An Individual’s Problem Space and Web Information Searching: A Proposed Study on Mental Organization of Keyword Importance and Efficiency in Everyday Web Information Searching

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Abstract

An individual’s problem space has been identified as important in problem solving. A problem space is a person’s inner representation of the task after extracting critical components in the external problem task. This paper proposes a study to probe whether there are different problem spaces for efficient and inefficient Web information searchers. The questions will be answered quantitatively using the psychometric scaling method TRICIR (for circular triads) and ANOVA.

1. Introduction

The quest for an “ultimate” version of Google, identified by Larry Page [1] and others as artificial intelligence, has led us to move beyond the early research into searching. This study focuses on the basic issue of why some people are more efficient in Web searching than others, even though they are using the same search engine. It is less an issue of finding out the black box (business secrets) of search engines like Google and more about figuring out why some people are better at it.

To respond to the question of differences in performance by searchers, I ask: “What seems to make people more efficient on Web information searching?” I argue that Newell and Simon’s problem space theory in Human Problem Solving published in 1972 [2], a seminal publication in the field of artificial intelligence (AI), may have relevance to this role. In combination with the problem space theory, I use Saracevic’s stratified interaction model as a foundation interface between the information searcher and the search engine [3]; I use information foraging theory to explain the searcher’s behavior on the Web and the consequences[4]; and finally I define mental organization of keyword importance in Web information searching. I argue that it is this mental organization that associates positively with search performance.

The proposed study aims to answer the following research questions: 1: Do efficient searchers share the same mental organization of keyword importance as slow searchers? 2: Are successively higher levels of search performance characterized by increasingly consistent mental organizations of keyword importance? Search performance on the Web has been studied for a long time. One stream of research is Web log studies [5, 6]. Though these studies have their good points, they also have inherent disadvantages: the researchers cannot tell from the logs whether or not searchers have found the correct answer. To avoid the disadvantages of search log studies, I propose a study that does not rely on Web logs, but on observation, to answer the research questions. The sample, using snowballing method, will be comprised of 90 volunteer participants in Hawaii. The search task, related to Hawaii but not about Hawaii, is “How did Taiwan’s native (aboriginal) people communicate in writing from roughly 200 to 400 years ago?” I will use the psychometric scaling method TRICIR [7] to discover the inconsistencies of the searcher’s mental concepts of keyword importance, classify participants into three levels based on their searching performance, use the statistical program TRICIR [7] and ANOVA (Analysis of Variance) to test hypothesis 1, and use Kendall’s concordance of coefficient to test hypothesis 2.

The current section introduces the study. Section 2 presents literature that this study is based on. Section 3 describes the theoretical basis. Section 4 details the research design, and Section 5 presents the conclusions.

2. Literature review

There are four components essential to this study: search engine log studies, information processing in problem-solving, information foraging theory, and mental organization.
2.1. Introduction to literature review

In everyday life when we find something interesting and want to know more about it, we search on the Internet. In fact, search engines have become human’s external memory; it has become our go-to guy, as in a recent article in *Science*, Betsy Sparrow et al concluded: “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.” Efficient web searching becomes important because 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. Under these conditions, queries are important for Web search engines, which can be 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 February, 2010 [9]. 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 indicate that information seekers have different priorities in terms of the importance of each query term. In everyday life we constantly prioritize tasks or choices, deciding 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. 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 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 [3]. 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 [10]. 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. In this study which applies information foraging theory [4], “patch activities” refers to the processes in which 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 (see Section 2.4.). How often do users reformulate or refine their keyword queries? Not very often. According to studies on the Excite search engine, Spink et al. found 52% of the users entered more than one unique query [5]. Lau and Horvitz found that relatively few users refine their searches by means of specialization, generalization, or reformulation [6]. With the inherent disadvantages of log-based studies (see Section 2.2.), we can never be sure about the relationship between users’ problem-solving tasks and their queries.

