. P. (1988). The problem solving inventory. Mountain View, CA: CPP.

Heppner, P. P., & Krauskopf, C. J. (1987). An information-processing approach to personal problem solving. *The Counseling Psychologist*, *15*(3), 371-447.

Heppner, P. P., & Petersen, C. H. (1982). The development and implications of a personal problem-solving inventory. *Journal of Counseling Psychology*, *29*(1), 66-75.

Heppner, P. P., Pretorius, T. B., Wei, M., Lee, D.-g., & Wang, Y.-W. (2002). Examining the generalizability of problem-solving appraisal in Black South Africans. *Journal of Counseling Psychology*, *49*(4), 484-498.

Heppner, P. P., Witty, T. E., & Dixon, W. A. (2004). Problem-solving appraisal and human adjustment: A review of 20 Years of research using the problem solving inventory. *The Counseling Psychologist, 32*(3), 344-428. doi: 10.1177/0011000003262793

How do I turn off autocomplete? Retrieved July 20, 2011, from http://www.google.com/support/forum/p/Web+Search/thread?tid=5a69f1094357f31b&hl=en

Jansen, B. J., Spink, A., & Saracevic, T. (2000). Real life, real users, and real needs: A study and analysis of user queries on the web. *Information Processing & Management, 36*(2), 207-227.

Johnson, T. J., & Kaye, B. K. (2003). Around the World Wide Web in 80 ways: How motives for going online are linked to Internet activities among politically interested Internet users. *Social Science Computer Review, 21*(3), 304-325. doi: 10.1177/0894439303253976

Kari, J., & Savolainen, R. (2007). Relationships between information seeking and context: A qualitative study of Internet searching and the goals of personal development. *Library & Information Science Research, 29*(1), 47-69.

Kim, K. S., & Sin, S. C. J. (2007). Perception and selection of information sources by undergraduate students: Effects of avoidant style, confidence, and personal control in problem-solving. *Journal of Academic Librarianship, 33*(6), 655-665.

Kirsch, I. (1995). Self- efficacy and outcome expectancies: A concluding commentary. In J. E. Maddux (Ed.), *Self- efficacy, adaptation, and adjustment: Theory, research, and application* (pp. 331- 345). New York, NY: Plenum.

Kohler, W. (1925). *The mentality of apes* (E. Winter, Trans.). New York, NY: Harcourt, Brace.

Krikelas, J. (1983). Information-seeking behavior: Patterns and concepts. *Drexel Library Quarterly, 19*, 5-20.

Kuhlthau, C. C. (1991). Inside the search process: Information seeking from the user's perspective. *Journal of the American Society for Information Science, 42*(5), 361-371.

Kuhlthau, C. C. (1993). *Seeking meaning: A process approach to library and information services*. Norwood, NJ: Ablex Corporation.

Kuo, F. Y., Chu, T. H., Hsu, M. H., & Hsieh, H. S. (2004). An investigation of effort-accuracy trade-off and the impact of self-efficacy on Web searching behaviors. *Decision Support Systems, 37*(3), 331-342.

Lau, T., & Horvitz, E. (1999). Patterns of search: Analyzing and modeling Web query refinement. *Proceedings of the 7th International Conference on User Modeling*, 119-128.

Leckie, G. J., Pettigrew, K. E., & Sylvain, C. (1996). Modeling the information seeking of professionals: A general model derived from research on

engineers, health care professionals, and lawyers. *The Library Quarterly, 66*(2), 161-193.

Levy, S. (2011). *In the plex: How Google thinks, works, and shapes our lives* New York, NY: Simon & Schuster

Liu, J., Zhang, S., & Yang, J. (2004). Characterizing Web usage regularities with information foraging agents. *Knowledge and Data Engineering, IEEE Transactions on, 16*(5), 566-584.

Lopez, S. J., & Janowski, K. M. (2004). The power of positive problem-solving appraisal: Comments on incremental validity, relationships with adjustment, and clinical utility. *The Counseling Psychologist, 32*(3), 460-465. doi: 10.1177/0011000003262798

Lucas, M. S. (2004). Problem-solving appraisal in counseling and with different populations. *The Counseling Psychologist, 32*(3), 450-459. doi: 10.1177/0011000003262797

Maddux, J. E. (1999). Expectancies and the social-cognitive perspective: Basic principles, processes, and variables. In I. Kirsch (Ed.), *How expectancies shape experience* (pp. 17- 39). Washington, DC: American Psychological Association.

