# MODELING USERS' CONTEXTUAL QUERYING BEHAVIOR FOR WEB IMAGE SEARCHING

by

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# Keywords

Web image searching, Web image searching modeling, Web image searching behavior, Web image query reformulation, contextual image search modeling, contextual Web image search, Web image search context, image search, image query formulation, query reformulation, search pattern, search strategy.

# Abstract

The rapid growth of visual information on Web has led to immense interest in multimedia information retrieval (MIR). While advancement in MIR systems has achieved some success in specific domains, particularly the content-based approaches, general Web users still struggle to find the images they want.

Despite the success in content-based object recognition or concept extraction, the major problem in current Web image searching remains in the querying process. Since most online users only express their needs in semantic terms or objects, systems that utilize visual features (e.g., color or texture) to search images create a semantic gap which hinders general users from fully expressing their needs. In addition, query-by-example (QBE) retrieval imposes extra obstacles for exploratory search because users may not always have the representative image at hand or in mind when starting a search (i.e. the page zero problem). As a result, the majority of current online image search engines (e.g., Google, Yahoo, and Flickr) still primarily use textual queries to search.

The problem with query-based retrieval systems is that they only capture users' information need in terms of formal queries; the implicit and abstract parts of users' information needs are inevitably overlooked. Hence, users often struggle to formulate queries that best represent their needs, and some compromises have to be made. Studies of Web search logs suggest that multimedia searches are more difficult than textual Web searches, and Web image searching is the most difficult compared to video or audio searches. Hence, online users need to put in more effort when searching multimedia contents, especially for image searches.

Most interactions in Web image searching occur during query reformulation. While log analysis provides intriguing views on how the majority of users search, their search needs or motivations are ultimately neglected. User studies on image searching have attempted to understand users' search contexts in terms of users' background (e.g., knowledge, profession, motivation for search and task types) and the search outcomes (e.g., use of retrieved images, search performance). However,

these studies typically focused on particular domains with a selective group of professional users. General users' Web image searching contexts and behaviors are little understood although they represent the majority of online image searching activities nowadays.

We argue that only by understanding Web image users' contexts can the current Web search engines further improve their usefulness and provide more efficient searches. In order to understand users' search contexts, a user study was conducted based on university students' Web image searching in *News*, *Travel*, and commercial *Product* domains. The three search domains were deliberately chosen to reflect image users' interests in people, time, event, location, and objects.

We investigated participants' Web image searching behavior, with the focus on query reformulation and search strategies. Participants' search contexts such as their search background, motivation for search, and search outcomes were gathered by questionnaires. The searching activity was recorded with participants' think aloud data for analyzing significant search patterns. The relationships between participants' search contexts and corresponding search strategies were discovered by Grounded Theory approach. Our key findings include the following aspects:

- Effects of users' interactive intents on query reformulation patterns and search strategies
- Effects of task domain on task specificity and task difficulty, as well as on some specific searching behaviors
- Effects of searching experience on result expansion strategies

A contextual image searching model was constructed based on these findings. The model helped us understand Web image searching from user perspective, and introduced a context-aware searching paradigm for current retrieval systems. A query recommendation tool was also developed to demonstrate how users' query reformulation contexts can potentially contribute to more efficient searching.

# Statement of Original Authorship

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

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**ENDORSEMENT**

**Supervisor's signature:**

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**Date:**

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# CHAPTER 1: INTRODUCTION

## 1.1 Problem Statement

With the rapid growth of personal digital imaging devices such as digital cameras and video camcorders, millions of photos and videos are created anytime and anywhere in the world. These multimedia materials are often uploaded to Web pages as a new medium for professional publishing such as online news or magazines, or are distributed by various people who want to share information with others (Vasconcelos, 2007). As a result, Web users' multimedia contents, such as the photos uploaded to Facebook or Flickr, have all emerged as important information resources for online activities nowadays (Jain & Sinha, 2010). However, due to the extreme diversity in contents and quality, photos and videos uploaded by various users are very difficult to handle or index by one unified retrieval system, and this prohibits effective searches for general Web users (Datta, Joshi, Li, & Wang, 2008; Kherfi, Ziou, & Bernardi, 2004). Studies of online users' searching behavior have already demonstrated that multimedia searches are more challenging than textual Web searches, as shown by the longer query length, search session time (S. Ozmutlu, Spink, & Ozmutlu, 2002, 2003) and more query reformulations (Goodrum & Spink, 2001; Bernard J. Jansen, Goodrum, & Spink, 2000; Spink, Goodrum, & Hurson, 2001; Tjondronegoro, Spink, & Jansen, 2009).

Among all types of multimedia searches, image searches appear to be the most problematic and requiring more in-depth investigations. First, image search is the dominant multimedia search type (Tjondronegoro, et al., 2009) and typically has longest session length and more terms per query, compared with video and audio searches (B. J. Jansen, Spink, & Pedersen, 2003; Tjondronegoro & Spink, 2008). There are more reformulations in image queries (Goodrum & Spink, 2001) and image searchers seek more assistance from the system (Spink & Jansen, 2006). The large proportion of unique terms used in image queries indicates that image users have more diverse search interests (Goodrum & Spink, 2001; S. Ozmutlu, et al., 2003; Spink, et al., 2001). All these findings suggest that users need to put more effort in searching Web multimedia contents, especially when searching for images.

Image retrieval systems typically perform better in specialized collections, such as face detection for forensic purposes or a celebrity image database in news publishing industries (Datta, et al., 2008; Gudivada & Raghavan, 1995; Kherfi, et al., 2004; Ranjeet, Tripathi, & Tiwari, 2011). These systems only need to deal with specific contents with greater controls in the way they are being generated, annotated, or being presented; thus higher accuracy and usability are usually expected. Web image contents, on the other hand, are much more diverse but less controlled in terms of the devices people use to generate, the places and settings being captured, and the way people summarize them (e.g., annotate). The heterogeneity of Web image contents further hampers the already difficult retrieval systems. Hence, there is a fast growing need to manage and retrieve such vast and diverse contents effectively.

In fact, the ability to facilitate intuitive search has become the major issue for new developments in online image retrieval systems (Datta, et al., 2008; Jing Huang, Kumar, Mitra, Zhu, & Zabih, 1999; Jacobs, Finkelstein, & Salesin, 1995; Jaimes, Christel, Gilles, Sarukkai, & Ma, 2005; Kherfi, et al., 2004; Spink, 2002; Stan & Sethi, 2001; Yanai, 2002). Since most online users can only express their needs in semantic terms or objects, content-based retrieval systems that utilize visual features (e.g., color or texture) or sample images to search are not as user-friendly as conventional textual searches (Chen, 2001; Youngok Choi & Rasmussen, 2003; Enser, 1995; Jorgensen & Jorgensen, 2005; Magalhaes, Ciravegna, & Ruger, 2008; Othman, 2005; Smits, Plu, & Bellec, 2006; Spink, Jansen, & Pedersen, 2004; Tam & Leung, 2001; Westman & Oittinen, 2006). Therefore, the majority of current online image search engines (e.g., Google, Yahoo, Flickr) still use textual queries as their primary search method despite recent advancements in Content-Based Image Retrieval (CBIR) and indexing technology (Datta, et al., 2008; Jaimes, et al., 2005; Jain & Sinha, 2010).

The difficulties of using text to search visual contents originated from the conversion of the two types information. Clearly people use languages to describe their problems, which is inherently ‘semantic’ and best represented in textual form. CBIR systems, however, require the conversion of semantic needs to visual features, and thus inevitably create a gap or some loss of fidelity after the conversion. Such gap is commonly referred as the biggest and most well-known problem in visual information searching, the *semantic gap* problem (Enser & Sandom, 2003; Hare, Lewis, Enser, & Sandom, 2006; Smeulders, Worring, Santini, Gupta, & Jain, 2000; Zhao & Grosky, 2001). Smeulders et al. (2000) defined the semantic gap as:

> *…the lack of coincidence between the information that one can extract from the visual data and the interpretation that the same data have for a user in a given situation.*

In other words, semantic gap refers to the differences between a semantic meaning given by a user and the corresponding visual presentation. It is difficult, if not impossible, to interpret one semantic object by a definite set of visual features, or to use a definite set of words or terms to cover all visual information in one image. Therefore, any attempt to convert the semantic description into quantified visual features (e.g., RGB value of a color, lines and contour of an object) would inevitably create the semantic gap, let alone the higher abstract part of language expressions such as feelings or emotions.

Another problem for content-based visual searches is the *page zero problem*, which refers to the difficulties in finding good examples to initiate a search (Kherfi, et al., 2004; La Cascia, Sethi, & Sclaroff, 1998). As most retrieval systems capture users' information needs in terms of formal queries, the implicit and abstract parts are constantly understated (Jorgensen & Jorgensen, 2005). As a result, users often struggle to formulate queries that best represent their information needs, and some compromises have been observed (Kuhlthau, 1991; McDonald & Tait, 2003). Such a problem is especially prominent in using the query-by-example (QBE) retrieval theme, because the search's success and effectiveness are largely dependent on the choice of the initial sample images (La Cascia, et al., 1998; C. C. Yang, 2004). As users may not always have the most representative image at hand or from the top results, it would be problematic for them to steer the search in the intended direction.

For example, if a user wants to search for photos of Steve Jobs presenting at different conferences, usually the most intuitive way is to put 'Steve Jobs' as the search keyword and iteratively review the retrieved images for the relevant ones. It would be really difficult for the user to draw the face of Steve Jobs as the sample query to retrieve similar images. It would also be difficult for users to express their criteria for 'presenting at a conference' by drawing alone. When using a sample photo of Steve Jobs presenting at a particular conference, the QBE system, which is at its best in finding visually similar items, still requires the user to rely on text descriptors or annotations (e.g., image filenames, captions, or user tags) in order to verify whether the retrieved pictures are from the same conference in the sample image. As users' search needs are rarely limited to visual features, the searching modality provided by a good retrieval system should not be limited to these features. In fact, even if it is possible to solve a visual problem by QBE, most users would still prefer using textual queries as they are easier and more intuitive to search without the trouble of having sound drawing skills or good sample images (Jaimes, et al., 2005; Jorgensen & Jorgensen, 2005).

Research in visual information searching has focused on the various approaches for bridging the semantic gap over the past decade. However, this remains an active research topic (Datta, et al., 2008; Stan & Sethi, 2001). Some studies tackle the problem bottom-up by linkages of low level visual features with higher level semantic concepts (Y. Liu, Zhang, Lu, & Ma, 2007; Zhao & Grosky, 2001). Others use top-down approaches such as ontologies (Hare, et al., 2006) or concept templates (Cheng, Chen, & Sundaram, 1998) to help users search. Despite some success in specific image collections or scenes, Web image searching is still far from success for content-based approaches. To facilitate visual information retrieval in the semantic space (i.e. predominantly the textual space), many state-of-the-art retrieval techniques have been applied to image annotations (Qian, Li, Zhang, Ma, & Zhang, 2003). By associating brief descriptors (either textual or visual) to the salient objects or general themes in an image, searching is much more efficient and easy because these descriptors represent meaningful concepts to humans. Retrieving images with annotations thus becomes similar to textual information retrieval. However, the accuracy of annotation remains the major problem when using text to search images. Users are inconsistent in describing what they see in an image, which makes human annotation or user tags unreliable and difficult to index (Enser, 1995; Qian, et al., 2003). The vast amount and heterogeneity of Web image collections also make manual annotation impractical. Attempts have thus been made to utilize automatic detectors to annotate images, but with only limited semantics (Datta, Joshi, Li, & Wang, 2007; L. Yang, Liu, Yang, & Hua, 2007).

It is clear that visual information searching is not only difficult for users to make systems understand their needs, but is also challenging for systems to provide simple and effective searches. Recent studies that attempt to resolve the querying and indexing problems roughly fall into two groups based on their focuses: *system-centered* or *user-centered*. System-centered approaches try to link low level visual features with some primitive semantics (i.e. visual concept mapping) (J. Liu, Lai, Hua, Huang, & Li, 2007; Qi et al., 2007; Vasconcelos, 2007; Zha, Mei, Hua, Qi, & Wang, 2007), or to represent images in semantic space other than visual space in order to approximate people's need and similarity interpretation (i.e. via image annotation) (Magalhaes, et al., 2008; Natsev, Haubold, Tesic, Xie, & Yan, 2007). User-centered approaches aim to identify the salient concepts from users' queries (i.e. query concept mapping or relevance feedback) (Datta, Ge, Li, & Wang, 2006; D. Wang, Li, Li, & Zhang, 2007; Xirong, Dong, Jianmin, & Bo, 2007) or to study users' searching behaviors in greater depth to shed light on new system design (Chen, 2001; Youngok Choi & Rasmussen, 2003; Enser, 1995; Jorgensen & Jorgensen, 2005; Othman, 2005; Smits, et al., 2006; Spink, et al., 2004; Tam & Leung, 2001; Westman & Oittinen, 2006). Although there is a clear trend of moving retrieval towards concept-based rather than low level features (e.g., TRECVID, SIGIR Multimedia) (Magalhaes, et al., 2008; Natsev, et al., 2007; Qi, et al., 2007; Zha, et al., 2007), studies in each approach are still isolated from others despite the interrelatedness of problems they are trying to overcome. For example, a concept-based retrieval system may still return irrelevant images if it is unable to differentiate important concepts in user's query. Since users may typically have multiple concepts in their queries, given the diverse interests among online users, it is important for the system to consider users' querying behaviors in order to gain more information about their search contexts (Lawrence, 2000). Likewise, user-centered studies lack the ability to demonstrate how their findings can improve either the system design or the retrieval process. It is easy for a researcher to know what a study subject wants by close observation or interview during a search session. However, it is not feasible for the system to collect such information by the same method, even with the most advanced artificial intelligence agents. Given the unpopularity of explicit relevance feedback among Web users, retrieval systems need other ways to utilize what is learnt from user studies about helping users with more intuitive searches.

Regarding the limitations in the system-centered or the user-centered approach, there is a need to combine these two approaches for holistic improvements in image retrieval, especially for Web image searching. In-depth understanding of general users' search contexts (e.g., the motivation for search, the intention of use) and behaviors is needed for systems to improve their search performance and provide a pleasant searching experience. As most user studies in image searching have been devoted to professional users such as journalists, artists, and historians (Chen, 2001; Y. Choi & Rasmussen, 2002; Youngok Choi & Rasmussen, 2003; Eakins, Briggs, & Burford, 2004; Frost et al., 2000; Jorgensen & Jorgensen, 2005; Markkula & Sormunen, 1998, 2000; Othman, 2005; Westman & Oittinen, 2006), or to limited search topics such as research writing (Weedman, 2002) and pre-defined retrieval tasks (Fukumoto, 2006; Westman, Lustila, & Oittinen, 2008), few studies have investigated general users' Web image searching behaviors, especially their query formulation/reformulation processes. Since many users have difficulties formulating effective queries or expressing their interests, most of the interactions between the system and the user take place in query formulation and reformulation processes, which makes them crucial to search success and worth further research attention.

In addition to the in-depth understanding of users' search contexts and behaviors, a theoretic framework for modeling Web image searching is also being developed. This framework helps to investigate users' search contexts and to identify the important behaviors. Based on the framework, a model depicting the relationship between users' search intents and corresponding search strategies is constructed. The model also associates users' search strategies with significant searching behaviors identified in this study. By incorporating this model with current Web image retrieval systems, context-aware search assistance can be provided upon user's individual search intent at different stages of searching to facilitate efficient searches. Hence systems no longer merely consider the best way to index images, as users' needs now becomes active agents that drive the retrieval process. From users' perspective, more intuitive and effective Web image searching is expected from the context-aware assistance. Not only it bridges the gaps between textual and visual searching, but it also rejoins the previous seemingly disconnected system and user together in solving the Web image searching problems.

## 1.2 Research Aims and Objectives

The foremost aim of this research is to develop a framework for modeling general users' Web image searching behaviors. Most user studies in image searching are limited to professional users (e.g., journalists or artists) or particular collections with much less heterogeneity. Their findings cannot be easily applied to Web image searching as Web users and Web image contents are very different from previous study data. More studies focusing on general Web image searching are needed in order to understand the diversity of online users' searching behaviors and intents. A contextual user model is then developed based on the user modeling. This model is specific to Web image searching and helps better understanding of users' searching behaviors and the related search strategies.

Information studies, which consider the information agent (the information seeker/searcher/user), information object, and information behavior, typically utilize theories to explain and describe the observed behaviors/phenomena, as well as to predict future actions (Lakshminarayanan, 2010). As noted by Talja, Keso, and Pietilainen (1999), "the aim of information needs and seeking studies is to build models of information behavior which show how different factors or variables influence information seeking", thus models are often defined in close relation to theories, and make their contents more concrete through a diagram of some sort (Case, 2007). Information models generally include information [objects], activities, relationships and constrains that can be used as an analytical tool in making forecasts of information needs, information users and their behaviors, and the effects on the quality of information resources and access (Case, 2007). Although information behavior models are developed under specific contexts, they aim to provide understanding of wider/generalized situations of how most people seek, search, organize, and use information (Lakshminarayanan, 2010).

The user models developed in this study focus on the user perspective of Web image searching, which emphasize the process of users' searching behaviors and cognitive states/changes. Unlike system-oriented models, the indexing and retrieval processes during image searching (e.g., image annotation, content analysis, feature extraction and matching, etc.) are not considered in our model. These user models are constructed based on intensive observation and analysis of user behaviors, thus should provide better descriptive and predictive abilities in general Web image searching.

Current information searching models, including the ones that consider information seeking in electronic/Web environment, can be classified into two broad types: *information science-oriented* and *cognitive models* (Dinet, Chevalier, & Tricot, 2012). The information science-oriented models mainly concentrate on the external actions/behaviors during a searching process, thus overlook the internal cognitive/psychological processes undergo in searcher's mind, and are prone to over simplify searchers' versatile search experience/paths. For example, the eight steps in Marchionini's (1995) information searching model are all behavioral and loop linearly without the inclusion of cognitive factors to divert different search paths (details in *Section 2.5.3*). Kuhlthau's (1991) information seeking process model (details in *Section 5.7*) integrates cognitive and affective factors in the model, but does not depicts how these factors affect the search process or strategies.

Other interactive search models highlight on the interaction between user/searcher and the information environment, but are seemly too broad to be applied in characterizing Web searching behaviors. For example, Ingwersen's (1996) information search process model emphasizes on the interaction only among information objects, IR systems, and user's cognitive space. Saracevic's (1996) stratified interactive IR model (details in *Section 2.5.3*) also signifies the interaction between user and computer into three levels (i.e. strata): surface, cognitive, and situation. These models, however, only offer the macro view of searching behaviors and overall interactions (i.e., the overall process with identified factors/agents involved in the process, but not the effects of individual interactions in certain behaviors). Neither they provide enough understanding of the problematic process particular in Web searching, the query formulation/reformulation and result reviewing process.

The comprehension-based linked model of deliberate search (CoLiDes) proposed by Kitajima (2003) provides detailed process of how user select relevant/appropriate information from Web pages regarding the search goal. Recently, Sharit et al. (2008) developed a model of search engine information-searching behavior. Their models explicitly depict the problem-solving aspects/processes in Web searching, and their interactions with various cognitive abilities (e.g., problem identification, resolution planning, reasoning, and comparing). While these two models are closely related to the current research, they are not still suitable for explaining many searching behaviors unique to Web image searching, such as repeating same query over and over in one session, navigating back and forth in different result pages, and the use of different combinations of same pool of keywords to reformulate queries. These interesting behaviors are specific and important to Web image searching, which were unveiled only by several log analysis studies using search engines' data. Prior research in Web image searching generally adopts log analysis methods as the primary means for understanding users on a large scale. However, with the realization of the limitations in analyzing individual log records, research has now shifted the focus to consecutive query formulations as new means to investigate the dynamics of users' Web image searching (D. He, Goker, & Harper, 2002; Bernard J. Jansen, Spink, & Narayan, 2007; H. C. Ozmutlu & Cavdur, 2005; Seda Ozmutlu, 2006).