Information-processing theories shed light on this [11,12]. Greeno maintains that problem solving involves two major aspects: (a) construction of a problem space and (b) understanding solutions and procedures [11]. When facing a problem-solving task, the problem solver conceptualizes the problem in terms of a problem space that could be searched selectively for a solution [12]. Based on Simon Herbert’s 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 [13], each information seeker has his or her own problem representation which I call mental organization (see Section 2.5.). First, in an analogy to Web information search, 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 keep refining or reformulating their keyword queries until they are satisfied with the list or results returned by the system in which answers can be found. 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 in which the information seeker uses query terms randomly; it takes a long time because the searcher does not know which keywords best represent the problem space, let alone the relative importance of keywords in 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.

2.2. Search engine log studies

Previous research that uses search engine logs has had some problems. First, most researchers analyze the logs of only one search engine. For example Spink et al. [5], Lau and Horvitz [6] and others used the Excite search engine to study queries. According to SearchEngineWatch.com [14] 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 [14]. Third, while the collection of log analyses is possible with the Excite engine, which has advantages in some studies (for example, in large-scale unobtrusive studies in real world, which makes their conclusions more generalizable), these 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. Researchers cannot exclude the possibility 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 do not want to be dependent on logs. My study has the advantage of observation of participants so that I can clearly identify their session boundary and queries.

2.3. 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 [15]. 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 [16, 17]. Some researchers postulated that it is the individual’s perception of the situation that’s the most important [18, 19]. Instead of advancing the constructivists’ ideas about the human mind, some investigators looked at how to develop a mechanical model of a 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 [20].

In the book Human Problem Solving, Newell and Simon 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 serially, due to the narrowness of its momentary focus of attention. The inputs and outputs of these processes are held in 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 use 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.

2.4. Information foraging theory

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 [21, 22]. 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 [23]. As the cost changes, information foraging theory has become popular as an explanation of information search behavior. Information foraging theory is a concept based on the idea that information seekers are analogous to animals foraging for food [4]. 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 [24].

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 WWW 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 is 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 [23]. 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. Some searchers 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; 2. Some searchers 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.

2.5. Mental organization

The concept of mental organization is informed by Shuqiang Zhang’s findings on semantic differentiation in the acquisition of English as a Second Language study [25]. Zhang found that native speakers of English share tacit understanding of intensifiers and quantifiers whereas non-native speakers have trouble differentiating those words. In short, Zhang found that there are different mental organizations of intensifiers and quantifiers between native English speaker and non-native speakers.

It is important not to confuse mental organization with the term “mental model.” Mental model is a term used in the research field of cognitive psychology and later Human-Computer Interface (HCI) under Computer Science. The term is similar to but different from how I use “mental organization.” Carroll and Olson define mental model as the mental representation that reflects the user’s understanding of the system [26]. Mental model is an important concept for system designers because it captures the way users understand or misunderstand the devices they design [27]. A good example of mental model research in HCI is Cockburn and Jones’ study about users’ models of the navigation facilities provided by Internet browsers [28]. 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. HCI researchers are interested in mental models because of the notion that it is possible to design systems that support the acquisition of the appropriate mental models and avoidance of performance errors [29].

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 is not used as a design element that fosters users’ proficiency. I use mental organization to refer to how people organize the relative importance of keywords in Web information 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 their designs are devices that foster proficiency. In this paper, I look for individuals’ mental organization of keyword importance so that I can capture people’s ways of understanding the relative importance of keywords and associate these ways with different levels of proficiency in information searching.

Though my mental organization is defined differently from the mental model defined by Carroll and Olson, my study relies on the initial-representation principle of mental-model: people commence the interpretation process by constructing a minimal initial representation [30]. Because humans have limited processing resources and a small working memory (or short-term memory as defined by Newell and Simon [2]), we cannot consider all true 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 [31]. According to the finding of Zeng et al [32], 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-model and the finding of Zeng et al [32], I will ask participants to rank order seven sets of keywords—one set at a time—giving each set a ranking of between one and three based on how important they think each of the three keywords in a set is to finding the correct answer (see Section 4.5.); I do not ask them to rank all seven keywords at one time.