Maddux, J. E. (2005). Self-efficacy: The power of believing you can. In C. R. Snyder & S. J. Lopez (Eds.), *Handbook of positive psychology* (pp. 277-287). New York, NY: Oxford University Press.

Maddux, J. E., Brawley, L., & Boykin, A. (1995). Self-efficacy and healthy behavior: Prevention, promotion, and detection. In J. E. Maddux (Ed.), *Self-efficacy, adaptation, and adjustment: Theory, research, and application* (pp. 173- 202). New York, NY: Plenum.

Maddux, J. E., & Lewis, J. (1995). Self-efficacy and adjustment: Basic principles and issues. In J. E. Maddux (Ed.), *Self- efficacy, adaptation, and adjustment: Theory, research, and application* (pp. 37-68). New York, NY: Plenum.

Maddux, J. E., & Meier, L. J. (1995). Self-efficacy and depression. In J. E. Maddux (Ed.), *Self- efficacy, adaptation, and adjustment: Theory, research, and application* (pp. 143-169). New York, NY: Plenum.

Maddux, J. E., & Rogers, R. W. (1983). Protection motivation and self-efficacy: A revised theory of fear appeals and attitude change. *Journal of Experimental Social Psychology, 19*(5), 469-479.

Maddux, J. E., & Snyder, C. R. (1997). Self-regulation: The pursuit of goals. In David F. Barone, James E. Maddux & C. R. Snyder (Eds.), *Social cognitive psychology: history and current domains* (pp. 277). New York, NY: Plenum

Maier, N. R. F. (1970). *Problem solving and creativity*. Belmont, CA: Brooks/Cole.

Making the World's Information Accessible. Retrieved July 20, 2011, from http://www.achievement.org/autodoc/page/pag0int-3

Marchionini, G. (1995). *Information seeking in electronic environments*. Cambridge, United Kingtom: Cambridge University Press.

More Search Help. Retrieved July 8, 2011, from http://www.google.com/support/websearch/bin/static.py?hl=en&page=guide.cs&guide=1221265&answer=136861&rd=1

Newell, A., Shaw, J. C., & Simon, H. A. (1958). Elements of a theory of human problem solving. *Psychological Review*, *65*(3), 151-166.

Newell, A., & Simon, H. A. (1972). *Human problem solving.* Englewood Cliffs, NJ: Prentice-Hall.

Newell, K. M. (1978). Some issues on action plans. In G. E. Stelmach (Ed.), *Information processing in motor control and learning* (pp. 41-54). New York, NY: Academic Press.

Nielsen Reports December U.S. Search Rankings. Retrieved February 9th, 2010, from http://blog.nielsen.com/nielsenwire/online_mobile/nielsen-reports-december-u-s-search-rankings/print/

Papacharissi, Z., & Rubin, A. M. (2000). Predictors of Internet use. *Journal of Broadcasting & Electronic Media*, *44*(2), 175.

Park, H. M. (2009). *Comparing Group Means: T-tests and One-way ANOVA Using Stata, SAS, R, and SPSS*. Indiana University. Retrieved from www.indiana.edu/~statmath/stat/all/ttest/ttest.pdf

Pirolli, P. (2007). *Information foraging theory: Adaptive interaction with information.* New York, NY: Oxford University Press.

Pirolli, P., & Card, S. (1999). Information foraging. *Psychological Review, 106*(4), 643-675. doi: 10.1037/0033-295x.106.4.643

Powers, W. T. (1991). Commentary on Bandura's "human agency.". *American Psychologist, 46*(2), 151-153.

Price, D. J. D. S. (1963). *Little science; big science*. New York, NY: Columbia University Press.

Priester, M. J., & Clum, G. A. (1993). Perceived problem-solving ability as a predictor of depression, hopelessness, and suicide ideation in a college population. *Journal of Counseling Psychology, 40*(1), 79-85.

Robertson, S., Vatrapu, R. K., & Medina, R. (2009). *The social life of social networks: Facebook linkage patterns in the 2008 U.S. presidential election*. Paper presented at the Proceedings of the 10th Annual International Conference on Digital Government Research: Social Networks: Making Connections between Citizens, Data and Government.

Robertson, S., Wania, C., & Park, S. J. (2007). *An observational study of voters on the internet.* Paper presented at the Proceedings of HICSS-40: Hawaii International Conference on System Sciences.