This research endeavors to understand users' visual query formulation process in greater depth by adopting mixed methods of user studies and log analysis. Specifically, the relationships between users' search contexts and search strategies are investigated by both qualitative and quantitative analysis. The user study and log analysis complement each other, as they provide different aspects of Web image searching. The transaction logs record users' interaction with the system, as measurable behaviors from the system perspective. However, users' thoughts and opinions toward the search results are absent in the log data. By conducting user studies, users' motivations and intents for search, as well as their judgments on the retrieved results, can now be collected along their search paths. On the other hand, the rich and mostly descriptive user study data can be extracted and quantified in a more objective way by adopting log analysis techniques.

Finally, a contextual visual search model is constructed based on the study findings. The model depicts how users' search intents affect Web image search strategies at different stages of searching, and how different strategies affect users' search behaviors. The significance of identified searching behaviors under each strategy is also statistically tested. In addition, a contextual query recommendation tool is built based on the visual search model. This recommendation tool helps demonstrate how the theoretical model can enhance Web users' image searching in real-world situations.

## 1.3 Operational Definitions

In order to facilitate readability and to scope the terminology used in this thesis document, several operational definitions are drawn in this section. We begin with the broadest terminologies such as information behavior in information science research, and gradually focus on the specific terms that are essential to the current study.

*Information seeking behavior* –"a subset of information behavior that includes the *purposive seeking* of information in relation to a goal (Spink & Cole, 2006)". This includes information retrieval which incorporates retrieving information from external sources, such as database systems. Information seeking behavior is bound to the problem-solving perspective in which gaps between the current situation of the information problem and the desired outcome drive the behavior (Lakshminarayanan, 2010; Spink, Wilson, Ford, Foster, & Ellis, 2002; Wilson, 1999). Thus information seeking is active and conscious which excludes the passive or unintentional information behaviors such as *information encountering*.

*Information searching behavior* – "the behaviors exhibited during the process of searching and locating information (Lakshminarayanan, 2010)". This behavior emphasizes the interplay between the searcher and the formal information systems such as libraries, online databases, or the Web, and thus is often conceived as a process (Lakshminarayanan, 2010). In this research, information searching refers to all kinds of Web searching as a subset of information seeking behaviors, and always involves the Web as the information resource. Inherently from the problem-solving perspective in information seeking, information searching relies on the search task or search goal at hand to initiate the searching process.

*Web searching* – the searching for general information on Web search engines without explicitly using the search tab selection (e.g., Web, Image, Video) to restrict the type of information being searched. Although users can now search any type of information via one unified textbox in many commercial search engines such as Google, we define such searches as Web searches because of the inability to distinguish the exact type of information being searched, especially in the log data. In fact, people use this search mode primarily because their search targets are text-based information, or they just want any type of information. These searches typically return lists of Web pages with various information (e.g., Web pages that contain text, image, and even Youtube links), thus are difficult to determine the exact type of information being sought, and only suitable to be referred as 'Web searching'.

*Web image searching* – searching for visual information on Web by textual queries and explicitly selecting the 'Image tab' on search engines to restrict the type of information being searched. Although users now also get image results from Web search textbox, it is the only way to limit the search targets to images if the image tab is selected. Users typically use the image tab when they only search for images, and thus are suitable for our analysis to be precise that the findings are drawn from image users exclusively.

*Search context* – the context of user's information searching, including the search problem at hand, the searcher's knowledge resources and experience, information requirements, the resulting information behaviors, and the outcomes of the searching. This definition differs from the 'context' commonly used in 'context-aware' research, which usually implies the environment or situations a person or entity is in (Dey, 2001). In particular, the current research utilizes several user background factors (e.g., knowledge, experience, task specificity, and task tangibility) and outcome measurements (e.g., task completion level, satisfactory level, task difficulty) to provide search context information for analysis.

*Contextual search modeling* – the modeling of users' searching including contextual factors beyond the observable behaviors, such as the search problems, users' knowledge and search experience, various search intents during query reformulation, and the subjective experience toward the outcomes.

*Search tactic* – the single searching behavior which manifests the reaction to a particular interactive intent during the searching process. In the current research, a search tactic is equivalent to a single query reformulation behavior. For example, if a user finds a new search term during reviewing the retrieved information, she may want to include this term in the next query to see if it is useful. Adding the term to the query is her search tactic, and verifying whether the term helps her search is the interactive intent behind such tactic.

*Search pattern* – the patterns of user's consecutive searching behaviors in relation to a particular search task or current search goal. In this research, the explicit behaviors from search patterns are confined to query reformulation patterns, such as constantly deleting or adding terms, or the interchange of different synonyms. However, search patterns identified in the current research also imply a certain search goals behind, or tend to correlate with certain task types.

*Search strategy* – the plan of using multiple search tactics to achieve a search goal. The strategy may be inferred from series of search tactics without the user consciously/explicitly expressing such a plan before the actual searching behavior. In the context of this research, search strategies can include other searching behaviors beyond query reformulations, such as result reviewing and comparing information from different resources. For example, when feeling not having enough keywords or information to formulate a query, users may cross check the results from Web searches or other search modes without consciously saying "I'm looking for other resources to expand my knowledge on this topic". However, such knowledge expansion behaviors are regarded as a search strategy in our data analysis.

*Query reformulation* – the syntactic and semantic differences/changes in the consecutive queries. Due to the limitation of the automated query log analysis method, query reformulations are limited to syntactic changes in queries, such as addition, deletion, replacing terms, and formulating new queries that do not have syntactic commonalities. Semantic changes are manually analyzed only in user study logs, and thus can be classified as changes to related, new, or synonym terms.

*Query reformulation pattern* – the observed patterns of series of query reformulations within a search session (i.e., searching for the same topic in this research). The term shares the same fundamental concept as *search pattern* in the current research, as the focus behavior is always query reformulations. However, this term delineates only the observable query reformulation behaviors without taking the underlying search goal into account.

*Query reformulation strategy* – the strategy inferred from a query reformulation pattern in relation to a particular search goal. Similar to the relationship between *search pattern* and *search strategy*, query reformulation strategy is elaborated from query reformulation patterns with the connection of the current search goal. This term differs from *search strategy* as it only considers query reformulation behaviors to characterize the strategy.

In summary, *Figure 1.1* shows the aforementioned terminologies and their relationships among various contextual factors considered in the current study.

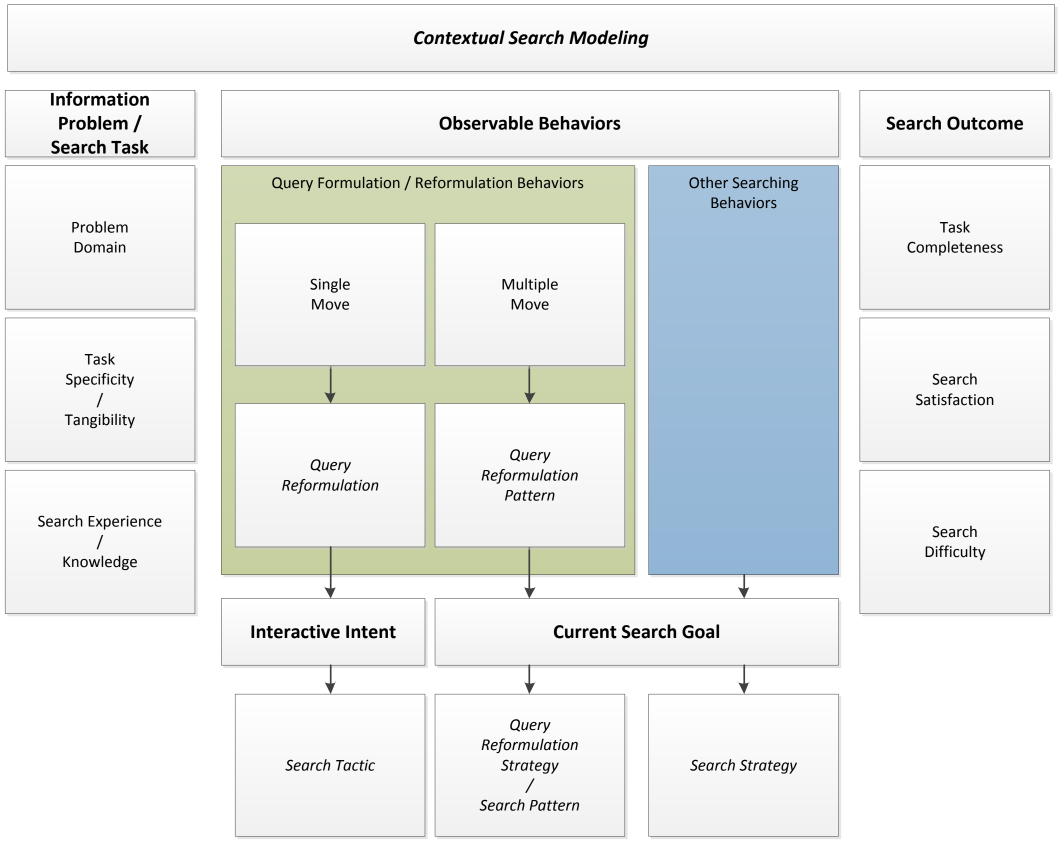



*Figure 1.1* The structure of important terminologies in this research and their relations to various contextual factors in Web image searching

# 1.4 Research Assumptions and Questions

The main idea of this research is that Web image searching can benefit greatly from understanding users' search contexts and intents. Current studies provide little knowledge in general users' searching behaviors and strategies, especially when searching for Web image collections. In-depth understanding of general users' Web image searching should help identify the common search problems users encountered most and their corresponding search strategies. Systems can thus be improved from this user-centered approach for providing context-aware search assistance.

Based on the literature review and Web log analysis in the current study, the following findings form the basic assumptions supporting the current research:

- Users would have general ideas about their search intents when starting the search; however, they need to compare the results from conceptually related search terms to decide the best way to describe their problems.
- Query reformulation activities are a progressive refining process in which search terms constantly appear in consecutive queries should be important and center to users' higher level search intents.
- Search terms being replaced and the semantic relationships between them are important in identifying users' current search intents.
- Users' interactive and dynamic search intents will be easier to capture by modeling the changes among series of query reformulations.

In summary, a good retrieval system should not only perform well in indexing and retrieving precise visual contents, but also be able to detect user's search context and provide assistance accordingly (Allan, Croft, Moffat, & Sanderson, 2012), such as related term suggestion and relevance feedback based on the important search concepts. The research questions are formulated with two aspects, *Web image searching modeling* and *contextual query reformulation modeling*. Two main research questions and their corresponding detail questions are outlined here.

## Web image searching modeling

1. How do users perform searches and query formulations under different search contexts?

- What are the differences in users' search tasks and searching behaviors among the frequent image search domains?
- What are the common problems users encountered during Web image searching?
- What search strategies do users adopt according to the search needs and problems encountered?

## Contextual query reformulation modeling

2. How can users' contextual query reformulations help a user-centered search?

- What information can be inferred from users' contextual query reformulations?
- How can this contextual information be utilized in providing better search assistance?

## 1.5 Significance and Contributions

### Overview of the research outcomes

Three stages of search intents and six distinctive search patterns were identified in the current study, as well as significant searching behaviors under each pattern. The stages of search intents include:

- *Knowledge State* – the state in which users primarily engage in gathering more information or knowledge about the search task / problem
- *Search State* – the state in which users endeavor to formulate better queries according to their interactive search intents
- *Review State* – the state in which users try to improve the current search results regarding their search experience and the nature of search tasks

The six distinctive search patterns (corresponding to the three stages of search intents) include:

- *Knowledge expansion for new ideas or keywords (KEI/KEK)*
- *Query reformulation for exploration or retrieval (QRE/QRR)*
- *Result expansion for accuracy or sufficiency (REA/RES)*

These search intents and search patterns were identified using the Grounded Theory approach. The significant searching behaviors were statistically tested to ensure the reliability of the identified search patterns. A user-centered Web image searching model was then constructed from these findings, which provided in-depth understanding of the relationship between users' image search contexts and the corresponding searching behaviors. A contextual query term recommendation tool was also built based on the model to demonstrate how the current study findings can enhance Web image searching systems.

## Contributions to research

First, the current research provides more in-depth understanding of general Web users' image searching, especially the query formulation and reformulation behaviors. Such findings complement current image search studies, as they provide little information on general Web users' search contexts. Findings from this study also highlight the important behaviors that systems should take into account when providing user-centered searches. The relationships depicted in the Web image searching model help systems elicit users' search contexts and intends in terms of measurable behaviors, and thus can provide context-aware assistance. No previous research has found the connections of users' search intents and behaviors in this manner, which makes it easy and practical for system implementation. Moreover, this is the first research in Web image searching domain to focus on consecutive query reformulation behaviors. As most systems are limited in capturing users' interactions during query formulation and reformulation, such focus provides a clear direction for future system-oriented studies in improving Web image searching.

In addition to the understanding of users' searching behaviors, research methodologies utilized in the current study also provide a good framework for future Web image user studies. The innovative contextual query modeling approach can be utilized to capture the dynamics of user's image needs more accurately. As more and more research is now interested in query reformulations, such an approach sheds light on how to infer search intents from various querying behaviors. The mixed methods of qualitative data analysis and quantitative log analysis not only strengthen the findings in our study, but also serve as a practical approach for future research studying complex user-system interaction like Web image searching. The triangulation of research data collected from both Web image search logging and user study, as well as the instruments used to assess users' background information, are useful in systematic observation and instigation of searching behaviors in relation to various search contexts, such as different search goals, prior experience and knowledge, and the problems encountered. Finally, the contextual query recommendation tool built on our user model is able to respond and make suggestions according to user's search intent in real time. Not only does this tool demonstrate the feasibility of current research findings; it also connects a user-oriented study with a system-based solution. *Figure 1.2* depicts a conceptual model for the current research, including the system and user-oriented problems in Web image searching, the intended integral study and the resulting user model, as well as the main contributions in system development and research community.

The entire research (i.e. the user model and the query suggestion tool together) enhances the existing Web image search system's usefulness by changing user's role in the search process, from passive recipient of any information given by the system to actively steering the search direction. The user model summarizes our theoretical understanding of how users' various contextual factors affect search strategies and the associated behaviors. Unlike most user-oriented studies, this research further demonstrates the potential usefulness of the resulting user model in the contextual query recommendation tool. However, as this research only aims to develop the framework rather than building the actual system, system-oriented evaluations such as performance and retrieval effectiveness are not within the scope of the current study.

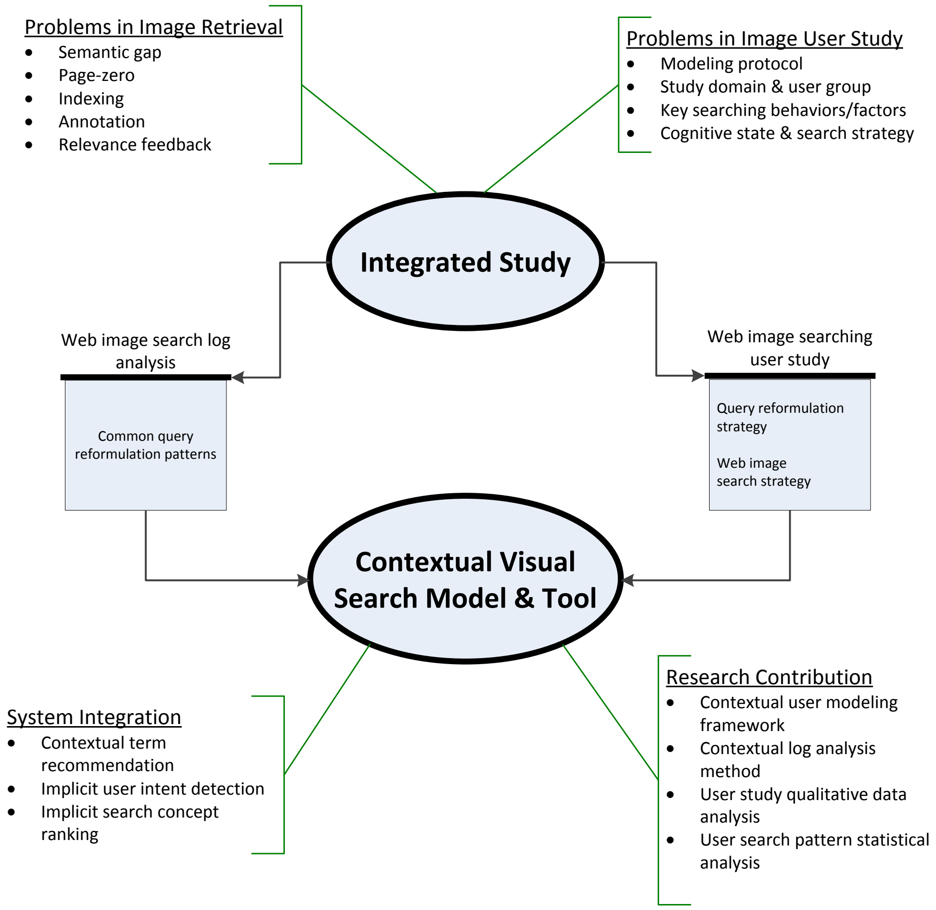



*Figure 1.2* The conceptual model of the current research

# 1.6 Structure of the Document

This thesis investigates issues of current Web image searching from both system and user perspectives. The first part of *Chapter 2* provides literature reviews on the current image retrieval systems and their limitations from user's perspective. An overview of new developments in systems to resolve user's visual query formulation problems is also provided. The second part of *Chapter 2* covers user's visual information searching modeling, with a focus on the query formulation strategies and our research assumptions. Several user models are also proposed based on the literature reviews in this chapter. *Chapter 3* presents the methodology and details for our Web log analysis and Web image searching user study. The results of the log analysis and user study are presented in *Chapter 4*, followed by the discussions of key findings and the contextual visual search model in *Chapter 5*. Finally, Chapter 6 provides the conclusions of the current research method and findings, and indicates some future research directions in Web image searching.

# CHAPTER 2: LITERATURE REVIEW

This chapter reviews literatures on issues with current image retrieval paradigm from both system and user perspective. The motivation for this research is stated in *Section 2.1*, with reviews on the overall problems and limitations in current image retrieval. In particular, *Section 2.1.1* begins with issues in Content-based Image Retrieval (CBIR) approaches, followed by the new research implications from recent user studies (*Section 2.1.2*). As research interests in solving the image retrieval problems shift from system-oriented to user-oriented, *Section 2.1.3* focuses on the study findings in users' image needs, including three main aspects: *the use of images*, *the types of image being sought*, and *the way people look for images*.

From *Section 2.2* to *Section 2.4*, the system perspective of image retrieval problems is discussed. In *Section 2.2,* a concise review of state-of-the-art image retrieval systems is provided, as well as significant search paradigms from query-based and browsing approaches. *Sections 2.3* addresses the open issues in image retrieval in terms of content indexing, understanding search needs, and intuitive searching modalities. These issues become the direct motivations for this research, particularly the difficulties in understanding users' image needs and providing intuitive searching. *Section 2.4* discusses some new developments that are related in resolving the problems stated in *Section 2.3*.

From *Section 2.5*, user perspective on the studies of image retrieval problems is explored. First, some important theoretical models for general information searching behaviors are introduced in *Section 2.5*. The preliminary user models that outline the qualitative framework for studying Web image searching behaviors are proposed in *Section 2.6*. *Section 2.7* focuses on the study findings and approaches in Web search log analysis, which contributes to the quantitative research method in the current study. Finally, users' Web searching strategies are reviewed in *Section 2.8* with emphases on query formulation and reformulation activities. A concise summary of the chapter is provided in *Section 2.9*.

## 2.1 Motivation

With the advancement in Content-Based Image Retrieval (CBIR) systems and visual object recognition techniques, the majority of visual information retrieval studies have been concentrating on the accuracy of image indexing and matching (Datta, et al., 2008; Kherfi, et al., 2004; Zhao & Grosky, 2001). However users seldom reported such approach useful or beneficial, especially for the vast heterogeneous Web image users (Jain & Sinha, 2010). Because Web users usually possess limited domain knowledge and searching skills, and they only have patience to interact with the retrieval system (i.e. the Web search engines) over a very short period but with greatly varied intents and highly dynamic search needs, systems that either require specialized knowledge to use, or perform well only in selective domains, are thus not suitable for general Web users. As a result, more and more research attentions have been drawn from system perspectives toward user-centered studies in order to understand users' search needs and behaviors in greater depth.