3. Theoretical basis

My study looks at Web searching by applying Saracevic’s stratified interaction IR model, information-processing theory, and information foraging theory as discussed above. Using these theoretical ideas, I concluded that this is what most
people do in everyday information searching: (a) According to the concept of problem space of the information-processing theory, an information searcher first extracts components (keywords) of the external task environment—the search task; (b) According to information foraging theory, 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. I had to take into consideration the theory of information foraging because it explains why non-efficient information searchers may be timed out (see Section 2.4); (c) According to Simon, an effective problem solver must be decisive when extracting components of the external task environment and conducting selective heuristic searches for solutions [13]. I believe, similarly, that an efficient information 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, a non-efficient information searcher is indecisive about his/her selection of keywords. When an information searcher is indecisive, he keeps changing and refining keywords and will spend more time on the task or will be timed-out (see also earlier).

The two questions in my study (see Section 4.1.) are based on Newell and Simon’s 1972 book and framework of information-processing and problem-solving discussed above and further on Simon Herbert’s 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 [13]. I believe that the same conclusion is true in Web information searching. When people search 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 will give subjects all the keywords that cover the possible range of the task environment and test my belief that an efficient searcher, through heuristics, can identify the critical keywords to generate his problem space. I think that inefficient searchers cannot pick the crucial keywords. The key difference lies in their mental organization of keyword importance.

4. Research design

4.1. Research questions and hypotheses

This proposed research is an observational study about Web information searching. The research question will be answered by observing subjects as they search, and through questionnaires. I will use the psychometric scaling method TRICIR and ANOVA to answer the research questions. There will be no treatment or control on how the participants interact with the Web to find the answer to the task. These are the questions I ask:

**Question 1**: Do efficient searchers share the same mental organization of keyword importance as slow searchers?

Hypothesis 1: There is significant difference in mental organization of keyword importance among three levels of search performance.

**Question 2**: Are successively higher levels of search performance characterized by increasingly consistent mental organizations of keyword importance?

Hypothesis 2: Successively higher levels of search performance (from timed-out to slow to efficient) are characterized by increasing stronger mental organization of keyword importance.

4.2. Sample

The sample will consist of 90 volunteer participants from various educational and occupational backgrounds in Hawaii. A snowballing method is used to locate participants in the study. Snowballing involves approaching participants known to the researcher. These participants are then requested to suggest anyone suitable for this study. The proposed subjects should be able to search the Internet. According to Chi and Glaser, the knowledge of problem domain can influence the use of the general problem-solving heuristics [33] (p.239). To minimize a possible confounding factor, the data will exclude people who are from Taiwan (see the task below). This will allow me to minimize a potential bias in favor of participants who already know the answer to the task in the study.

4.3. 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 [34]. Sapir’s statement is generally accepted by linguistic scholars. Blust found the deepest divisions of Austronesian
languages existed among the native Taiwanese aboriginals and suggested the home of the Austronesian languages is the main island of Taiwan, also known as Formosa [35]. Comrie 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 [36]. The search task which is related to Taiwanese aboriginals and Austronesians is chosen because it is a topic most people in Hawaii are not familiar with, yet it should be of interest to them because the background of the task is related to Hawaii which is part of Austronesia. Some participants may not work as hard simply because they are not interested in the search task—this initial bias cannot be excluded. But it can be minimized by this 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?

4.4. Procedures

The participants will be scheduled to participate in the study at their convenience. Participants will read the instructions of the study and the description of the information seeking task (omitted because of limited space). After the participant clearly understands the task and before he/she begins the search, a questionnaire will be used to collect the searcher’s mental organization of keyword importance. The participants are allowed thirty minutes to find the answer on the Internet. After the task is done, a background questionnaire is given to all participants, whether or not they have completed the task.

4.5. Instrument

To ascertain a searcher’s inconsistencies or confusion on keyword importance which I call mental organization of keyword importance (see Section 2.5.), I selected the psychological scaling method TRICIR as an appropriate method. Like any scaling method, the appropriate data collection method is required for a specific scaling method—the appropriate data collection method for TRICIR is pair-wise comparisons. In this study searchers’ mental organizations of keyword importance are 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 are six terms that might be used by searchers. Since the most important term in the background information of the task is the word “Austronesian,” it is added to the six keywords, making a total of seven keywords that searchers may use. Since some participants might not have been able to come up with the seven keywords on their own, but for measurement purposes and considering the initial-representation principle of mental-model and the finding of Zeng et al [32], it is necessary to give every participant the same information.