Robinson, J. P., DiMaggio, P., & Hargittai, E. (2003). New social survey perspectives on the digital divide. *IT & Society, 1*(5), 1-22.

Rogers, R. W. (1975). A protection motivation theory of fear appeals andattitude change. *Journal of Psychology, 91*(1), 93.

Rotter, J. B. (1978). Generalized expectancies for problem solving and psychotherapy. *Cognitive Therapy and Research, 2*(1), 1-10.

Sandstrom, P. E. (1994). An optimal foraging approach to information seeking and use. *The Library Quarterly, 64*(4), 414-449.

Sapir, E. (1968). Time perspective in aboriginal American culture: A study in method. In D. G. Mandelbaum (Ed.), *Selected writings of Edward Sapir in language, culture and personality*. Berkeley, CA: University of California Press.

Saracevic, T. (1997). The stratified model of information retrieval interaction: Extension and applications. *Proceedings of the ASIS Annual Meeting, 34*, 313-327.

SAS/STAT User's Guide, Version 9.1. Retrieved April, 7th, 2011, from http://support.sas.com/onlinedoc/913/docMainpage.jsp

SAS Annotated Output: Proc TTest. Retrieved April,7th, 2011, from http://www.ats.ucla.edu/stat/sas/output/ttest.htm

Savolainen, R. (1995). Everyday life information seeking: Approaching information seeking in the context of "way of life". *Library & Information Science Research, 17*(3), 259-294.

Savolainen, R. (2006). Time as a context of information seeking. *Library & Information Science Research, 28*(1), 110-127.

Schroyens, W., & Braem, S. (2011). The initial representation in reasoning towards an interpretation of conditional sentences. *Quarterly Journal of Experimental Psychology, 64*(2), 339-362. doi: 10.1080/17470218.2010.513734

Schunk, D. H. (1981). Modeling and attributional effects on children's achievement: A self-efficacy analysis. *Journal of Educational Psychology, 73*(1), 93-105. doi: 1939-2176

Sen, T., & Boe, W. J. (1991). Confidence and accuracy in judgments using computer displayed information. *Behaviour & Information Technology, 10*(1), 53-64.

Silverstein, C., Marais, H., Henzinge, M. R., & Moricz, M. (1999). Analysis of a very large web search engine query log. *SIGIR Forum, 33*(1), 6-12. doi: 10.1145/331403.331405

Simon, H. A. (1978). Information-processing theory of human problem solving. In W. K. Estes (Ed.), *Handbook of learning and cognitive processes* (Vol. 5 pp. 271-295). Hillsdale, NJ: Lawrence Erlbaum Associates.

Simon, H. A. (1979). Information processing models of cognition. *Annual Review of Psychology, 30*(1), 363-396. doi: doi:10.1146/annurev.ps.30.020179.002051

Skinner, B. F. (1974). *About behaviorism*. New York, NY: Knopf.

Smith, E. A., & Winterhalder, B. (Eds.). (1992). *Evolutionary ecology and human behavior*. New York, NY: Aldine de Gruyter.

Sonnenwald, D. H., & Iivonen, M. (1999). An integrated human information behavior research framework for information studies. *Library & Information Science Research, 21*(4), 429-457.

Sparrow, B., Liu, J., & Wegner, D. M. (2011). Google effects on memory: Cognitive consequences of having information at our fingertips. *Science, 333*(6043), 776-778. doi: 10.1126/science.1207745

Spink, A., Wolfram, D., Jansen, M. B. J., & Saracevic, T. (2001a). Searching the Web: The public and their queries. [Article]. *Journal of the American Society for Information Science and Technology, 52*(3), 226-234.

Spink, A., Wolfram, D., Jansen, M. B. J., & Saracevic, T. (2001b). Searching the web: The public and their queries. *Journal of the American Society for Information Science and Technology*, *52*(3), 226-234.

Stephens, D. W., & Krebs, J. R. (1986). *Foraging theory*. Princeton, NJ: Princeton University Press.

Search Engine Sizes. Retrieved January, 23rd, 2010, from http://searchenginewatch.com/2156481#key

Tabachnick, B. G., & Fidell, L. S. (2007). *Using multivariate statistics* (5th ed.). Boston, MA: Pearson Education, Inc.

Tabatabai, D. (2002). *Modeling information-seeking expertise on the Web.* Doctoral dissertation, McGill University, Montreal, Canada. Retrieved from http://proquest.umi.com/pqdweb?did=765136751&Fmt=7&clientId=23440&RQT=309&VName=PQD

Tabatabai, D., & Shore, B. M. (2005). How experts and novices search the Web. *Library & Information Science Research, 27*(2), 222-248.