Early research has highlighted the importance of solving *semantic gap problem* (i.e. the problem of how users' semantic image problems can be expressed in terms of low level image features such as color, shape, and texture) (Smeulders, et al., 2000), and *page zero problem* (i.e. difficulty in finding a representative image that best describes users' image problem to start the retrieval process) (Kherfi, et al., 2004) in order to build more effective image retrieval systems.

Various approaches have been proposed to overcome the aforementioned problems. For example, semantic gap can be reduced by using semantic objects to search, or pre-existing query templates; page-zero problem can be eased by incorporating browsing ability to Query-by-Example (QBE) search engines (Kherfi, et al., 2004). The most significant attempt to solve these problems is the introducing of relevance feedback (RF) mechanism. Relevance feedback systems typically ask users to select/rate the relevant results (explicit relevance feedback), or assume the top few results are close to users' intention (implicit or pseudo relevance feedback). The systems then automatically adjust the retrieved results toward these relevant items, thereby improve the retrieval accuracy. However such approach is not perfect. As image search users generally have longer interactive session with the system

(Tjondronegoro, et al., 2009) and the iterations in relevance feedback process will further extend such session times, there is a risk that users would lose interest or patience in the middle of a search session such as skipping the RF iterations or terminating the whole session. Thus more and more researchers have addressed the need for an effective way to capture users' intention of image use. Moreover, with the increasing availability of Web images, there is also an emerging need for management tools to effectively handle these vast and diverse collections of online images in order to fully utilize them (Jing Huang, et al., 1999; Jacobs, et al., 1995; Kherfi, et al., 2004; Stan & Sethi, 2001; Yanai, 2002).

While searching upon collections of categorized images with annotation and keyword indexes may seem to be somewhat similar to traditional text search (Qian, et al., 2003), some images are very difficult to annotate, such as images taken by surveillance camera or Web images uploaded by various users. In addition, manually annotating images is not only time and effort consuming, but the inconsistency in annotations also becomes problematic because different annotators may use different ways and vocabularies to describe same images (Enser, 1995; Qian, et al., 2003). Thus early image retrieval systems mainly focus on the content-based indexing techniques.

### 2.1.1 Issues of content-based image retrieval approaches

Early CBIR systems and related studies devoted to automatically storing images based on its visual features such as color histogram, edge orientation, and texture/object extraction, etc. (Gevers & Smeulders, 2004; Venters, Hartley, & Hewitt, 2004). General applications for such image retrieval systems range from law enforcement (e.g., forensic purpose), content filtering (e.g., parental control for WWW), copyright protection (e.g., trademark registration), entertainment, education, travel and tourism, training, creative design, and other domain specific knowledge management (Gudivada & Raghavan, 1995; Kherfi, et al., 2004; Ranjeet, et al., 2011). These are just some indications of common image usage, much more domain specific image applications can be drawn from particular collections.

However, indexing low level features can result in considerable issues in both computation performance due to the complexity of feature vector metrics, and the accuracy of interpreting users' semantic visual needs by a set of corresponding image features. The latter phenomenon is commonly referred as the *semantic gap* problem (Datta, et al., 2008; Stan & Sethi, 2001). To tackle the computation problem, research has been successfully applied various dimension reduction (e.g., PCA) and machine learning algorithms (e.g., SVM, Bayesian network, k-means clustering) to improve indexing and retrieval performance (Gondra, Heisterkamp, & Peng, 2003; Hoi & Lyu, 2004; Wu, Lu, & Ma, 2004). With continual improvements in sophisticate algorithms and advancements in computing powers, promising results have been constantly reported over the years.

### *Semantic gap*

The most significant problem in content-based visual information retrieval appears to be the semantic gap problem (Jain & Sinha, 2010). Smeulders et al. (2000) defined semantic gap as:

> *The semantic gap is the lack of coincidence between the information that one can extract from the visual data and the interpretation that the same data have for a user in a given situation.*

As research in this area only considers how computers recognize an image but ignores how the same image is seen by real people, the CBIR systems have never been fully successful in closing the gap. Such situation is clearly evident by that CBIR techniques are hardly, if any, adopted by the current search engines people use every day (Jain & Sinha, 2010). In fact, despite those technical achievements, users still prefer to use semantic terms or objects to search images and therefore limit the usability from content-based approaches (Chen, 2001; Youngok Choi & Rasmussen, 2003; Enser, 1995; Jorgensen & Jorgensen, 2005; Magalhaes, et al., 2008; Othman, 2005; Smits, et al., 2006; Spink, et al., 2004; Tam & Leung, 2001; Westman & Oittinen, 2006).

## *Image annotation*

Image annotation is an intuitive and direct solution to the semantic gap problems, especially for Web images. Since manual annotation does not seem feasible for Web images, much of the research effort in this area attempts to use textual information to describe the content of images automatically. Because Web images usually accompany surrounding text descriptions, some researches have attempted to use such textual information to serve for image annotation purposes (L. Yang, et al., 2007). However the surrounding text may not always be related to the images within the same page, such approach brings accuracy concerns if automatic annotation is being applied. Various techniques have been proposed to complement the drawback, such as relevance feedback and human computation (i.e. the ESP annotation game) (Ahn & Dabbish, 2004; Datta, et al., 2008). For example, Datta (2007) proposed a meta-learning image annotation framework which utilize black-box (i.e. free-text image tags from users) vocabularies, lexicon knowledge base (e.g., WordNet ontology) and ground-truth vocabularies to achieve automatic image annotation. They also proposed an algorithm for correcting image tags from users' feedback over time, which is able to re-train the system toward more accurate annotation as more feedback data becomes available.

## *Object recognition*

Other than annotating images using textual descriptors, object recognition techniques have also been widely studied. Since users mostly search on some particular objects in images (e.g., people, place, namable objects) (Chen, 2001; Youngok Choi & Rasmussen, 2003; Enser, 1995; Tam & Leung, 2001), the object recognition technologies have become popular in many domain specific image retrieval systems such as face recognition and vehicle plate recognition. This is probably the most developed area in content-based image annotation approaches. By automatic object identification and annotation techniques, some degrees of image content semantic can be indexed for retrieval, and thus partially reduces the semantic gap. However the accuracy of object recognition and the complexity of object that can be automatically identified remain the main challenges in this area.

In order to achieve more accurate object recognition, researchers have also investigated various image segmentation techniques. There are two mainstreams in segmentation approaches, namely *fixed* and *region based segmentation*. While fixed segmentation (i.e. partitioning images into pre-defined and invariant segments) improves indexing performance and reduces computation complexity, it does not benefit object recognition much because one object may be accidentally divided into several segments, which makes recognition even harder. Recent research focuses on region based segmentation (i.e. soft segmentation) to help recognition. By contrasting the potential target objects against its background, segmentation algorithms can identify the contour of an object, and partition that object into an individual segment with a record of its spatial relation to the entire image. Hence the background noise is largely eliminated and recognition accuracy can be improved. Promising as it may sound, the remaining issue in such soft segmentation is the difficulties to intelligently detect the region and contour of the target object and perform automatic segmentation, especially in low object-to-background contrast conditions (J. Z. Wang, Jia, & Wiederhold, 2001).

Other limitations regarding the feature extraction and representation of images are also reported in many different studies. For example, Stan and Sethi (2001) pointed out that human's color perception is not similar to the RGB color space widely used in image processing domain (i.e. the sensory gap), thus results in considerable issues when retrieving images based on color features.

### 2.1.2 User studies in image retrieval

Besides the system prospective, users' search context, such as their background motivation for searching images, the influence of their cognitive states in the search process, and their expectation in result evaluation, should also be taken into consideration when designing a user-oriented retrieval system. As CBIR usually treats visual information independent of different situations, users' search context gains more importance because research has realized that the meanings of images are always 'contextual' (Jain & Sinha, 2010). Clearly, an image can be interpreted in many different ways depending on the viewers, just as the concept of Rorschach tests suggested (Exner Jr, 2003). As long as image searches rely on some sort of annotation or textual description to bridge the semantic gap, searchers' context cannot be neglected as "*A linguistic description is almost always contextual, whereas an image may live by itself*." (Smeulders, et al., 2000).

Recently there is an increasing interest in studying users' interaction with the retrieval system to understand users' intent and preference for more interactive searches (Datta, et al., 2008; Kherfi, et al., 2004; Spink, 2002). Users often find it difficult to have a proper starting point to commence their search simply because the retrieval need is not always as lucid as exact query keywords or set of sample images. McDonald and Tait (2003) observed one phenomenon that some degree of compromise appeared in users' acceptance of result images which may be caused by the difficulties in forming better search queries. Hence researches have begun to realize the importance of system's ability to guide users from problem identification to query formulation.

User studies can help understanding users' search needs, as well as designing user-oriented retrieval system which cannot be achieved solely from system perspective. Despite the variations in methodologies used in user studies, three major aspects of users' image need and image searching behavior are being explored:

- The use of images
- The types of images that people are searching for
- The way people search/describe images

Detailed discussions and empirical findings are presented in the next section.

### 2.1.3 Users' image need

#### ***What's the use of retrieved images?***

Fidel (1997) classified general image use into a continuum spectrum which consists of the data-pole and the object-pole on either ends. Data-pole of image retrieval refers to when user seeks images as a kind of information media to solve their problems. On object-pole, images are defined by its appearance to the retrieval task context (e.g., images sought to be used in design works). Other usage of images falls in-between these two poles. Similarly, Allen (1991) suggested that the use of images can also be presented in contrasting pairs, such as known vs. unknown need, variable vs. fixed, precise vs. general target, simple vs. complex, and values vs. text. Other than presenting and positioning the use of image on a bi-polar dimension, Conniss (2000) suggested seven classes of general image usage:

- *Illustration*
  Images under this category are used as supplementary information to the associated text content, such as news images.
- *Information Processing*
  The content of this type of images is essential to fulfill users' information need, that is, images belong to this category are used as the source from which more information can be extracted. Examples will be maps, medical imaging, etc.
- *Information dissemination*
  Using the data contained in the image to convey information or concepts to others.
- *Learning*
  This type of usage aims to gain knowledge or information from images, related to educational purposes.
- *Generation of ideas*
  Images retrieved as a mean for inspiration falls into this category.
- *Aesthetic value*
  One unique character of images is that it can serve as decorations to existing works to appeal people due to their nature of visual attractiveness, such in that when designers seeking photos or illustrations for their design works.
- *Emotive or persuasive*
  Image can also be used to simulate emotions or feelings. Such purpose is most commonly seen in portrait photographer's albums.

When considering the use of images in academic context, Weedman's (2002) study identified three functions of images use across different stages in sociology research: a *tool for thinking*, a *carrier of information*, and a *memory system*. Among the three functions, tools for thinking emerged as the most important and primary use since the research work constantly requires constructing new knowledge. Thus images serve as a stimulus to inspire researcher's existing knowledge base and help generating new ideas.

### *What images people look for? (Types of images being sought)*

Studies have shown that users are generally more interested in finding images about people, place/location, or some particular objects (Chen, 2001; Youngok Choi & Rasmussen, 2003; Enser, 1995; Tam & Leung, 2001). Enser (1995) suggested that over 70% of image retrieval needs were to find some unique person, object, or event after reviewing more than 2,700 user requests. Chen (2001) analyzed search queries from 29 art history college students when they were instructed to retrieve images for their school paper. After mapping student's queries with Jorgensen and Jorgensen's (2005) 12 image attribute classes, location class received the most judgment. However, as the authors acknowledged, this may partially due to the nature of the image collection used in their study (i.e. HAA 1200), which focused on medieval cities. Literal objects and art historical information were the second and third most frequent judged classes, followed by people related class. Choi and Rasmussen (2003) conducted a similar study on 38 graduate students of American history. Their image search queries revealed consistent findings that students also mostly looked for general person and thing, events with some condition limits such as location or time period.

In Westman and Oittinen's (2006) study, they compared written image requests by archivists and image queries from the newspaper editorial system. They found that most image requests were specific, with a person's name being the major request type. However there were a significant proportion of requests and queries for general objects and themes. Thematic needs seems important to journalists in their illustration task and browsing is the most frequent search strategy after initial query. Their They also noted that grouping images thematically based on informational content, compositional features, and contextual factors (e.g., the photographer who created the image, the type of the image, and the publishing time, etc.) would help journalists structuring the images and facilitate collective image retrieval.

Smits, Plu, and Bellec (2006) analyzed the annotations of personal online photos from users' album, personal website, and blogs. The annotations from 637 pictures revealed that most annotation focused on people (family members), place (visited during holidays), and events. In fact, 95% of data studied is about people or place. Such findings further signify the prevalence of people, location, and objects from the image provider's perspective (i.e. people who produce the images and annotate them for others to search upon).

Based on the literatures reviewed, we have concluded that people, location, and specific objects are important image attributes not only in providing retrieval information, but also center to people's construct when describing images. The following section will discuss image query classifications, frequent used image attributes in user queries, and some search strategies.

## *How people search for images?*

### *Classification of image queries and visual descriptors*

Various works have been done in the attempt to categorize users' image need on a global dimension. Followings are some significant researches in recent years:

Chen (2001) compared the art history students' queries with Enser and McGregor's (1992) four image query categories, Jorgensen's (1998) 12 image attribute classes, as well as Fidel's (1997) data and object pole. Unlike Enser and McGregor's findings which reported that unique queries were the most frequently used and non-unique queries being the least used, they found participants mainly submitted unique and non-unique queries, seldom with refinements. The small number of queries judged in Fidel's data-object pole classification manifested the difficulty to classify image queries into this dichotomous/bipolar theme. As a result, the author has integrated Jorgensen's image attributes with Enser and McGregor's categories of image queries. Because of the prevalence of people, location, event, and particular object in image needs, these four attributes were used to classify queries into unique category. Non-unique category can be viewed as a broaden classification of unique queries, such as people-related, time-related (event), or general objects. The last is the refiner category which the authors did not further differentiate between unique or non-unique as Enser and McGregor did. Instead they constructed refiner in a more universal dimension such as time, location, format and visual elements (e.g., color, shape, etc.) to reflect the findings that their participants seldom add refiners to their queries.

Choi and Rasmussen (2003) mapped American history student's queries to Batley's (1988) categorization of image search needs and found more than 60% of requests fell into general/nameable category with specific need came in second place (26.3%). Thus most people seem to have some broad ideas about their image needs at initial stage with limited keywords to express the full range about their ideas. The analysis of search terms revealed that around 65% of terms in all requests are general terms, with date, title, and subject descriptors being the most important factors for representing images. Jansen (2008) also tried to map Web image queries to the three known query classification schemes proposed by Enser and McGregor (1992), Jorgensen (1998), and Chen (2001). However he found that the frequency and categorization of Web image query terms differed significantly from previous studies which were based on specialized image retrieval systems. Such finding suggested that image queries may be collection and user group dependent, and previous study findings may not be well generalized to Web image collections and more research is needed.

In terms of image descriptors, Greisdorf and O'Connor (2002) proposed seven categories of image attributes that user usually adopts when describing images, including color, shape, texture, object, location, action, and affect. The first three are the innate properties of image itself. Object, location, and actions need to involve some degree of cognitive effort to identify and are the dominant attributes users would use to describe images when first encountered (Jorgensen, 1998). The last one, affect, is the top level semantic representation of image which is largely subjective to individual's interpretation. In Jorgensen's (1998) study, participants used more content and story attributes when recalling the previous seen images. Othman (2005) further confirmed this point of view that when asking users to annotate images, object, location and action are the three most frequently used attributes, whereas in the case when image's topicality is not easy to extract, users tend to express an image by its visual attributes, leaving high semantic level of emotional descriptors rarely assessed.

*Users' image querying strategies*

Search strategies can generally be classified into two groups based on the way they were deduced, either from the whole search session (Fukumoto, 2006; Rieh & Xie, 2006) or from single query reformulation (Bates, 1979; Westman, et al., 2008). While the transitions between query reformulations provide good granularity for predicting users' upcoming query reformulation behavior (Bernard J. Jansen, Booth, & Spink, 2009), strategies from the whole search session provide better picture of users' overall search plan and thus become the focus of this study. To avoid confusion, in this document, Web search refers to searching for textual Web contents, whereas image search indicates searching for Web image contents. Reviews on some important findings in general Web searching strategies are presented next.

The general implications of Web searching strategy are that browsing is more preferred by novice users or users who have exploratory goals, whereas querying is perceived as more suitable for experts or specific retrieval tasks (Frost, et al., 2000; Sutcliffe & Ennis, 1998; Westman, et al., 2008). In particular, browsing is an important tactic in Web searching which received much attention (Carmel, Crawford, & Chen, 1992; Catledge & Pitkow, 1995; Cove & Walsh, 1988; Frost, et al., 2000; Savolainen & Kari, 2006). Savolainen and Kari (2006) found 13 search tactics originated from three major problems in Web searching: *problematic content of information*, *insufficient search competence,* and *problems caused by the search environment*. Browsing related tactics dominates (81.7%) while only three other tactics (18.3%) are associated as analytical search tactics, including *using search engine*, *finding search terms*, and *narrowing searches*.

Rieh and Xie (2006) manually investigated 313 sessions of five reformulations or more and classified the overall query reformulation approaches into one of the eight distinct strategies, including: *generalized*, *specified*, *dynamic*, *parallel*, *block-building*, *multi-tasking*, *recurrent*, and *format*. While generalized and specified searching strategies have been extensively discussed in other studies, dynamic, multi-tasking, and recurrent are the three newly discovered strategies. Users who adopt dynamic search strategy inconsistently broaden or specify the query within a search session, representing a trial-and-error searching style, especially when encountering problems. Recurrent reformulation signifies that users attempt to compare different variations of search queries, and re-enter the most promising one later for more results.

Thatcher (2008) identified 12 search strategies from the analysis of the influence of Web experience and task types. Despite no significant difference in search strategies among levels of Web experience across different tasks, higher level experience was more closely associated with '*parallel player*' or '*known address domain search*' strategies. Thus participants with higher Web experience are more likely to simultaneously deploy several slightly different search approaches for the same task, or directly access a known website to retrieve the required information. On the contrary, participants with lower Web experience are more likely to systematically follow the links from a website or category search results. However, the author merely reported participant's preferences in each task type rather than further investigating the cause of these search strategies.

Tseng, Tjondronegoro, and Spink (2009) studied Web image query reformulation and showed that image searchers are generally prone to adopt a *top-down* strategy, with a considerable proportion of constant reformulation in which queries were replaced with equal number of terms throughout the entire session. In addition, Aula, Khan, and Guan (2010) found that users' query reformulation became unsystematic when facing difficulties and exhibit behaviors resembling novice searchers.

Jorgensen & Jorgensen (2005) investigated image search behaviors and query reformulations among image professionals involving advertise, marketing, and graphic design versus general Web users. No significant difference was found between these two groups of users, indicating image professionals have no better search strategies for retrieving images. Users normally start with general queries then iteratively interchange related terms to explore different results. This indicates that users would have a broad idea about their targets, but was unable to consolidate to specific images or visual object at the initial stage of their searches, even the professionals suffer from the same difficulties. With a closer observation of query reformulations, it is interesting to note that a large number of queries only have adjectives as search terms. These adjectives may function as concept terms rather than modifiers of other objects that are commonly used in natural language expressions. Change of terms is the most common reformulation type (accounted for nearly 60% of all reformulations), and around 94% of change reformulation are switching between related terms. Thus, it seems users adopt the approach of 'stab in the dark' when reformulating their queries by switching different types of related terms (e.g., replacing a noun with adjective or visual construct) and browse for the relevant images. Unique search terms were found to be less than previously reported, but possibly due the more restricted definition of unique terms as 'proper nouns'. Far fewer searches appear to be sexual related than general Web search studies as expected from professional searches (Bernard J. Jansen, Spink, & Saracevic, 2000; Spink, Jansen, Wolfram, & Saracevic, 2002; Tjondronegoro, et al., 2009). More details and discussions on the findings of Web query log analysis are presented in *Section 2.7 and 2.8*.

# 2.2 Image Retrieval Systems

## 2.2.1 Reviews of contemporary image retrieval systems

### *Current Web image search engines*

Commercial Web search engines, such as Google, Bing, or Yahoo, all allow searching for images as one of the search types they offer. By selecting the image tab on the top of search input page, users can limit the retrieved information to images only. It is a convenient way of performing image search, as in the long-existing Web searches. However, the main problems of these search engines are the accuracy of the retrieved images, and the assistance they offer for users to drive/refine their searches.