Instead of using 21 pair-wise comparisons of the seven keywords, the Youden Square of Balanced Incomplete Blocks is used to rank order three keywords at a time and collapse the comparisons to seven. The participants are asked to compare three keywords at a time and do it seven times (as shown below). The participants are asked to rank order each comparison according to their importance in finding the answer (1 meaning the most important keyword, 2 the second, and 3 the least important keyword).

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<td>IV.</td>
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<td>V.</td>
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<td>VI.</td>
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<td>200 to 400 years ago How</td>
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4.6. Data analysis

After participants finish the comparisons above, the statistical program TRICIR [7] is used to detect the inconsistencies of the information searchers’ mental concepts of keyword importance. TRICIR does a circular triads analysis, one of many scaling methods which are used in research measuring people’s preferences or attitudes toward something. In scaling methods, a person is called a “judge” and the preference or attitude rated by a person is called an “object.” When a judge has inconsistencies in his/her preferences, two kinds of circular triads can be found: one is Judge Circular Triads (JCT)—used to show cognitive confusion, the other is Object Circular Triads (OCT)—used to show which object causes the confusion. Using the keywords of the study for example, Judge A has one JCT: “Taiwan-Communicate-Writing.” While Judge B has two JCTs: “Taiwan-Communicate-Writing” and “Writing-200 to 400 Years ago- Austronesian.” In this example, Judge B shows more inconsistencies or confusion in the keywords’ importance than Judge A. And we found that the keyword “Writing” elicits two OCTs. In this study, I will use JCT because I am interested in knowing if the judge’s (searcher’s) number of circular triads (cognitive confusion) is associated with search performance, not which object (keyword) elicits most circular triads. There is only one correct answer to the search task. I will classify participants into three levels based on their search performance: 1. Those who find the correct answer in the thirty minutes, 2. Those who find wrong answers in the time limit, and 3. Those who are timed out. This classification will be used as the independent variable.

To test hypothesis 1, I will use ANOVA (Analysis of Variance) to determine the relationship between the number of judge’s circular triads and three levels of search performance with search performance as the independent variable and number of inconsistencies as the dependent variable. I use the number of circular triads to detect the inconsistencies of the information searchers’ mental concepts of keyword importance. The more inconsistencies the searcher has on keyword importance, the less sure the searcher is about the keywords’ importance in finding the answer. If, for example, there is a statistically significant difference in the number of circular triads between levels of performance, my hypothesis is confirmed.

To test hypothesis 2, I will use Kendall’s coefficient of concordance to show the varying strength of consensus at different levels of search performance. 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 within the group. On the contrary, the lower coefficient indicates more discriminate opinions existing within the group. For any group of ranked data, we can have two numbers. One is the number that shows how different the ranking is 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. If, for example, the result shows the Kendall’s coefficient of concordance is higher for efficient searchers than non-efficient searchers, my hypothesis is confirmed.

5. Conclusion

As Betsy et al found in a recent article in *Science*, we rely on Google as our transactive memory online [8]. I believe it is time to look at how a searcher’s problem space, represented in our short-term memory, plays a role in searching. This paper looks at how to probe the association between mental organization of keyword importance and Web information searching from the problem space perspective of the information-processing theory, together with information foraging theory, a stratified IR model, and search log studies that form the basis of this proposed study. This paper focuses on the design and the selection of a search task that simulates an everyday Web search scenario—finding interesting information within a limited time while minimizing the confounding effects as much as possible.

In this paper I use psychometric scaling method TRICIR, ANOVA, and Kendall’s coefficient of concordance to test the research hypotheses. I hope this paper will stimulate new ideas and research to extend or refute my proposed study. And ultimately help people to achieve effective searches.
6. References


[34] Sapir, E., "Time Perspective in Aboriginal American Culture: A Study in Method", in (Mandelbaum, D.G., 'ed.' Selected Writings of Edward Sapir in Language, Culture and Personality, University of California Press, Berkeley, 1968