Thatcher, A. (2006). Information-seeking behaviours and cognitive search strategies in different search tasks on the WWW. *International Journal of Industrial Ergonomics, 36*(12), 1055-1068.

Todd, P., & Benbasat, I. (1992). The use of information in decision making: An experimental investigation of the impact of computer-based decision aids. *MIS Quarterly, 16*(3), 373-393.

Todd, P., & Benbasat, I. (1999). Evaluating the impact of DSS, cognitive effort, and incentives on strategy selection. *Information Systems Research, 10*(4), 356-374.

Top 10 Global Web Parent Companies, Home & Work. Retrieved July 12, 2011, from http://www.nielsen.com/us/en/insights/top10s/internet.html

Topi, H., & Lucas, W. (2005). Mix and match: Combining terms and operators for successful Web searches. *Information Processing & Management, 41*(4), 801-817.

Tsai, M.-J., & Tsai, C.-C. (2003). Information searching strategies in Web-based science learning: The role of Internet self-efficacy. *Innovations in Education & Teaching International, 40*(1), 43.

van der Veer, G., & Puerta Melguizo, M. C. (2003). Mental models. In J. A. Jacko & A. Sears (Eds.), *The human-computer interaction handbook: Foundamentals, evolving technologies and emerging applications* (pp. 52-80). Mahwah, NJ: Lawrence Erlbaum Associates.

Vancouver, J. B., Thompson, C. M., Tischner, E. C., & Putka, D. J. (2002). Two studies examining the negative effect of self-efficacy on performance. *Journal of Applied Psychology, 87*(3), 506-516.

Vancouver, J. B., Thompson, C. M., & Williams, A. A. (2001). The changing signs in the relationships among self-efficacy, personal goals, and performance. *Journal of Applied Psychology, 86*(4), 605-620.

Vealey, R. S. (1986). Conceptualization of sport confidence and competitive orientation: Preliminary investigation and instrument development. *Journal of Sport & Exercise Psychology, 8*(3).

Vealey, R. S. (1988). Sport-confidence and competitive orientation: An addendum on scoring procedures and gender differences *Journal of Sport & Exercise Psychology, 10*(4).

Wayne, B., & Alice, R. (2008). Trends in Internet information behavior, 2000-2004. *Journal of the American Society for Information Science and Technology, 59*(11), 1743-1760.

Web search engine. Retrieved July 12, 2011, from http://en.wikipedia.org/wiki/Web_search_engine#cite_note-11

Wendy Lucas, H. T. (2002). Form and function: The impact of query term and operator usage on Web search results. *Journal of the American Society for Information Science and Technology, 53*(2), 95-108.

Williams, J. G., & Kleinfelter, K. J. (1989). Perceived problem-solving skills and drinking patterns among college students. *Psychological Reports, 65*(3, Pt 2), 1235-1244.

Wilson, T. D. (1981). On user studies and information needs. *Journal of Documentation, 37*(1), 3-15.

Wilson, T. D. (1999). Models in information behaviour research. *Journal of Documentation, 55*(3), 249-270.

Witty, T. E., Heppner, P. P., Bernard, C. B., & Thoreson, R. W. (2001). Problem solving appraisal and psychological adjustment of chronic lowback pain patients. *Journal of Clinical Psychology in Medical Settings, 8*, 149-160.

Wood, R. E., Kakebeeke, B. M., Debowski, S., & Frese, M. (2000). The impact of enactive exploration on intrinsic motivation, strategy, and performance in electronic search. *Applied Psychology: An International Review, 49*(2), 263.

Wu, T. (2003). Network neutrality, broadband discrimination. *Journal of Telecommunications and High Technology Law, 2*. doi: 10.2139/ssrn.388863

Zeldin, A. L., & Pajares, F. (2000). Against the odds: Self-efficacy beliefs of women in mathematical, scientific, and technological careers. *American Educational Research Journal, 37*(1), 215-246.

Zeng, L., Proctor, R. W., & Salvendy, G. (2011). Fostering creativity in product and service development. *Human Factors: The Journal of the Human Factors and Ergonomics Society, 53*(3), 245-270. doi: 10.1177/0018720811409219

Zhang, S. (1995). Semantic differentiation in the acquisition of English as a second language. *Language Learning, 45*(2), 225-249.