The first problem was due to that these text-based image search engines mainly rely on nearby textual information to index images (e.g., surrounding paragraph text, filename of the image, or the alternative title of an image imbedded in html codes) (Cui, Wen, & Tang, 2008; Hua & Tian, 2009; JISC Digital Media, 2008). Hence the content of the images may not always match the textual information nearby, resulting inaccurate annotation/indexing, and impedes the quality of retrieved results. The second problem is related to the search and result reviewing interface, in which mainstream search engines endeavor to make as similar to general Web searching as possible, and minimize the impact on searching experience. We briefly discuss several different result displaying methods in the current systems.

## *Visualization for result display*

Regarding the visualization/interface of retrieved results from current Web image search engines, only limited displaying methods are offered. Image result presentation can generally be classified as following (Datta, et al., 2008):

*Relevance-Ordered*

This is the most popular and widely-accepted way to present search results. Images are displayed in their relevance order regarding the query user inputted. Their individual relevance score is the key to the ordering, however, the scoring systems/algorithms are in-house developed and thus are not transparent to general users.

*Time-Ordered*

Images are displayed in chronological order according to the date created. This is a popular displaying method for personal image collections, such as Google Picasa (Google, 2012) and Apple iPhoto (Apple Inc., 2012).

*Clustered*

Clustering images based on their visual content or meta-data. This has been an active research topic for recent years as such feature is desirable for customizing result displaying for individual needs. Google and Bing image search offer the option to search similar images based on particular image in the result set, which works as content-based similarity clustering, but with limited usability (Hua & Tian, 2009).

*Hierarchical*

Arranging images based on the hierarchical structure of their meta-data, or semantics such as WordNet, has been advocated in advanced image retrieval development, particularly for concept-based retrieval. This presentation is desirable for searching on archives, such as retrieval for educational purposes.

*Composite*

Displaying results in the combination of two or more aforementioned methods. For example, images are first clustered based on their associated concepts, and hierarchically presented in related concepts. This type of presentation is useful for personalized systems as more features are available for searching and the indexing complexity is more readily to support displaying in this mode.

Because retrieval speed is usually the priority of Web image search engines, they are constrained in providing complex search tools as their search methods. Google image search, for example, does not have the ability to dynamically cluster multiple images as examples, nor can it present nearly duplicate images in same clusters. The content-based features it currently provides are refining results with people's faces in the retrieved images, and searching based on the content similarity of a particular image (predominately color feature similarity) (JISC Digital Media, 2008). These two features are also supported by Bing image search (Hua & Tian, 2009).

Advanced content-based search schemes, such as *query-by-drawing* or *query-by-concept*, are only seen in certain research systems. Next, we reviewed some significant content-based retrieval systems over the years.

## *The QBIC system*

Currently, lots of image retrieval systems are still in research stage, commercially available systems or packages are still rare, especially the CBIR systems (Deb, 2004). Arguably the first best-known and comprehensive CBIR system is the QBIC (Query By Image Content) system developed by IBM's Almaden Research Center in the early 1990s (Deb, 2004). The system makes use of all three primary visual features, namely color, shape, and texture, and incorporates many query tools such as color histogram selection, query by image example, and sketch tools (Flickner et al., 1997). However, the QBIC system only focused on retrieving based on low level image features and inevitably neglected the importance of image's semantic meanings to users' image problems. Thus the majority of contemporary online image retrieval systems still utilize textual information as the only means to search images such as category browsing and keyword search. Text-based search is also more efficient than content based search in most cases and more close to human thoughts (Jorgensen & Jorgensen, 2005). Here we review two advanced image retrieval system developed by Wang, Jia, and Wiederhold (2001).

### *The SIMPLIcity system*

The state-of-the-art CBIR system tries to incorporate low level visual features with higher level semantic meanings to be searched upon, such as the SIMPLIcity (Semantics-sensitive Integrated Matching for Picture Library) system developed by Wang et al., (2001). Their system classifies images into global semantic categories (i.e. textured or non-textured, graph or photograph) based on sets of empirically predefined features, and uses what they called integrated region matching (IRM) for image similarity measurement based on matching the properties of multiple regions between two images. The IRM has been proven to be a superior matching theme than single region matching method and promising results have been reported from their study.

In a recent review of the currently 'live' CBIR systems, the SIMPLIcity system performed well in *Blumen* (i.e. flowers) domain images showing a high potential of the IRM mechanism (Kosch & Maier, 2009). However it performed poorly in other domains such as street band (group of people) and texture images, showing the limitation for fully automated CBIR approach in heterogeneous image domains.

### *The ALIPR system*

Li and Wang (2003, 2008) developed a real time automatic image annotation system based on the functionality of SIMPLIcity system and IRM retrieval theme, namely the APLIPR (Automatic Linguistic Indexing of Pictures Real-time). They used multi-resolution segmentation to extract and index image features. In their system, merely 40 images are required to train each concept to obtain a statistical model. They also manually create a cluster of keyword descriptors for each concept. When indexing images, ALIPR uses indexed feature to compare with each concept model, obtain probability measures of significant concepts and stores with the image. To perform retrieval task, ALIPR calculates significant concepts and displays associated keywords based on query image or query text. A more detailed review of ALIPR's image categorization and annotation approach can be found in Datta, Ge, Li, and Wang's (2006) study. Thus although it seems no much difference from traditional keyword-based retrieval system, ALIPR has successfully combined both textual annotation and visual content to facilitate an intuitive search. The main strengths in ALIPR system include:

- Scalability for real time image indexing
- Accessing both content-based and semantic image concepts
- User-friendly keyword based querying interface

Xu, Wang, Hua, and Li (2010b) demonstrated a new interactive image search system by enabling users to position semantic concepts on a 2D canvas and formulate the visual query. This concept map query not only contains semantic objects user wants to find, but also specifies the spatial relationships between the target objects. By doing so, the authors claimed the search interface combines the advantages of *query-by-text*, *query-by-example*, and *query-by-drawing* retrieval systems while maintaining intuitiveness for general users.

In terms of contemporary commercial Web image retrieval systems, Tjondronegoro and Spink (2008) conducted a survey on the multimedia search functionality supported by a number of major Web search engines such as Google, Yahoo, MSN and AOL, they found that less than 5% of investigated retrieval systems provided content-based search method, and most of keyword search engines demonstrated limited ability in image retrieval as text descriptors often varied from user to user and user dictionary is yet to be structured. Different search engines have different purpose and possess different collections of images (Spink, Jansen, Blakely, & Koshman, 2006), sometimes it relies on users' domain knowledge and experience to choose a proper image retrieval system and get satisfactory results. Furthermore, Kherfi et al., (2004) have pointed out the lack of survey on specialized retrieval system. Hence the full potential of current online image retrieval systems is still unknown and lots of in-depth assessments have to be done to provide a holistic view of the current state of system development. The following section is designated to provide an overview of the current image retrieval system's functionality and attempts to identify some problems of these systems from user perspectives.

## 2.2.2 Search paradigms of visual retrieval systems

Generally, there are two mainstreams of image retrieval systems that can be identified based on their search approach, either query-based or browsing (Kherfi, et al., 2004). Query-based retrieval system takes user input, whether keywords, image examples or both, as the initial query to perform retrieval process. Browsing style search allows users to go through images within a predetermined category. Based on the search themes, query-based approaches can be further classified as *query-by-keyword*, *query-by-example*, and recently emerged *query-by-concept* paradigms.

### ***Query by keyword/free-text***

Among these three major variants of query-based retrieval systems, query-by-keyword/free-text approach is the earliest developed and most widely adopted search theme. This type of search approach is found to be useful when users have a clear set of target images (Frost, et al., 2000; McDonald & Tait, 2003). Typical examples would be Google image, Yahoo image, and Flickr's search, which they ask users to input some descriptive keywords for the category, title, or objects appeared in the target images to initiate the search. Textual based query method has been proven to be more intuitive to general users and easier to represent users' image needs (Jorgensen & Jorgensen, 2005; Lew, 2000). However the important issue with such query approach is the demand of image annotation/labeling. Because an image can be described in many ways, the accuracy and consistency of annotations and the accuracy of image descriptors are always the concerns in image annotation. In addition, the labor and time involved in manual annotation process for large image collections hindered the utilization of textual information for heterogeneous image collections like Web images. Thus textual descriptors usually have only been effective for specialized collection such as news images (Westman & Oittinen, 2006). Although there is an emerging trend of utilizing the collective effort from Web users, such as the tags associated with Flickr images (i.e. folksonomy), its validity and accuracy are difficult to assess and thus limits its ability to generalize to other image collections (for more details in image annotation, see *Section 2.1.1 - Image annotation*).

### ***Query by example (QBE)***

In order to overcome the image annotation problems when retrieving based on textual information, researches have proposed the Query-by-Example (QBE) retrieval approach. In QBE, sample images are sent to the system as templates for users' image needs and similarity matching calculations are performed based on the content features of these images. QBE image retrieval system can be further classified into two groups, one requires the user to submit or select some sample image(s) as an initial query, the other asks user to draw a sketch that represents the target images (McDonald & Tait, 2003).

Other than QBE, a slightly variation is the query-by-icon which allows user to position icons on the query canvas. Because the icon appears to be high level semantic objects, users usually find it more intuitive and easier to query an image than other methods stated above (Venters, et al., 2004). In a recent system developed by Wang and Hua (2011), they built an interactive search interface which a user can either scribble the overall color composition (i.e. the dominant colors and their spatial arrangements) of the target image, or select a representative image from the initial textual search result and highlight the areas of interest. The system even incorporates a hybrid search paradigm which not only allows the user to select and highlight from the sample image, but also let the user draw other concepts onto the image. In this way, visual features from the sample image can be utilized for searching, as well as the concepts that are not represented in the sample image are included. Users can also eliminate irrelevant areas in the sample image to perform partial matching searches, which was not available in traditional QBE systems.

The main advantage of QBE approach is that it bypasses the need for intensive human effort to process and index images and its validity can always be assured. However it also introduces the *semantic gap* problem which is unlikely to be solved by using low level features alone (for details in semantic gap, see *Section 2.1.1 – Semantic gap*). Some approaches that endeavor to make linkage between visual features and semantic meanings such as recognizable objects or concepts have been proposed. The mixture of semantic and visual information for retrieval is referred as *query-by-concept* in this document which is discussed in the next section.

### ***Query by concept***

Given the constrains in query-by-keyword and query-by-example retrieval paradigms, research has now moved to query-by-concept methods (e.g., TRECVID) to extract users' visual concepts from queries and perform searches based on these concepts. Furthermore, some systems even provide general users with some meaningful objects (e.g., some icons for primary semantic objects such as people, vehicle, or building) or templates to start their search (e.g., the ImageScape system (Lew, 2000)). While this method may still utilize content-based image indexing techniques to calculate similarity and perform relevance ranking, query-by-concept enhances the focus on users' semantic needs and has preliminarily reduced the semantic gap.

#### *Concept detection and annotation*

In order to perform retrieval tasks in concept spaces, visual contents have to be semantically indexed in database and the most immediate approach is to annotate them with concept descriptors or tags. Early research that first adopted such approach evolved from video retrieval community in which the "context" from visual contents is more important and abundant than single images. For example, Qi, Hua, Rui, Tang, Mei, and Zhang (2007) proposed a multi-label annotation paradigm to complement the traditional individual concept detection, and the Context Based Conceptual Fusion (CBCF) in current video annotation approaches. Typically, multiple concepts in videos are detected individually and independently (individual concept detection) using some clustered/combined low level features. However such method does not consider the correlation between semantically related concepts, such as “crowd” and “people”. CBCF takes a step further to refine individual concept detectors/classifiers using predefined ontology models. Although such method appears intuitively promising in increasing concept detection accuracy, empirical studies showed the gain in performance is not stable which may be compromised by the propagation of erroneous concept detection. Thus the authors introduced a third automatic annotation method, namely Correlative Multi-Label (CML) annotation. This method utilizes the pair-wise correlation between detected concepts and simultaneously train and optimize the concept classifier in one single step. Similarly, Zha, Mei, Hua, Qi, and Wang (2007) also utilized pair-wise concurrent relation among detected concepts to refine video annotations. By adopting this approach, the propagation problem of concept detection error can be minimized because the correlation of each concept pair is calculated concurrently and no predefined contextual model is required.

*Concept-based querying and searching*

Once visual contents are annotated with concepts, systems can utilize such additional feature to perform concept-based search. Xu, Wang, Hua, and Li (2010a) used a free-composition concept map query that allows users to specify relevant concepts and their spatial positions to search images. Users simply type in the textual concepts that should appear in the target images at the corresponding places in a blank canvas. This textual concept map is then transformed into a visual instance map which is used to retrieve relevant images based on their visual similarity. The proposed system exploited the strength of both textual and content-based searches in providing intuitive and specifiable querying methods, which further enhanced the concept-based search paradigm to a more useful state.

*Concept-based query expansion*

Users' queries, however, are not always as precise and controllable as system annotations. Same visual concept/instance may be described by different terms among different users, likewise a concept term may indicate varied appearances. Hence some degree of flexibility is usually needed in concept-based queries to search similar or closely related concepts. Such approach is referred as concept-based query expansion.

Natsev, Haubold, Tesic, Xie, and Yan (2007) proposed several new approaches for visual query expansion. In addition to sophisticate text-based query processing for concept-based query expansion (e.g., *lexical concept mapping* which matches query terms with concept descriptors, *lexical rule-based ontology mapping* which deals with the part-of-speech of query terms and their context to match the established visual concept ontology), they used statistical correlations between terms and visual concepts to retrieve more conceptually similar video shots. Their result showed an overall 77% improvement over text-based retrieval baseline and 31% improvement over multimodal baseline. However the statistical correlation approach performed no better, or even worse, in specific person retrieval, which may suggest the topic dependent nature of query expansion methods.

Similarly, Liu et al., (2007) combined text-based concept retrieval with content-based similarity pruning. The query is first extracted for its concepts and corresponding relevant video shots are retrieved with individual relevance score. Then a virtual hyperlink is created between any pair of the relevant shots. With content-based similarity measure, shots that are not visually similar are removed despite their potential semantic relevance. Finally all linked shots are re-ranked by PageRank-like algorithm which assumes the random walk between each shot and the hyperlinks are treated just like Web page links. Their result showed the new re-ranking algorithm improved 53.6% over text-based search baseline.

Although extracting concepts from users' queries may seem to be a viable approach, there are two open issues that require further research in concept-based retrieval (Wei & Ngo, 2007):

- How to building concept ontology

- How to perform Query-Concept Mapping (QUCOM)

The concept ontology helps expand the exact concept terms in queries in order to retrieve results in similar concepts (i.e. like using synonyms to retrieve), or highly related concepts (i.e. the inclusion of novel but relevant results). While the use of ontology to perform query expansion has been widely studied and applied in many research areas, the construction of a comprehensive ontology on large-scale remains as the major challenge. Some ontology for Web and multimedia information exists, such as WordNet and the Large-Scale Concept Ontology for Multimedia (LSCOM) (Naphade et al., 2006). Since the construction of ontology in particular information domains still requires a lot of research, it is too early to draw any conclusion on the applicability of using ontology for query expansion purposes and thus will not be discussed further in this thesis. The second issue in relation to performing QUCOM tasks is discussed next.

*Query-concept mapping and selection*

Concepts can be extracted from query terms by either concept descriptor matching or statistical model classification (Natsev, et al., 2007). Recent research even utilizes pre-defined ontology (e.g., WordNet, LSCOM) for concept similarity measure and query concept expansion purposes. Since concept extraction techniques have been successfully applied in many researches, the focus has now shifted to the selection of salient query concepts that best represent users' needs. Query-concept mapping and selection is important because retrieving visual documents based on too many concepts may result in noisy results and deteriorate performance due to the irrelevant concepts being searched (D. Wang, et al., 2007). Xirong, Dong, Jianmin, and Bo (2007) treated annotated video shots as text documents with concept descriptors and used a *concept tf-idf* formula to select the most relevant and informative concepts from users' queries (i.e. only the top distinctive concepts are selected to generate the concept subspace and perform search upon). Likewise, Datta (2006) calculated the saliency of query words using the inverse frequency in the categorization training set and WordNet-based relatedness measure.

Wang, Li, Li, and Zhang (2007) achieved better Mean Average Precision (MAP) by combining QUCOM from both textual and visual (i.e. visual samples) queries. They also examined the impact on MAP that is affected by the amount of selected concepts used. Although their combined approach is relatively resistant than other approaches such as text matching alone or concept *tf-idf*, performance degenerates a lot if 10 or more concepts are selected for search. Despite the positive results that research has obtained when evaluating the effectiveness of QUCOM against video retrieval data set, this finding raises another question of what is the optimal number of selected concepts for performing QUCOM tasks. In addition, Haubold, Natsev, and Naphade (2006) addressed the importance of semantic relatedness measure between retrieved concepts, especially when mapping to concept ontology.

*How many concepts are sufficient?*

Since the selection of concepts in QUCOM is critical to the performance of query by concept retrieval, researches have investigated the number of relevant concepts that is sufficient to produce satisfactory results. Particularly, in Wang et al.'s (2007) study, they found an average of 6.1 relevant concepts from the analysis of user queries. However the standard deviation was of 7.3 concepts, which indicates the high variation of the concepts users employed for search.

Attempts have also been made to build several semantic concept sets to facilitate the annotation and concept detection of multimedia information. For example, the Large-Scale Concept Ontology for Multimedia (LSCOM) (Naphade, et al., 2006) and MediaMill (C. G. M. Snoek et al., 2007; Cees G. M. Snoek, Worring, van Gemert, Geusebroek, & Smeulders, 2006). Hauptmann, Yan, and Lin (2007) investigated the number of indexed concepts that are necessary to produce sufficient accuracy in video retrieval (i.e. more than 65% MAP as the benchmarks in text search engines). Based on a typical broadcast news collection, they concluded that several thousand (typically under 5000) concepts are sufficient to achieve such goal, even with low concept detection accuracy (i.e. minimal 10% of detection accuracy).

Besides the aforementioned query-based search paradigms, browsing is essential to all kinds of searching activity. Although being presented separately in the next section, browsing is not exclusive to the query-based searching. In fact, results from query-based searching still require considerable browsing activity to filter irrelevant information. The current state of browsing search paradigm in image retrieval is discussed next.

### *Browsing in image retrieval*

Browsing is a primary information seeking behavior that human usually engages in (Vakkari, 1999; Venters, et al., 2004). Search engines such as AltaVista and Yahoo index textual information about each image. By adopting this approach they offer users the ability to search upon particular categories as semantic taxonomies applied in information retrieval, and browse through images within the selected category. It is a useful retrieval method when users do not have a clear target for their image need, or when they only have a broad idea about their intended usage (Westman & Oittinen, 2006). Such search goal is often referred as exploratory search since users' image needs are yet be further refined and consolidated through the interaction with system. One important phenomenon is worth noting here, users generally feel more comfortable with browsing tool because of the high sense of control comparing to query-based retrieval (Markkula & Sormunen, 1998). In Jorgensen and Jorgensen's (2005) study, they found that browsing usually results in downloading images, which they conceptualized as a successful search. Thus a user-centered retrieval system should incorporate an interactive browsing interface to help the image review and selection process.

The major issue with browsing search is users usually get tired or bored easily after reviewing a number of items before their information problems can really get consolidated. There is still lacking of empirical studies on the maximum number of images users are willing to go through until they find the proper image, thus left the true usefulness of browsing tool unaccounted for (Venters, et al., 2004). As mentioned before, although most of image retrieval systems utilize either query-based or browsing-based searches, they are not exclusive to each other. Current Web image retrieval systems such as WebSeek offers a hybrid search functionality which incorporates both query-based search and category browsing in order to provide more search flexibility to users (Kherfi, et al., 2004).

In addition to the type of search paradigms a retrieval system provides, browsing can be regarded as a user-oriented activity within the broad information seeking behaviors. Such view is more important to the current study, as users intentionally engage in browsing for certain needs, rather than as one variation in the whole range of searching paradigms from the system perspective. As the research focus shifts from system to user, browsing becomes one important problem-solving strategy that users constantly perform in many information seeking situations. Hence, it is appropriate to introduce different types of browsing and their implications for different search needs and intents later in the chapter (In *Section 2.8.4 – Browsing* under *Web search strategies*).

## 2.3 Open Issues in Web Image Searching

After the brief review of current image retrieval systems and search paradigms, this section discusses the open issues that drive the focuses of ongoing research in Web image searching. Although image retrieval is not a brand new research area in the broad information retrieval domain, considerable issues still exist which prohibit the system from readily use for general public. Because the current study intended to focus on user aspects of online image retrieval system, technical issues such as visual feature indexing or image annotation and categorization will not be discussed in great depth and only relevant techniques are presented here.

### *Difficulties for effective image content indexing techniques*

The first problem is caused by the heterogeneity of online images which impedes the retrieval accuracy of the retrieval results, thus prevents users from benefiting from such enormous collection of visual data (Kherfi, et al., 2004). One solution for this problem could be developing separate search engines for specific image collection or retrieval purpose. Simple combination of image features is usually sufficient for performing retrieval calculation in specialized database, such as texture for fingerprint recognition, and joining shape and color features for facial detection. However, when dealing with heterogeneous image data like Web images, the choice of effective features is extremely difficult if not impossible (Kherfi, et al., 2004). Thus, research is still investigating image indexing problems in isolated applications or domains, leaving the unified indexing approach unaccounted for.

### *Difficulties in understanding users' dynamic and versatile image need*

In terms of user perspective, it is not always easy for users to articulate their visual needs into textual queries and they may not possess abundant vocabularies to interpret their needs in full. Even if the users are image specialists, it would still sometimes be obstructive for them to find the best combination of features, either visual or textual, to represent their image need (McDonald & Tait, 2003). In fact, as stated by Venters, Hartley, and Hewitt (2004), the primary challenge of image retrieval system is to provide an effective means to specify the initial query.

Users often find it difficult to have a proper starting point to commence their search because their search need is not always as lucid as sets of keywords or images. McDonald and Tait (2003) observed some degree of compromise in users' acceptance of result images which may due to the difficulties in forming better search queries. As a result, users who only have some broad ideas about their image needs with limited keywords will normally start with general queries, then iteratively interchange related terms to explore different results (Youngok Choi & Rasmussen, 2003; Jorgensen & Jorgensen, 2005). Such searching behavior typically indicates the difficulty of articulating and consolidating search intents into specific images at initial stage of search, even the professionals can suffer from the same problem (Jorgensen & Jorgensen, 2005). As user encounters with more information, the original search need is shaped to become more clear and specific, as well as adapted to new directions if new ideas or problems arise. Such shaping process is typically reflected in users' query reformulation behaviors, as most changes in query are dynamic and largely affected by a number of situational factors (Rieh & Xie, 2006).

### *Difficulties for intuitive searching modality*

In terms of querying style, users still regard textual based multimedia searches as more intuitive, thus the challenge of visual information searching paradigm becomes how to provide an effective way for formulating textual queries (Jaimes, et al., 2005). Automatic image annotation is still challenging for current image search engines, as high level semantics are difficult to identify using conventional content-based feature extraction approaches.

QBE remains impractical at present because of the page zero problem which occurs when starting with images that are not representative enough for users' underlying intention (Kherfi, et al., 2004; Qian, et al., 2003). An intuitive solution would be providing sample images from each category in the system for users to choose from, however this approach may potentially incur another issue of image classification and thus only a small number of Web image retrieval systems adopt this approach.

In addition, formulating image queries with free-text/keyword raised considerable issues that received much attention. Particularly, Tam and Leung (2001) addressed the following limitations of traditional "free-text" keyword index approach:

- Keyword search cannot associate modifiers with an entity or action, in other words, the link between indexed entity and modifiers are neglected
- Keyword search cannot detect relationships between search words, other than coincidental. This means the inexact match of search words may result in the retrieval of semantic irrelevant images because the indexed captions partially fit the current criteria
- Keyword search cannot distribute different weighting to different types of search words (i.e. entity, action, object, modifier, etc.) depending on the search context. However people generally are more interested in entities other than their modifiers

There is also a practicability issue regarding to relevance feedback mechanisms which usually require users to undergo a certain amount of relevance judgment iterations before satisfactory results can be retrieved (Qian, et al., 2003). Since the findings in some research indicated that the average time span of one information retrieval session is just as short as 5 minutes and less than 3 queries (Bernard J.

Jansen, Spink, & Kathuria, 2007), and users are usually only patient enough for reviewing up to 3 abstracts in each result page (Lorigo et al., 2006), traditional relevance feedback approach is somewhat implausible for online users and automatic relevance feedback techniques have become the new research focus in this area (detail discussion on relevance feedback will be presented in *Section 2.4 New trends in visual search and query formulation*).

Other problems can also result from the search tool the system provides. For example, query-by-drawing challenges users' artistic ability since it is essential for him to draw the target image close enough to his memory representation (McDonald & Tait, 2003). Some possible solutions to overcome current challenges in multimedia information retrieval systems were mentioned in Jaimes, Christel, Gilles, Sarukkai, and Ma's (2005) article:

- Using ontology to index images (e.g., the Large Scale Concept Ontology for Multimedia – LSCOM) and classify images
- Leveraging the collective intelligence and effort from Web user community

In next section, some new approaches in retrieval system's querying mechanism are discussed in relation to the issues stated above.

## 2.4 New Trends in Visual Search and Query Formulation

With regards to the three main open issues in Web image searching, research has proposed various tentative but not definite solutions to these problems. However, as image searching itself is multi-facet and involves many different disciplines, no research can solve all these problems at once. While users spend most of their searching time formulating queries and reviewing results, it is natural to focus on improving such processes and therefore make Web image searching easier. In this section, new development/trends in research focusing on the query formulation and result reviewing processes are discussed. These new developments enlightened the current research approach, especially for the text-based visual searches.

## 2.4.1 Query formulation/reformulation assistant

### *Predefined query template (iconized or query text)*

Cheng, Chen, and Sundaram (1998) used the idea of example icons to construct semantic visual templates for visual queries. Icons are associated with some real world objects that comprise the search concept, and their spatial and temporal relationships are exploited for constructing search queries. For example, user can use a white background to represent a ski slope, an icon represents the skier, and thus construct a slalom theme for search by sketching a movement line of the icon across the white background. Their semantic template querying system improved the recall on similar concepts and facilitated query refinement by relevance feedback on system generated template variants. Fang and Salvendy (1999) conducted an experiment comparing search performance with user-centered pre-defined query templates versus traditional keyword based search. Results showed that pre-defined query templates significantly increased the recall rate for relevant websites, and improved users' satisfaction by 23%. Hierarchy representation of the pre-defined keywords also facilitate the search process as it is a more intuitive way to match users' own mental models of the problem domain and reduced the representational disparities.

In Fang and Salvendy's (2000) study, they compared the performance of recalls on relevant websites between a new user-centered keyword comparison feature and traditional keyword based search engine (i.e. AltaVista). The keyword comparison function calculates the keyword frequency among the relevant websites identified by the user and updates the ranked keyword list to support query expansion. The results showed both significant improvement in identifying relevant websites within one hour test period and higher user satisfaction toward the feature. Such approach is beneficial in suggesting potential concept related terms when refining queries.

Fidel (1991a) conducted a series of research to analysis online users' behavior regarding query keyword selection. She first developed a decision tree for the keyword selection routine between pre-defined descriptors and free-text words. Two important criteria were identified in the decision tree model, as *single-meaning term versus common term* and w*hether a term can be mapped to the concept descriptors*. She also suggested that when a single-meaning term is mapped to a broader concept descriptor, the system should consult the user for recall and precision requirements. She investigated the use of controlled vocabularies (i.e. concept descriptors from thesauri) and free-text keywords (Fidel, 1991b). Users did not show a preference on using either of the keyword sources (i.e. a 50-50 chance) but consulted a thesaurus most of the time when selecting search keywords (75%). Furthermore, users consulted a thesaurus only when they perceived it useful. Thus the lack of quality thesauri and indexing, or their availability hinders the search performance.

### *Controlled vocabularies*

Controlled vocabularies are designed to resolve problems in expressing concepts in query formulation (Fidel, 1991a), however they are usually expensive to construct and indexing can be labor-intensive (Fidel, 1991b). Furthermore, as there is no explicit conclusion on the degree of control (Fidel, 1991b), the application of control vocabularies still requires further investigation.

In another Fidel's (1991c) research, the researcher investigated users' searching style on three dimensions: level of interaction, preference for operational or conceptual moves (i.e. query reformulation strategies), and the preference for free-text keyword or descriptors (i.e. controlled vocabularies). No specific type of move was found to be more prevailing, but nearly twice of the moves were to enlarge the result set (conceptualized as to improve recall) other than reduce it (conceptualized as to increase precision). Users who made more operational moves (noted as 'operationalist' searchers) used textword more frequently and tend to avoid consulting a thesauri. While it has been shown in Fidel (1991b) that generally there is no obvious preference between descriptors and textwords, the selection of these search keyword resources is affected by external factors such as the subject of search, the specific requirements, and the availability of quality thesauri. From this research, it is clear general online users are more concerned about recall rather than precision, which is contradict to most assumptions in this area. Thus the author suggested several features for an information retrieval system to improve recall:

- List of synonyms for search terms
- List of term frequency calculated based on user selected records
- Easy access to database's index terms
- Clear display of search history
- Hierarchical representation of the relationships between descriptors

## 2.4.2 Query preview and refinement

Other than reformulating a query from per-defined terms, queries can also be refined based on the scope of retrieved results. This approach refers to the concept of dynamic query previews using graphical representation of matching data sets (Greene, Marchionini, Plaisant, & Shneiderman, 2000; Plaisant, Shneiderman, Doan, & Bruns, 1999). Such query representation would assist user rapidly assess the relevance of retrieved items, and filter unwanted data to a more manageable size by unselecting certain attributes, then submit the refined query to the remote system (Plaisant, et al., 1999). The benefit has been evaluated by Tanin, Lotem, Haddadin, Shneiderman, Plaisant, and Slaughter (2000). They showed query previews can speed up search performance 1.6 to 2.1 times and lead to greater user satisfaction. Together with the studies in advanced browsing tool development, research has addressed the importance of user-system interaction during query formulation and result evaluation. With the advancements in interactive querying interface, the retrieval process and users' satisfaction can be greatly improved.

Query reformulation methods can also be used in conjunction with relevance feedback mechanism to dynamically provide user context-aware suggestions (e.g., local correlative concept extraction) (Natsev, et al., 2007). We discuss new developments in relevance feedback techniques at the end of this section.

### ***Ontology based concept mapping***

Modern approaches in concept-based retrieval use a pool of concepts to facilitate the understanding of users' query semantic and the associated low-level visual features (Wei & Ngo, 2007). Users' queries are reasoned and mapped to predefined concepts by concept detectors, ontology resources (e.g., WordNet), text description, or co-occurrence. Thus query-concept mapping becomes a pattern recognition problem and retrieval is performed based on the likelihood of corresponding concepts present in queries. Wei and Ngo (2007) proposed an Ontology-enriched Semantic Space (OSS) as a platform for uniform and consistent concept similarity measure. Because each concept pairs may be related via different classes in the ontology, direct computing the similarity based on the distance within individual classes is incomparable and cannot represent the actual relatedness. Hence the authors constructed OSS based on few key concepts to provide a high coverage of entire semantic space. All concepts are presented as individual vectors within this unified OSS and thus similarity measure between concept vectors are more intuitive and comparable. The OSS showed a clear improvement in MAP of word sense disambiguation, concept-based video search, and multi-modality fusion tasks with much higher feasibility for large-scale video retrieval, concept combination, and query dependent fusion with concept clusters.

In order to complement the limitations of free-text querying approach stated in previous section, Tam and Leung (2001) proposed a structured descriptive language for visual material semantics, which comprises agent (noun), action (verb), object and recipients (indirect objects), setting (time and space), and optional modifiers (visual elements/descriptions). The structured description annotation provides a concise method to annotate image contents, and more abstract level semantic can be achieved by linking entities and relationships to external databases, such as ontology or knowledge base. The authors claimed that the structured annotation is able to accommodate all perceptual and interpretive attributes of images and has been proven to significantly improve precision for retrieving football play images.

### *Browsing tools*

Browsing has sometimes been linked to an important search strategy in creative activities (Weedman, 2002). This may due to the fact that browsing of unpredicted encounters can stimulate existing knowledge. In addition, scholarly browsing can be viewed as deliberation in searching for new connections and is highly exploratory and interactive.

Recent studies have showed that browsing tool does improve retrieval performance. Rooij, Snoek, and Worring (2007) developed two browser interfaces which display similar video shots in static and dynamic threads/clusters. Such browsing tool helps user effectively navigate through the result set and identify relevant video shots more quickly and easily. Spoerri (2004) proposed two result fusion visualization tools (i.e. Category View and Cluster Bull-Eye tools) to facilitate user coordinate meta-search results. Browsing tool can also be used in query preview and refinement. The tool should help user dynamically eliminate undesired data sets and reduce the amount of retrieved information to a more manageable size (Plaisant, et al., 1999).

### *Relevance Feedback*

Recently there is a growing philosophy of leveraging users' interaction with the retrieval system to achieve/help machine learning mechanisms, such as relevance feedback techniques (Datta, et al., 2008; Lawrence, 2000). Relevance feedback can be regarded as a kind of query reformulation and refinement process which attempts to precisely capture users' search intent through iterative feedback rounds (Datta, et al., 2008). There are generally two ways to perform relevance feedback, namely implicit and explicit feedback approaches.

*Explicit feedback (ask user to select)*

Because of the semantic gap problem stated in previous sections, CBIR system users usually find it difficult to formulate pictorial queries that best describes their image needs (Gevers & Smeulders, 2004). Explicit feedback method has been developed to help system refine users' search queries through iteratively reviewing and judging the relevance of retrieved images. The most signification contribution of such relevance feedback technique is that it allows the system capturing the query-point movement, which makes the search query progressively become more representative of positive samples (i.e. retrieved images being rated as relevant by the user) after each iteration, and away from negative samples (i.e. irrelevant images reviewed by the user) (Kherfi, et al., 2004). New researches adopting this approach now investigate how to make query specification more intuitive and efficient (Datta, et al., 2008). Because an image can be relevant in some aspects/features but irrelevant in others, the traditional dichotomous feedback of positive and negative samples may not represent users' needs faithfully. A number of approaches have been proposed to facilitate feedback specification, such as *semantic feedback* proposed by Yang, Dong, and Fotouhi (2005) which utilizes pre-defined image semantic expressions to facilitate relevance feedback. Multilevel relevance scores were used in Wu, Lu, and Ma's (2004) study.

Other contributions of relevance feedback are related to feature weighting and dimension reduction, which can further enhance the effectiveness and efficiency of CBIR systems. However, the challenge with explicit feedback approach is users' willingness to undergo series of judging iterations, which subsequently makes this approach unsuitable for Web environment, especially when being utilized by general Web users (Datta, et al., 2008). Several attempts have been made to facilitate relevance feedback without much user involvement; we categorize those approaches as implicit feedback mechanisms.

*Implicit feedback (e.g., via click-through data)*

Relevance feedback data can be collected implicitly (i.e. without explicitly asking users to make decisions on retrieved items as relevant or irrelevant). The apparent benefit of collecting relevance information implicitly is the minimum requirements of users' involvement and thus attributes the success of relevance feedback algorithm to mainly system side. For example, making automatic relevance inference based on top N retrieved items (i.e. *Pseudo Relevance Feedback*-PRF or local feedback) has been a popular and widely studied method in recent SIGIR researches (Cao, Nie, Gao, & Robertson, 2008; Lee, Croft, & Allan, 2008). While this approach generally assumes that the top retrieved items would always be more relevant to the query, this assumption may not always hold in reality, especially when user only has vague concept/construct about her needs and requires a more explorative style of search (or need to compare between different results). Hence researches are now investigating more sophisticate methods to select relevant terms for query expansion (Cao, et al., 2008) or some other techniques that utilize users' behavior and interaction with the system to infer relevance (Buscher, Dengel, & Elst, 2008; Kumaran & Allan, 2008; X. Li, Wang, & Acero, 2008). For example, Ghosh, Poornachander, Mallik, and Chaudhury (2007) used click-through data to update a Bayesian Network ranking algorithm to adapt toward personalized ranking. Hoi and Lyu (2004) utilize users' prior feedback logs to serve for relevance judgment. Despite some promising results that have been reported in some studies, these approaches are relatively new and preliminary in the area and their validity and usefulness still needs to be further investigated.

## 2.5 Visual Information Searching Modeling

Despite the difficulties and limitations of current CBIR systems in fulfilling users' image needs, researches has started to realize the important role of user during the retrieval process (Ingwersen, 1992, 1996; Rieh & Xie, 2006; Tefko Saracevic, 1996). Since image retrieval process is a relatively new research area and it shares most major concepts within traditional information retrieval (IR) process, which mainly concerns textual information as the sole medium, the foundation of the image retrieval models in this study are based on traditional IR models and theories. To the researcher's knowledge, few studies have addressed the difference between traditional IR process (i.e. the process of retrieving textual information) and the retrieval of visual information. This section focuses on user study perspective of information retrieval process, and lays the context for current research. Our discussion of user modeling begins with the fundamental IR perspectives and their theoretical implications in *Section 2.5*. In particular, Saracevic's (1996) stratified model is discussed in greater depth and provide the framework for our user study. *Section 2.6* introduces some user models we proposed based on literature reviews. *Section 2.7* reviews the use of Web log analysis in user studies, as well as important literature findings in text-based Web visual searches. Finally, *Section 2.8* reviews literature findings and suggestions in users' query formulation strategies, which contribute to the assumptions in contextual query formulation modeling.

Because IR process is mainly about the interaction between user and system, human factors such as users' information needs and cognitive states should not be neglected when studying people's information searching behavior in full. First, we discuss the general cause of information need and important theoretical views on information seeking behavior as problem-solving process.

### 2.5.1 The problem-solving perspective

The majority of research regards information seeking behaviors as some kind of problem-solving activity. That is, the information seeker would have a certain kind of information task to complete or certain information goal to achieve, whether explicit or implicit. This problem-solving approach serves as the fundamental theoretical base in explaining human's information seeking behavior (Spink, Wilson, et al., 2002).

### *Anomalous State of Knowledge (ASK)*

Belkin, Oddy, and Brooks (1982) proposed the concept of *Anomalous State of Knowledge* (ASK) to explain the dynamics between information need and information-seeking behavior. According to him, the contradiction between the perception of an information problem and user's current domain knowledge creates the ASK. Information seeking behavior is the action undertaken to resolve this contradiction and reduce the uncertainty accompanied (Spink, Wilson, et al., 2002; Wilson, 1999). Similarly, Dervin's (1983) sense-making model focused on the gap between the current situation of the information problem and the desired outcome, which is closely related to Belkin's ASK construct (see *Figure 2.1*). Sense-Making remarks a shift in researches from information sources to information users (Tidline, 2005). Recently with the growing interest in the information seeking context, Sense-Making offers a "process" view of information behavior rather than categorization of needs, seeking, and use.

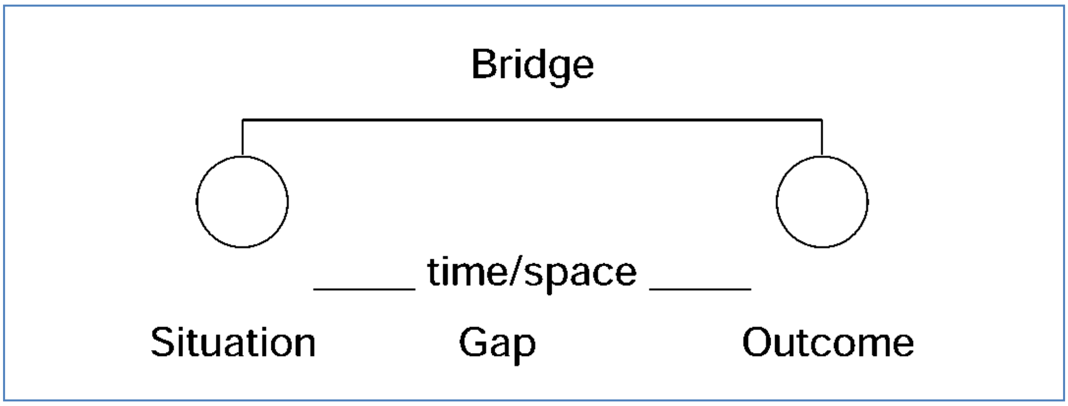



*Figure 2.1* Dervin's (1996) sense-making framework (adopted from (Wilson, 1999), p.254)

## 2.5.2 The information goal perspective

Another approach is taking information-seeking behavior as a goal-oriented activity. The information problem of current situation and ASK create some information intentions that can be represented in a hierarchy structure. According to Xie (2002), users' information-seeking goals generally fall into four levels:

- *Long-term goal* which represents the personal goal that a person has been pursuing over a period of time, such as professional achievement and personal interest
- *Leading search goal* which refers the task-related goal a person currently has, such as the task to write a paper, or to conduct a experiment
- *Current search goal* is the specific outcome that a person expects to achieve, such as to find literatures on a particular topic, or to construct a model for a study
- *Interactive intention* which is the sub-goals a person constructs along the information-seeking process in order to achieve the current search goal. For example, the intention to learn how to use an online database for finding literatures, or to find some particular papers written by the key researchers in current study area.

Because all problem-solving approach adopts the concept of ASK despite some terminology differences, studies in this area regard information-seeking as a deliberate behavior that user intentionally engages to reduce the uncertainty of current situation (Kuhlthau, 1991) and the anxiety or stress associated with the situation (Wilson, 1999). When modeling people's information seeking behavior in the context of human-computer interaction, such cognitive and affective aspects becomes more salient and important (Cole, O'Keefe, & Siala, 2000). Besides system performance and retrieval accuracy measures, system designers are now endeavoring to improve user-oriented search experience based on these aspects.

### 2.5.3 Information retrieval and Web searching models

### *Saracevic's interactive IR model*

Researches that focus on the interactive process of information retrieval tasks emphasize three components: user, the retrieval system, and the interaction between (Ingwersen, 1992, 1996; Rieh & Xie, 2006; Tefko Saracevic, 1996). In particular, Saracevic's (1996; 1997) stratified model provides a useful framework to frame our user study (see *Figure 2.2*). In his model, a system has three levels/strata: the information content and resources, the retrieval processing mechanism such as software and algorithm, and the engineering settings of hardware and various functionalities. There are also three strata on the user side, including the situational, affective, and cognitive aspects of a user and the information problem. The interaction happens at the surface level (usually the interface) in which user issues queries or commands that represent her information problem, and system returns with a set of retrieved results (Wilson, 1999). While the elements in system side are not in the scope of our study, we intend to measure all three levels of elements on user side in our visual search user study. More specifically, the pre-search questionnaire will be used to collect information about users' knowledge about the information problems (i.e. cognitive) and their contexts (i.e. situational). Think aloud data will provide more insight into users' thoughts toward the retrieved results and system (i.e. affective). As the model depicts, the interaction is confined in retrieval system's interface. In other words, the system can only detect and interpret users' situational, affective, and cognitive factors based on the characteristics in queries submitted to the system (Rieh & Xie, 2006). This is the reason that we aim to use query formulation/reformulation activities to build the contextual user model, which shares the same visibility as current retrieval systems.

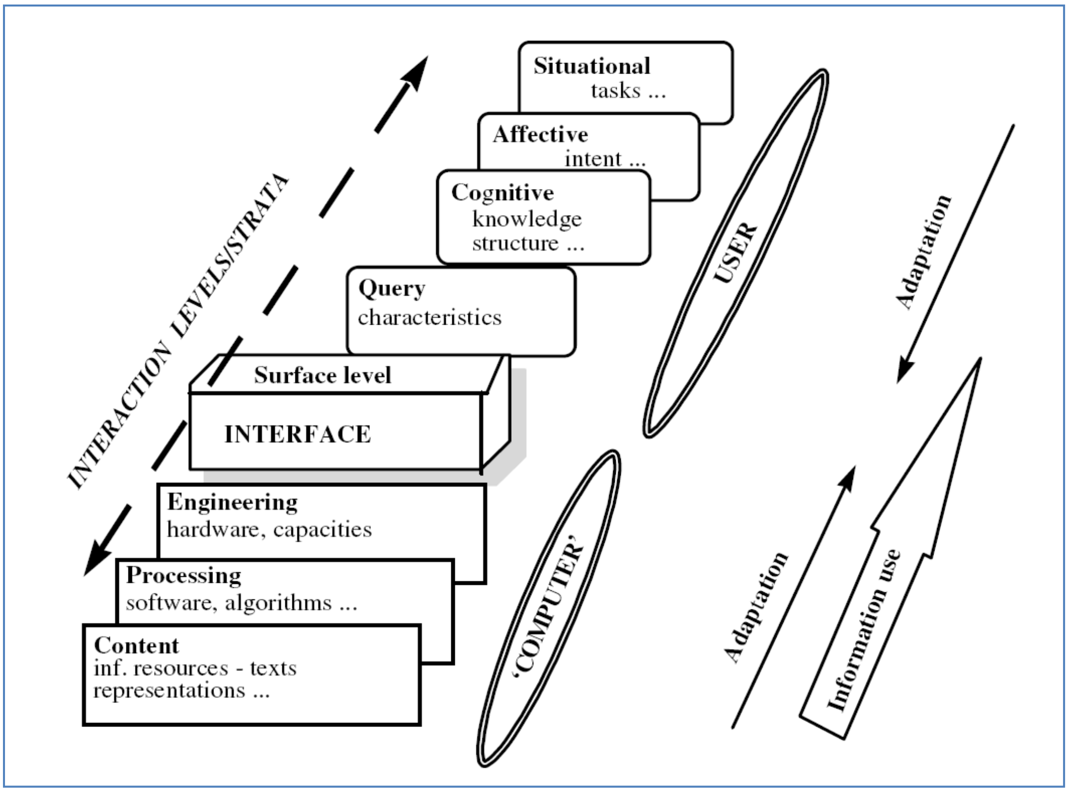



*Figure 2.2* Saracevic's (1997) stratified model

### *Marchionini's information seeking model*

Marchionini (1995) proposed a model of information seeking in electronic environments (*Figure 2.3*). The eight steps in the model detailed the common process of querying information systems, starting from recognizing and defining an information problem to extracting information and reflecting the information need. This model is useful in explaining general Web searching activities because of its relatively linear process (Dinet, et al., 2012; Knight & Spink, 2008). Yet the various interactions among the searcher's information needs, selected information sources, formulated queries, and the results also acknowledged the iterative nature of Web searching, such as re-defining the information need, using another information source, and formulating new queries (Knight & Spink, 2008). However, this model ignores the 'berry picking' nature of Web searching, such as browsing in undirected searches with unspecified search topics, and tend to oversimplify the process (Knight & Spink, 2008). Hence two more recent models are introduced to cover such aspect of Web searching.

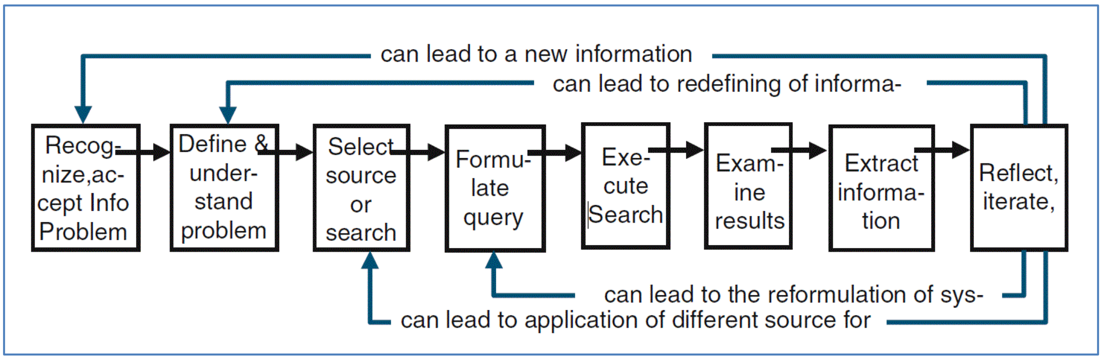



*Figure 2.3* Marchionini's (1995) information seeking model (adopted from (Knight & Spink, 2008))

### *Kitajima's comprehension-based liked model of deliberate search*

Kitajima (2000) proposed the Comprehension-based Liked model of Deliberate Search (CoLiDes) that emphasizes how users extract relevant information on Web pages. There are two types of processes when analyzing a Web page: *attention process* and *action selection process*. When reading a Web page, users first scan the structure and content of the page, then focus on the areas that possibly contains relevant information based on their domain and procedure knowledge. Once the areas are identified, users shift attention to these areas and activate knowledge from memory in order to understand the content. The comprehension of the information enables to construction of a new mental model, which is being compared with the representation of the original search goal to decide whether the intended information has been found. If the information has a highly related representation of the mental model, certain actions would be activate in order to retrieve more relevant information, such as following the links in the relevant content.

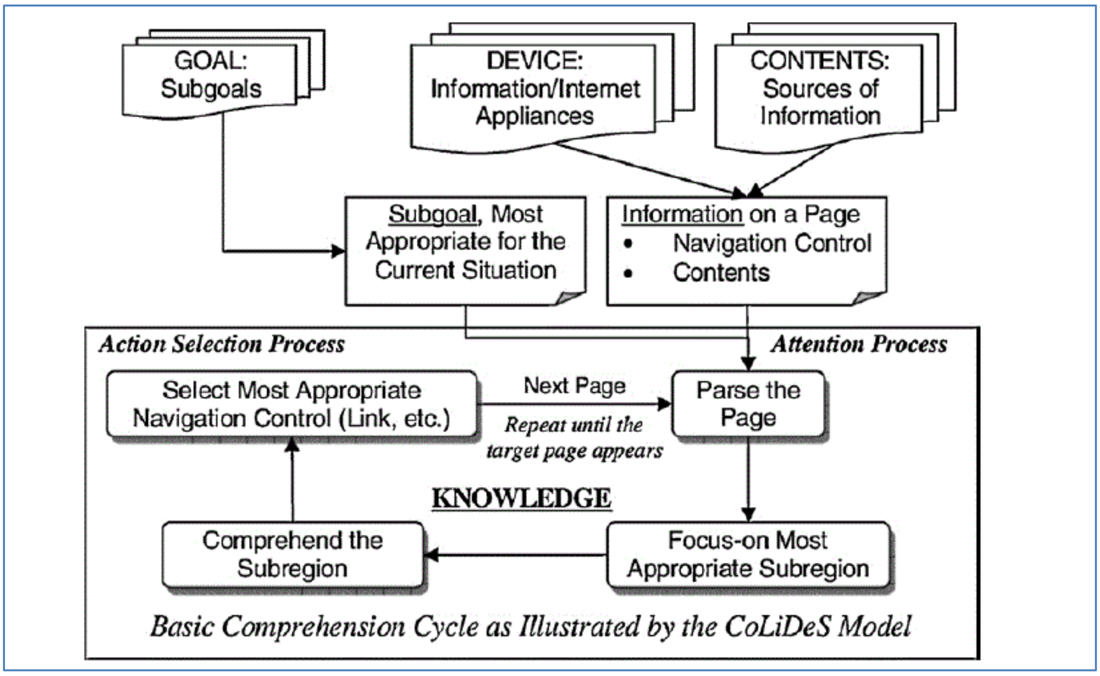



*Figure 2.4* Kitajima's (2000) Comprehension-based Liked model of Deliberate Search (CoLiDes) model (adopted from (Dinet, et al., 2012))

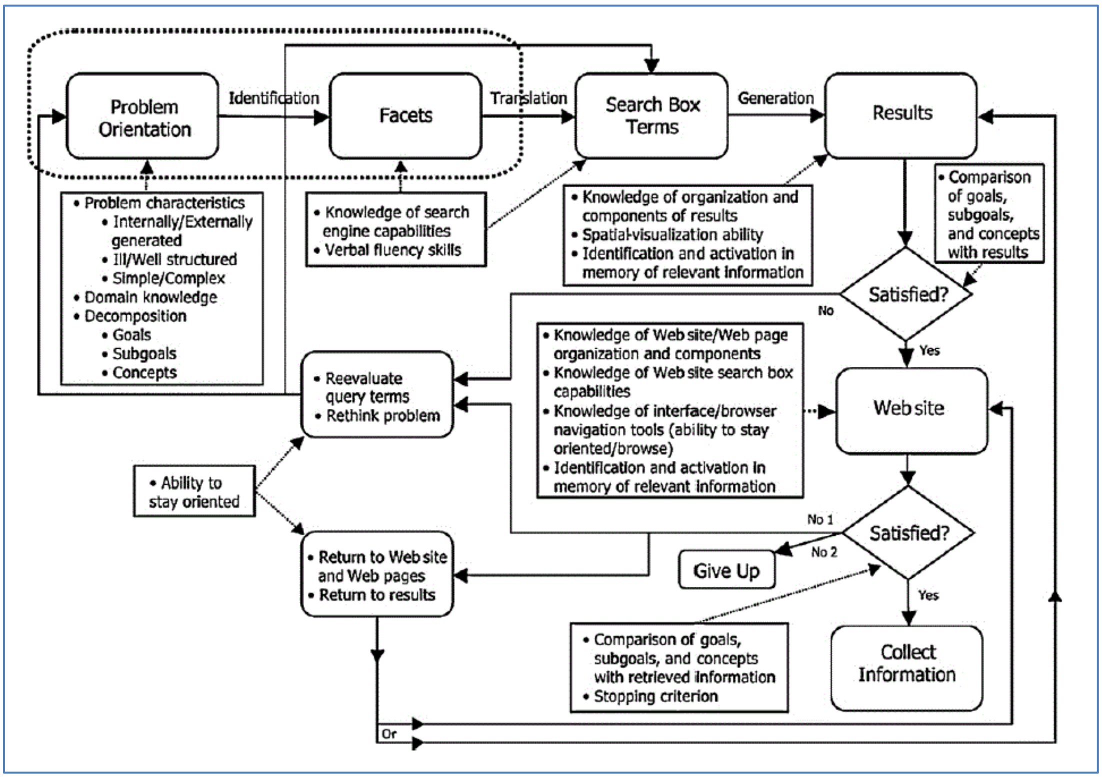



Figure 2.5 Sharit et al.'s (2008) search engine information-searching model (adopted from (Dinet, et al., 2012))

### *Sharit et al.'s search engine information-searching model*

Sharit et al. (2008) also developed a search engine information-searching model. In their model, various knowledge and cognitive abilities are crucial to search performance. For example, domain knowledge is important to problem identification, search engine knowledge and verbal skills to resolution planning and search execution, and knowledge of websites/Web pages and browser interface capabilities to result reviewing and comparing. Clearly, both Kitajima (2000) and Sharit et al. (2008)'s models have emphasized the importance of knowledge factor in Web searching, which was not commonly included in previous IR models.

Given the recent research focus shift from cognitive and affective aspects to situational and knowledge factors in Web searching modeling, it is necessary to consider all these in the new proposed model for this study. In particular, types of knowledge and their possible impacts on the searching behaviors are discussed in detail in *Section 2.6.1 – Knowledge resources*. In next section, we propose two preliminary user models which position our research in relation to broad information retrieval context, as well as focus our attempt in one particular stage of searching, the query formulation and reformulation process.

## 2.6 Proposed Theoretical User Models

Two models have been constructed based on literature reviews and modified to depict both the global process of cognitive information retrieval and the image query formulation/reformulation process.

## 2.6.1 The global user model for cognitive Web information retrieval

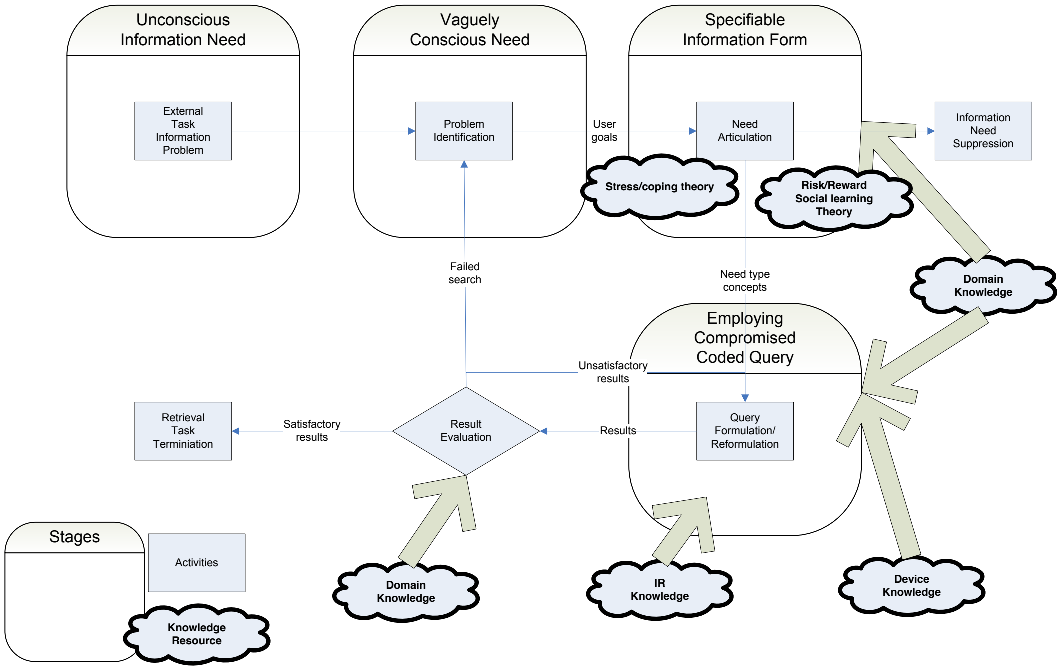



*Figure 2.6* The global user model for cognitive Web information retrieval [1]

Sutcliffe and Ennis (1998) identified three substantial agents that must be considered in the information retrieval process: *user*, *expert intermediary,* and the *retrieval system*. They also proposed a comprehensive cognitive process model for capturing users' information retrieval behaviors with regard to the factors that influence users' decision during various retrieval stages, such as the information need types, knowledge resources held by the user, and the task support facilities (TSFs) provided by the system. Two main components were identified in the model as *activities* and *strategies* (not depicted in the diagram), as well as an external factor that has effects on these two components, namely *knowledge resources*.

### *Activities*

The global model (*Figure 2.3*) is built on Sutcliffe and Ennis's (1998) process model of information searching activities and knowledge sources. The rectangle boxes represent the activities, which are the major actions users undertake during each stage of a generic information retrieval process. In addition, these activities are

[1] Adopted and modified from "Towards a cognitive theory of information retrieval" by A. Sutcliffe and M. Ennis, 1998, *Interacting with Computers, 10*(3), p.327.

mapped into Taylor's (1968) four stages of information retrieval model which are illustrated as round angle rectangles to further assure the validity and completeness of the model. In Sutcliffe and Ennis's (1998) cognitive IR model, there are four main activities inside the retrieval process: *problem identification*, *need articulation*, *query formulation/reformulation*, and *results evaluation*.

During problem identification stage, the user initially has some emerging information needs influenced by his background context (e.g., knowledge, profession, or temporal position). These information needs can then be expressed in natural languages as concepts and constructs which will be further partitioned into terms in need articulation stage.

Once these explicit terms representing users' information needs can be determined, users proceed to query formulation stage in which terms are translated into query keywords based on users' pre-existing knowledge resources, including domain knowledge, device knowledge, and IR knowledge. Then the actual retrieval behavior takes place.

After the system has returned some results, the result evaluation stage begins and user reviews the results according to different strategies. Several strategy selection rules were proposed in the paper which provides fundamental theory background for extensions of the current framework. If the user feels that the information need has been fulfilled, she can terminate the retrieval process, and the current search session. Otherwise, when the satisfactory level of the results has not been met, the user is likely to reformulate the search query either by narrowing/broadening the criteria (e.g., exploring different search synonyms as suggested by Jorgensen and Jorgensen (2005), or modifying his original information need such as an interest shifting). This is also the stage where interest shifting takes place and draws much attention of recent studies. For example, activity theory addresses a great detail of the query formulation/reformulation process in terms of multiple related sub-needs and corresponding queries (Y. Xu, 2007). These activities can nicely fit into Taylor's (1968) four stage model in information retrieval as unconscious information need may emerge from external task information problem; vaguely conscious need as the result of problem identification activity; specifiable information is formed by the need articulation activity; and finally the employment of compromised coded query happens during query formulation/reformulation activity. *Figure 2.3* also depicts such correspondence in the process model.

### *Strategy (operational retrieval skills)*

According to Sutcliffe and Ennis's (1998) definition, strategies are different types of information search skills that users can employ during different stages of information retrieval process. Different strategies that user adopts may be influenced by various factors, such as the type of information need or search task (Holscher & Strube, 2000), users' expertise and experience in the current retrieval task (domain knowledge), availability of search functionalities supported by the retrieval system, and specific retrieval techniques such as Boolean expression or SQL language (device knowledge), etc. Some strategies are highly domain dependent and are difficult to capture in a generic model (Sutcliffe & Ennis, 1998).

Examples of different search strategy employment can be, during problem identification stage, users may either approach their problems in divide-and-conquer manner which they separate the complex problem into different parallel tasks, or in top-down decomposition style if they are able split the problem into smaller, sub level components (Sutcliffe & Ennis, 1998). The general literature implications of search strategy style in information retrieval is that browsing is more preferred by users who have exploratory goals, whereas querying is perceived as more suitable for specific retrieval tasks (Frost, et al., 2000; Sutcliffe & Ennis, 1998).

Since our focus is the query formulation/reformulation activities, search strategies being studied in current research will be identified from the sequence of query reformulations. Initially, the researcher has analyzed four primary reformulation patterns (i.e. initial, addition, deletion, and replace) based on the structure and query term changes in modified queries. The syntactic and semantic analysis on modified query terms would help us construct a more detailed model to capture users' query reformulation processes and correspond search strategies.

### *Knowledge resources*

In Sutcliffe and Ennis's (1998) model, different types of knowledge resources play important roles in various stages that affect the corresponding activities as well. There are three kinds of knowledge resources relevant to the information retrieval process model: *domain knowledge*, *device knowledge*, and *IR knowledge*.

*Domain knowledge* represents the knowledge user has in the problem domain. Higher domain knowledge enables the user to have richer concept sets and terms in problem identification, which in term facilitates the query formulation process and helps evaluate the retrieved results more effectively.

*Device knowledge* relates users' knowledge about the system. Primary instance would be the knowledge of IR system's functionality, such as task support facilities (TSFs), image categories the system indexed for browsing, etc. Knowledge about the query language or syntax supported by the system contributes to another kind of device knowledge, such as SQL and Boolean expressions. Knowledge about the database's properties and collections' specialization areas (i.e. information resources) can be regarded as an extension of device knowledge as well.

The third kind of knowledge resource, the *IR knowledge*, refers to the available search strategies user can adopt, such as the ability to formulate complex queries. As for the current research, we confine IR knowledge to query formulation related strategies, such as strategies for query term selection and query expansion. General IR knowledge related to problem identification (e.g., divide-and-conquer) and need articulation activities are not considered in the current research.

The cloud shaped icons in *Figure 2.3* represent the knowledge resources. It is important to know the influence of knowledge resources on users' query formulation activities. For example, a user may want to find a photo of mountain scenery during need articulation stage. However if she does not possess enough domain knowledge (i.e. the knowledge about the problem domain) in photography, it may be difficult for her to know that the image she is looking for belongs to landscape category in photography taxonomy. Such situation creates a barrier for her to proceed to query formulation stage, and she may thus suppress her image need, that is, ignore without taking any further explicit actions.

Nevertheless, knowledge resource is not the only cognitive factor that will influence users' behaviors. Contextual factors introduced in psychology theories may also play some roles. For example, according to Wilson (1997, 1999) and Beaudry & Pinsonneault (2005), stress/coping theory is useful to account for the reason why some needs do not invoke information seeking behavior (i.e. performing searches on retrieval systems in the current research). Similarly the risk/reward and social learning theory can provide some insight into the different search strategies user adopts during the transition from need articulation to query formulation stage.

### *Experience*

Studies have shown that users' background knowledge (Holscher & Strube, 2000) and search task specificity can affect the way how user searches, especially in terms of query formulation. Novice searchers generally modified their queries more often, while domain expert searchers formulated the shortest queries and utilized more domain specific websites for search (Holscher & Strube, 2000). However, experienced searchers were not necessarily more successful or did not formulate more accurate queries than novices although they could better prioritize tasks (Khan & Locatis, 1998), or using more terms for search (Andrew Thatcher, 2008). For experience measures, the researcher asked participants to report the years of their Web image searching experience.

### *Task Specificity & Tangibility*

Fukumoto (2006) investigated the difference in Web image searching activities between open and closed tasks. The author found that both users' search processes (e.g., number of pages reviewed, the overall search time) and querying activities (e.g., the number of inputting keywords and the number of unique keywords) are significantly affected by the nature of tasks. However, there were no differences in single action execution time and the use of advanced operators in queries, which the author concluded were mostly due to individual differences.

Westman, Lustila, and Oittinen (2008) found that search task type significantly affects the choice of query modes. Known-item and data search task showed a variety combinations of query modes, including text, color, and category. Visual cue tasks incorporated both content-based (color, sketch) and textual (text, category) query modes. Conceptual and abstract tasks mainly involved text and category queries. However, text was the main search mode in all types of tasks for both professionals and non-professionals. Other studies also confirmed that textual queries are more intuitive to general users and easier to represent users' image needs (Jorgensen & Jorgensen, 2005; Lew, 2000). Overall, Pu (2003, 2005) found that image searches tend to have higher specificity (i.e. more unique terms and queries), more query reformulations, and are more skewed toward certain subjects than Web searches.

### *Research intentions elicited by the global process model*

Based on the global information retrieval process model, some highlights can be drawn for the current research interests:

- Relationship between users' domain knowledge (i.e. their expertise and experience in the problem domain, collected via pre-search questionnaire) and query term selection strategies
- Relationship between users' IR knowledge (collected by the pre-search questionnaire and the think aloud protocol in Web image searching sessions) and query reformulation patterns
- Device knowledge is neglected as it varies on the retrieval system being utilized

Hence, the global model is useful in proving the holistic view of the generic search process regardless the types of information being sought, and highlighting the important cognitive and affective aspects that a detail model should also consider. In next section, we will discuss our model on query reformulation process.

### 2.6.2 Activity theory based model for query reformulation

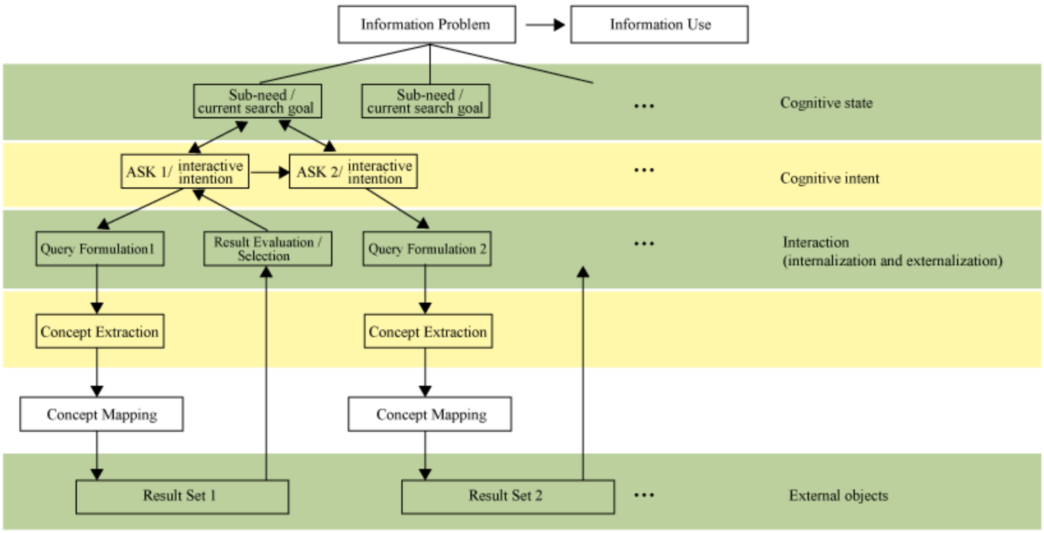



*Figure 2.7* The active theory based query reformulation model [2]

Based on the global model, the query formulation/reformulation and result evaluation activities can be further analyzed to construct an activity theory based query reformulation model. The model was originally presented by Xu (2007) and has been extended to illustrate the focus of the current research (*Figure 2.4*). The core concept of activity theory is that users' cognitive state associated with the original information problem, will cause a set of Anomalous State of Knowledge (ASK) by the contradiction between problem perception and users' current domain knowledge (details on ASK in *Section 2.5.1 - The problem-solving perspective*). The ASK then elicits the information seeking behavior which is manifested by the deployment of search queries in the process called "externalization". Once the system has returned some results, the evaluation of the retrieved items will cause some changes in users' original ASK (ASK 1) and thus moves to a new ASK (ASK 2), which is still under the same upper level cognitive state (i.e. same Sub-need/current search goal). This is the "internalization" process. The activity theory model is suitable for capturing the changes in users' cognitive intents between

[2] Adopted and modified from "The dynamics of interactive information retrieval behavior, Part I: An activity theory perspective" by Y. Xu, 2007, *Journal of the American Society for Information Science and Technology, 58*(7), p.964.

successive queries since it clearly depicts the interactive process of query reformulation behaviors.

Based on this model, two more layers can be added to illustrate the new focuses of recent research in this area, namely *concept extraction* and *concept mapping* activities (Details in *Section 2.4.2 – Ontology based concept mapping*). While users do not directly engage in these two activities, their roles as intermediate system agents can benefit from users' relevance feedback or query reformulation sequences. An example of utilizing explicit relevant feedback is that image retrieval system like ALIPR asks user to select relevant concepts among several system detected options to perform concept-based search (review of ALIPR system can be found in *Section 2.2.1 - Review of contemporary image retrieval systems*). Alternatively, as will be discussed in the hypotheses of our Web log analysis (in *Section 3.2 – Study Assumptions*), modeling the changes between users' consecutive queries may help identifying the important concepts in users' interactive intentions. By incorporating these two layers of activities to a traditional image retrieval paradigm, the model becomes a concept-based retrieval model. This shows the scalability of current research approach and signifies the extensibility of the entire framework as more sophisticated concept processing mechanisms can be progressively introduced without affecting the original model.

In next section, the main focus of our user modeling, query formulation and reformulation activities, is introduced. Starting from the findings and approaches in Web search log analysis, the discussion emphasizes how search logs can help modeling users' behaviors and what are the limitations of this approach. It complements the traditional user modeling techniques by providing more quantifiable data which can be statistically tested and maintains the link between user modeling findings and system implementation.

## 2.7 Web Log Analysis

As discussed in previous research findings (See *Section 2.1.3 – Users' image need*), multimedia search is more complex compared to general Web searches as evidenced by the longer session times and query lengths (B. J. Jansen, et al., 2003; Spink & Jansen, 2006). Web multimedia search users also perform many query reformulations (Pu, 2003, 2005), and have more difficulties in finding the appropriate terms to represent their needs. In addition, image search has the longest session length (i.e., more queries per session) (Tjondronegoro, et al., 2009) and more terms per query than video and audio searches (Spink & Jansen, 2006). Therefore, it is important to investigate users' multimedia query formulation behavior in orders to better understand the characteristics and obstacles in different types of multimedia searches.

Researchers have utilized Web transaction logs to study users' information searching behaviors and the search trends over the years (Bernard J. Jansen, Goodrum, et al., 2000; S. Ozmutlu, et al., 2003; Tjondronegoro, et al., 2009). The analysis of Web logs gains its popularity because of its relative low cost in terms of time and labor. These studies have shown that users submit relatively short search queries, typically around three terms per query (S. Ozmutlu, et al., 2003). Most users do not review many results, typically only the first result page (B. J. Jansen & Spink, 2006; B. J. Jansen, et al., 2003). Such little contextual information and brief interaction between the user and the search engine limited the understanding of users' searching behaviors, especially when the analysis is based on individual transaction records (H. C. Ozmutlu & Cavdur, 2005; Rieh & Xie, 2006). Thus, it is necessary to investigate multiple queries in order to provide more contextual information from Web log analysis.

In this research, Web logs were utilized to help construct the preliminary user model and form the basic assumptions in the user study. Related works and research findings in Web log analysis studies are reviewed first in this section, followed by an overview of the general procedures for conducting Web log analysis and the limitations of the current log analysis approach.

## 2.7.1 Overview of Web logs

Many studies have attempted to analyze users search intent from their queries, especially from Web search logs (Broder, 2002; Bernard J. Jansen, Booth, & Spink, 2007; Bernard J. Jansen, Goodrum, et al., 2000; B. J. Jansen & Spink, 2005; Lau & Horvitz, 1999; S. Ozmutlu, et al., 2002, 2003; Pu, 2003; Rose & Levinson, 2004; Spink & Jansen, 2004; Spink, Jansen, & Ozmultu, 2000; Tjondronegoro, et al., 2009; Zhang, Jansen, & Spink, 2006). Due to the availability and the enormous data of Web transaction logs, recent research has begun to leverage such data set to extract general users' searching behavior other than laboratory studies, in which the latter usually have been limited to a small group of participants in some particular information domains (Bernard J. Jansen, 2006; B. J. Jansen & Spink, 2003, 2005, 2006; Bernard J. Jansen, Spink, & Koshman, 2007; B. J. Jansen, et al., 2003; S. Ozmutlu, et al., 2003; Park, Ho Lee, & Jin Bae, 2005).

However, such large scale analysis has its strength and weakness. While it is relatively easy to collect a large amount of Web logs, analysis of such data can be quite challenging and the information extracted seldom goes beyond descriptive statistics and facts (H. C. Ozmutlu & Cavdur, 2005; Rieh & Xie, 2006). Generally, Web search log analysis has the following advantages over traditional observation or interview techniques (Bernard J. Jansen, 2006):

- Non-intrusive data collection process of users' unaltered behaviors
- Ability to collect large scale data at once with relatively low cost
- Most objective means to record users' interactions with the retrieval system

There are some limitations of Web log analysis as any other research methodologies too. Some concerns related to the current research are:

- Inability to capture cognitive information that is not reflected in users' query, such as users' thoughts, feelings, and preferences during search activity

- Inability to collect the background or demographical data from users
- Inability to accurately identify individual users as one computer can be used by multiple users within a relatively short time span which cannot be discriminated by Web browser cookies
- Data may be incomplete due to session caching technical problems
- Some behaviors may not be recorded in transaction logs, such as the backward action using browser's *Back* button and the extent to which user reviews the retrieval results if no click-through data was recorded (i.e. no result links being clicked/followed).

The last three limitations are not of significance for this study as the quality and accuracy of Web transaction logs are not the main concerns of the research interests. Several techniques can be applied to maintain data integrity. For instance, incomplete data can be preliminarily eliminated and the accuracy of user session identification can be improved by using contextual information (i.e. sequence of query reformulations) in conjunction with traditional browser cookie identifier. The first two limitations will have more impact on current research and will be complemented using user study and questionnaires (details in *Section 3.3.1 – Study methodology selection*).

## 2.7.2 General procedures for log analysis

In Jansen's (2006) review of current Transaction Log Analysis (TLA) methods, general procedures to conduct TLA include three major stages:

- *Collection*: the collecting stage of interaction data within a given period of time
- *Preparation*: the stage which raw transaction records are cleaned (e.g., eliminate incomplete data) and prepared for analysis (e.g., convert to correct date-time format, import to relational database if required).
- *Analysis*: the stage of analyzing prepared data

There are also three levels of analysis that can be conducted based on Web transaction logs:

- *Term level analysis*: the analysis based on search terms, such as term occurrence and term-term co-occurrence.
- *Query level analysis*: the analysis based on each query, which is generally each record in the transaction log. Such analysis focus on the complexity when users formulate their queries (e.g., the average query length, numbers of unique queries, etc.) Three types of queries can be identified:
  - *Initial query* which is the first query user submit in a session
  - *Modified / Reformulated query* which is the subsequent query that differs from the initial query
  - *Identical query* which is the subsequent query that is exactly same as its precedent query. This type of query typically represents browsing and clicks-through data (e.g., when user clicks on next result page link, the system records this action with a query that is identical to the previous one).
- *Session level analysis*: although there is no concrete consensus on session definition, researches typically used Web browser cookies to identify sessions (Bernard J. Jansen, 2006; Bernard J. Jansen, Goodrum, et al., 2000; B. J. Jansen & Spink, 2003, 2005; Bernard J. Jansen, Spink, Blakely, & Koshman, 2007; Bernard J. Jansen, Spink, & Narayan, 2007). Analysis based on session level can observe the interaction level between user and system, such as the numbers of queries submitted within a session (i.e. session length), session duration, and click-through analysis which measures the result viewing behavior of a user.

### 2.7.3 Summary of Web log analysis research findings

Web log studies have shown that user submit relatively short search queries, typically around three terms per query (Lau & Horvitz, 1999; S. Ozmutlu, et al., 2002, 2003; Pu, 2003; Spink, et al., 2001). Most users do not review many results, typically only the first few result pages and sometimes merely the top results (B. J. Jansen & Spink, 2006; B. J. Jansen, et al., 2003; Bernard J. Jansen, Spink, et al., 2000). Thus the information that can be inferred from transaction logs is usually limited (H. C. Ozmutlu & Cavdur, 2005; Rieh & Xie, 2006).

More recently, studies begin to extract contextual information (i.e. changes in consecutive queries) to unveil more information about users' searching behaviors, particularly in detecting new search topics (D. He, et al., 2002; H. C. Ozmutlu & Cavdur, 2005; Seda Ozmutlu, 2006). Some success has been obtained from these studies, but the full use of such analysis method still requires further investigation as most studies only examined search patterns based on individual transactions (B. J. Jansen & Spink, 2003).

In terms of visual search intent, studies constantly found *people*, *location*, and *specific objects* are the most frequent searched topics (Chen, 2001; Enser, 1995; Othman, 2005; Smits, et al., 2006; Spink, et al., 2004; Tam & Leung, 2001; Westman & Oittinen, 2006). In addition, studies also found that sexual related searches remain dominant through years (Bernard J. Jansen, Spink, et al., 2000; Lau & Horvitz, 1999; Spink, Jansen, et al., 2002; Tjondronegoro, et al., 2009). Although Jansen and Spink (2006) reported a decrease in sexual related searches after analyzing nine Web search engine transaction logs across 1997 to 2002, interests in finding people, places, or things still account for the major part of Web image queries. Spink, Jansen, and Pedersen (2004) also discovered the dominance of people search and found that nearly 25% of personal name queries (PNQ) are celebrities' names.

Studies of Web multimedia searches have observed that image queries generally contain a large number of unique terms and are generally longer than textual Web search sessions (Goodrum & Spink, 2001; Bernard J. Jansen, Goodrum, et al., 2000; Spink, et al., 2001). Goodrum and Spink (2001) also reported that image queries have more search terms per query and more modified queries than in textual information (i.e. general Web) searches. In terms of query reformulations in multimedia searches, Jansen, Spink, and Narayan (2007) discovered that most reformulations were formulating new search topics (63.34% of all transaction records) followed by query reformulation related to the original topic. They also found that users primarily shift search content between Web and images. While the increase in search terms may be due to the complexity of image content, the longer session times with more query reformulations should indicate the deficiency of current Web image search engines in satisfying users' needs.

As research in log analysis progresses, there is an increasing difficulty in discovering new searching behaviors from the limited information that individual transaction record shows. In addition, the fact that users tend to go through fewer pages over the years (i.e. less click-through data) with a growing diversity in search topics (i.e. more dynamic search needs) (B. J. Jansen & Spink, 2006) makes it even harder to study individual's searching behaviors by the traditional log analysis approaches. This means the real difficulty in knowing what each user really intends to find from just few terms in one single query and the overall statistical evidence is not enough to tell more about the diverse interests of individual users. With such limitations of the analysis and the complexity of image queries, new trends in Web log studies have emerged based on query reformulations from consecutive queries or session aggregation rather than individual records (D. He, et al., 2002; Bernard J. Jansen, Spink, & Narayan, 2007; H. C. Ozmutlu & Cavdur, 2005).

The investigation of consecutive queries generally has to two focuses:

- To detect new search topics or sessions
- To predict users' upcoming searching behavior and provide suitable assistance

Early studies focused on the validity and feasibility of using query reformulations to automatically detect session boundaries. For example, He, Goker, and Harper (2002) combined time interval between two clicks and search pattern (i.e. different types of query reformulation) to detect the beginning of a new search session. Their algorithm produced better precision and recall rate than using either search pattern or time interval alone, but the improvement is marginal comparing to using search pattern alone. Ozmutlu and Cavdur (2005) applied He et al.'s (2002) algorithm to automatically identify new search topic from Excite search engine logs. Although the findings are mixed and the algorithm seems to be somewhat data dependent, they supported the use of query reformulation pattern and time interval information in identifying new search topics.

In Ozmutlu‘s (2006) study, query reformulation pattern and time interval have been proved to have significant effect on judging topic shift by multi-factor ANOVA test. The precision and recall rate in classifying topic shifts were also compared between a multiple linear regression equation incorporating query reformulation pattern factor and several SVM methods. The result showed the equation achieved 95% or more precision and recall in topic continuation cases and 35% or more in topic shift cases, far better than its SVM counterparts.

In addition to session or topic identification, more recently, studies have also utilized Web logs to predict users' upcoming search moves, or search intents and make context-aware assistance (V. Hollink, Tsikrika, & de Vries; Vera Hollink, Tsikrika, & de Vries, 2011; Lau & Horvitz, 1999). For example, Lau and Horvitz (Lau & Horvitz, 1999) used query reformulation pattern and time intervals to successfully predict users' upcoming search behavior based on a Bayesian probability model. In a more recent work, He and his colleagues (Q. He et al., 2009) investigated the sequence of queries in session to predict users' search interests and provide query recommendations that are both highly relevant and with good coverage. Unlike the conventional pair-wise approaches on query recommendation processing, such as the use of co-occurrence or adjacent queries, the study utilized the entire sequence of queries in same session (i.e. a sequence-wise approach) to calculate recommended queries. Results showed that the sequence-wise approach significantly outperformed its pair-wise counterparts as it provided richer user search context for making suggestions.

Hollink, Tsikrika, and de Vries (2011) used linked data (i.e. DBpedia Ontology and WordNet) to identify queries that are not syntactically related (i.e. no common terms shared in the queries) but semantically related. Previous approaches that only considered syntactic differences have limited interpretation of users' interests and accuracy in detecting search topic shifts as related queries do not necessarily share terms in common. The semantic based approach (i.e. using other resources to assess the semantic relationship of queries or entities) is useful in determining users' query-to-query relations and thus the frequent modification patterns or search strategies among professional image users (e.g., journalists, magazine editorial staffs).

Given the advantages of utilizing contextual information in session detection applications, this research also adapts He et al.'s (2002) and Ozmutlu & Cavdur's (2005) query reformulation pattern classification algorithm for analyzing users' query reformulation behavior in image searches. The investigation of query reformulation sequences helps understand the process during query reformulation activities, as well as the search strategies users adopted along their search pathway.

### 2.7.4 Limitations of current Web log analysis

As discussed earlier in *Section 2.7*, Web logs can be effectively used to understand general users' online searching behavior on a large scale (Bernard J. Jansen, 2006; B. J. Jansen & Spink, 2005, 2006; B. J. Jansen, et al., 2003; S. Ozmutlu, et al., 2003) and are generally more objective and non-intrusive than other data collection methods (Bernard J. Jansen, 2006). Such unique characteristics make researchers regard Web log data representative of users' unaltered behaviors and as the most convenient way to study users in real world situation (Bernard J. Jansen, 2006).

Findings from individual transaction log are usually limited to the descriptive aspects of users' behaviors but lacking the contexts in users' searches (i.e. without enough explanatory information about users' searches such as the intents for search) (Jeff Huang & Efthimiadis, 2009; Rieh & Xie, 2006), especially for identifying users' search intents (Grimes, Tang, & Russell, 2007). Hence, recent studies have begun extracting contextual information from consecutive query reformulations (Grimes, et al., 2007; D. He, et al., 2002; H. C. Ozmutlu & Cavdur, 2005; Seda Ozmutlu, 2006).

However, most of these studies are limited in the amount of queries that can be investigated because of the need for manual reviewing processes (Lau & Horvitz, 1999; Rieh & Xie, 2006; Zhang, et al., 2006). Other studies using large-scale data only examine searching behaviors based on two consecutive query reformulations. Thus, the full potential of contextual Web log analysis has yet to be discovered.

Initially, analyses of search context information mainly focused on identifying new search sessions based on query reformulations between consecutive queries (D. He, et al., 2002; H. C. Ozmutlu & Cavdur, 2005). Some used the combination of query reformulations and other features (e.g., time interval between queries or clicks) to detect new search sessions (D. He, et al., 2002), while others used only query reformulations or search patterns. Their findings generally supported the usefulness of query reformulation patterns in detecting new sessions or topic shifts, which outperformed the traditional use of time interval in such tasks (Seda Ozmutlu, 2006). In addition, query reformulation has also been used for studying the uptake and effectiveness of terminology feedback provided by retrieval systems (Anick, 2003).

## 2.8 Web Search Strategies

Beyond the overall process of information-seeking behavior, it is necessary to have a more detail look into users' search strategies, and gain insights on the specific approaches Web user adopts under different information search contexts. In particular, strategies on query formulation (i.e. the selection of query terms and the reformulation of queries) as well as browsing tactics will be discussed in greater depth.

Bruza and Dennis (1997) investigated users' query reformulation behaviors by manually classifying more than one thousand queries into one of the eleven types of query reformulations. With the exception of the repeating queries, term substitution was found to be the most dominant type of query reformulations, followed by term addition and deletion. A similar finding was also reported from the study on a meta-search engine *Dogpile.com* (Bernard J. Jansen, Spink, & Narayan, 2007). Jansen, Spink, and Narayan (Bernard J. Jansen, Spink, & Narayan, 2007) investigated query reformulation behavior among large-scale Web log data. Despite the large proportion of formulating new search queries, query reformulation (which is equivalent to substitution in (Bruza & Dennis, 1997)) accounted for more than 15% of all eight types of reformulations, with specialization (i.e. addition) occurring more than twice of generalization (i.e. deletion). They also concluded that major search content transitions were between Web and image collections.

Currently, only limited query reformulation studies have investigated more than two consecutive queries to infer users' search strategies (Rieh & Xie, 2006) or tactics (Bates, 1979). Rieh and Xie (2006) manually investigated 313 sessions of five reformulations or more to classify the overall query reformulation approach into one of the eight distinct strategies, including: *generalized*, *specified*, *dynamic*, *parallel*, *block-building*, *multi-tasking*, *recurrent*, and *format* (details in *Section 2.8.3 – Web query reformulation strategies*). Although they did not report the frequency for each strategy, they concluded that the first four (i.e. generalized, specified, dynamic, and parallel) are the most popular strategies. A similar categorization of search strategies can also be found in Bates (1979).

### 2.8.1 Search term selection/query expansion

Users often have difficulties in finding appropriate keywords to formulate queries that reflect their information need. One major challenge of current Web search engine design is to assist users in formulating more accurate search queries (Fang, Chen, & Chen, 2005).

Spink and Saracevic (1997) studied the interaction between online users and professional intermediaries and identified four approaches to automatically select search terms: *statistical techniques*, *automatic relevance feedback techniques*, *natural language processing techniques*, and *various intelligent systems*. They also categorized search terms into five sources:

- Users' written question statements (QS)
- Terms derived from users' domain knowledge (user interaction terms - UI)
- Terms extracted from retrieved relevant items (TRF)
- Database thesaurus (TH)

- Terms derived by intermediaries (IN)

Among these sources, search terms derived from users' question statements (QS) contributes the largest proportion of all search terms investigated. This is also the resource that has the highest relevant search terms percentage (i.e. search terms that is able to retrieve relevant or partially relevant items). Although TRF terms only contribute to a small proportion of the term pool, they are effective in retrieving relevant items, especially of those that were chosen by expert intermediaries. Surprisingly, thesaurus terms (TH) did not show much effectiveness in retrieving relevant items as generally expected. In fact, they manifested the poorest ability to retrieve positive items at the risk of introducing more irrelevant items, which is the same characteristic shared with intermediary terms. The reason behind such phenomenon is still unclear and may due to the classification method used in the study. However, TH terms somewhat improved effectiveness when combined with user terms and were often used toward the end of search statement. As the concept of TH term classification is somewhat related but not identical to controlled vocabulary construct, the real usefulness of deriving search terms from thesaurus is still half-folded.

In terms of system development perspective, two types of search term aids have been proposed by Fang and Salvendy (1999, 2000) to facilitate query formulation and expansion process:

- *Keyword comparison* which displays a list of high frequency keywords extracted from relevance Web documents identified by the user. This concept is close to deriving thesaurus from relevant retrieved items.
- *Search query templates* –a set of pre-defined search queries to help user conduct efficient initial search, which works similarly as the controlled vocabulary.

More detailed review of these two search term aids can be found in *Section 2.4.1 – Query formulation/reformulation assistant*. Finally, Fang, Chen, and Chen (2005) identified an issue that Web users, unlike traditional IR system users, lack training on advance search syntax such as Boolean operators. Thus the design of future Web search engine's querying interface should focus on improving basic search performance (i.e. facilitating the use of simple Boolean operators), rather than the functionalities in advance search.

### 2.8.2 Free-text search term vs. controlled vocabulary

Fidel (1986) outlined a decision tree for the selection routines of search term performed by human intermediaries. Three important dimensions that affect users' selection strategies were proposed: *common term vs single-meaning term*, *the ability to match to a descriptor*, and *the matching relationship between the term and descriptor* (i.e. a search key from controlled vocabulary). Since a free-text search term may be or may not be mapped to a descriptor, the decision tree depicts the rules for selecting between free-text and descriptors to formulate the search query. By compensating search terms with free-text and descriptors/controlled vocabulary, the expert intermediary system will be able to help users to improve recall and/or precision in their queries.

From query formulation perspective, if the system cannot be helpful in deploying relevant search terms during initial querying stage, the system should focus on deriving terms from relevance feedback based on relevant items, and fusion with some intelligent intermediaries to produce better retrieval effectiveness (Fang, et al., 2005; Spink & Saracevic, 1997). Various solutions have been proposed to assist query formulation and expansion by relevance feedback mechanisms, which were discussed in *Section 2.4.2 – Relevance feedback*.

### 2.8.3 Web query reformulation strategies

Due to the lack of research particularly focusing on Web query reformulation strategies (Bates, 1979), and some contradictory findings among Web users' query reformulation behaviors (e.g., some indicates a general to specific approach (Jorgensen & Jorgensen, 2005; Y.-H. Liu & Belkin, 2008; Zhang, et al., 2006) while some report otherwise (Fidel, 1991c)), the current study intended to construct the reformulation classifications that are able to cover the variety of different approaches. The classifications are primarily based on Rieh and Xie's (2006) study and expanded using Grounded Theory approach. The followings are the list of reformulation strategies used in this study (with Rieh et al's (2006) original terminology in brackets), as well as our analysis assumptions in detail descriptions:

- *Bottom-up (Generalized reformulation)*

  User may begin with several search terms describing some specific objects or entities, then subsequently drop some of the terms to include more results. This is the generalized reformulation and is most often manifested by term deletion changes (Rieh & Xie, 2006). It can also be characterized by replacing terms with broader concept classes.

- *Top-down (Specified reformulation)*

  When user persistently specifies a query (e.g., adding more search terms or change to more specific object of same concept), we classify the reformulation strategy as specified approach. Incorporating more search terms (Y.-H. Liu & Belkin, 2008) and combining concepts were found to be the most frequent reformulations in Rieh and Xie's (2006) study.

- *Divide-and-conquer (Building-block reformulation)*

  If user identifies some core search concepts and tests different combinations of these concept terms in subsequent queries, the reformulation strategy is referred as building-block (Rieh & Xie, 2006), or divide-and-conquer (Sutcliffe & Ennis, 1998). Users usually engage in this reformulation strategy when knowledge about the problem domain is sufficient but need to interact with the retrieval system more to find out the best combination.

- *Trial-and-error (Dynamic reformulation)*

  When user inconsistently switches between generalized and specified reformulation, such reformulation pattern is characterized as trial-and-error strategy. Such reformulation pattern is not as straightforward as previous ones and manifests the unplanned nature of users' searching processes. We assume users who adopt this search strategy have most unconsolidated and least structured image problems, and require most interaction with the retrieval system.

- *Parallel*

  Parallel reformulation occurs when user modifies terms of same concept level and shares some common characteristics, for example when substituting with related objects (e.g., from PC to Mac) or synonyms. Although this pattern may not be very distinctive from divide-and-conquer strategy, parallel reformulation usually results in the discovery of new search terms or concepts via association, whereas divide-and-conquer only utilizes the concepts identified at the beginning of a session. Thus we expect users who primarily adopt parallel reformulation strategy are more likely to shift their search interest and have an explorative intent for search.

Other query reformulation patterns such as *multi-tasking*, *recurrent*, and *format* change have also been identified in Rieh and Xie's (2006) study. However, as our focus is the term reformulations that can be mapped to concept ontology, these patterns do not demonstrate the same characteristics as other patterns listed above and therefore will not be considered in our data analysis method. Bates (1979) also identified several search formulation tactics (equivalent as our query reformulation strategies) that shares much similarity with Rieh and Xie's (2006) classification. For example *REDUCE* tactic is close to *generalized reformulation*, *SPECIFY* as specified reformulation, *EXHAUST* is related to *building-block* approach, and *PARALLEL* is similarly defined in both studies. The classification will be tested upon our user study data. While we believe these strategies should also be applicable to the reformulations of image queries, Grounded Theory approach was adopted to discover any new strategies that may be specific to image search behaviors.

### 2.8.4 Browsing

Apart from search term selection and query formulation, the reviewing of retrieved results and relevance judgment are also essential to the whole retrieval process. One essential technique in information searching behavior, in fact, central to all information behavior, is the browsing activity. Browsing is an inherent activity that human normally engages in when seeking information, and is not exclusive to any other techniques or strategies. Furthermore, because browsing strategy largely results from on-the-fly selections, as opposite to carefully planned querying activities, it is more unpredictable and depended on the selection, navigation, and trial-and-error tactics (Gary Marchionini, 2006). In Savolainen and Kari's (2006) study of self-development oriented (exploratory) Web searching (e.g., hobbies), 81.7% of all 13 search tactics identified were browsing related. In particular, *following links*, *going back*, and *remembering a URL* are the three most popular browsing related tactics.

Carmel, Crawford, and Chen (1992) investigated different browsing styles between novices and experts and subsequently identified three main browsing strategies:

- *search-oriented browsing* (finding information relevant to a fixed/planned task)
- *review browsing* (reviewing information for a changing task, endeavor to integrate information into one's mental model)
- *scan browsing* (looking for interesting information by scanning through acquired information, but does not involve review to integrate the information)

These browsing strategies correspond to Cove and Walsh's (1988) classification as *Search browsing* (browsing with a specific goal), *General purpose browsing* (browsing information of searcher's own interest), and *Serendipitous browsing* (randomly scanning through information without particular goal).

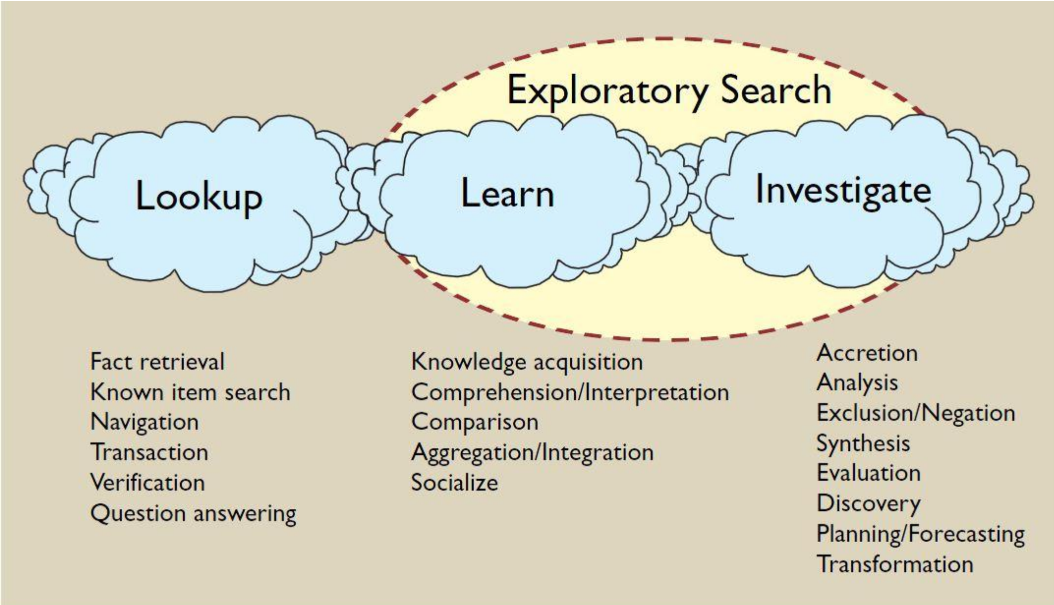


*Figure 2.8* Search types and activities (adopted from (Gary Marchionini, 2006))

As *Figure 2.5* shows, Marchionini (2006) categorized search activities into *lookup*, *learning*, and *investigate* searches. While lookup can be regarded as search-oriented, learning and investigate activities are characterized as exploratory search and are usually accompanied with serendipitous browsing to stimulate analogical thinking.

This may look somewhat contradicting with previous study definitions of 'serendipitous browsing', which is often not bound with a clear or specific search goal. However, as the author further explains, such investigative searching is more concerned with 'recall' against precision, which is usually the primary concern in lookup searches. Serendipitous browsing, in this context, thus becomes a strategy to engage in browsing for more information (i.e. to maximize recall) other than verifying the precision of the retrieved information. Clearly one can either use 'serendipitous browsing' to learn or investigate 'new' information, or use 'review browsing' to further integrate the information with existing knowledge, depending on the search requirements at hand. The association of serendipitous browsing with learning and investigation manifests the exploratory nature of search, whereas review browsing emphasizes on the apprehension of the retrieved information. To avoid confusion, in this study, types of browsing activities (i.e. intensive browsing and serendipity browsing) are explicitly defined based on their temporal duration other than the associated search goals behind (details in *Section 3.6.2 - Searching behavior coding*).

While review browsing is observed as the primary activity in both novices and experts, experts browsed in more depth and concentrated on fewer topics that are related to their expert knowledge. Novices, on the other hand, browsed more topics based on common sense or special interest (Carmel, et al., 1992). In terms of the browsing interaction, serendipitous browsers tend to avoid repetitive long navigation sequences, on the other hand, users conducting search-oriented browsing undergo long navigation sequences more often (Catledge & Pitkow, 1995).

Xie (2002) inspected 40 representative cases from the study of various library users and developed eight categories of interaction and information-seeking strategies, including *scanning*, *searching*, *tracking*, *selecting*, *comparing*, *acquiring*, *consulting*, and *trial-and-error*. She further investigated the relationship between different types of interactive intention and frequent strategies associated with the intention. Although users may not always adopt same information-seeking strategies under specific interactive intention, her study showed that some strategies are frequently associated with certain type of interaction.

This finding leads to the recommendation of IR system design to support interaction beyond query formulation level, with more in-depth support of the entire information-seeking process including result evaluation. For example, if a user is trying to find some known items, the system should provide a browsing mechanism to allow user scan through items returned by partial search (i.e. search with incomplete information about the target item, such as partial title, partial author). Alternatively, the system can provide options based on the characteristics of the target item from which user can choose (e.g., the format of an image, the file size, or the created date). If the search intention is to find something new or interesting, in other words, without strictly pre-defined criteria, the system should facilitate browsing items from different subjects or formats and thus help users further consolidate their intentions.

## 2.9 Chapter Summary

This chapter reviews literatures of issues in Web image searching from both system and user perspectives. First, Content-Based Image Retrieval (CBIR) has its limitations such as semantic gap and page-zero problems, as well as the accuracy in object recognitions. Images with textual annotations are more intuitive for Web users and still widely adopted by current search engines, as users' search needs are mostly semantic, with general focuses on people, location, and objects. However, the inconsistency from user image annotations remains the major problem in this approach and many state-of-the-art retrieval systems seek to fusion visual features with concept descriptors to partially overcome the problem by introducing the third kind of image retrieval paradigm, the concept-based image retrieval. The new trends in visual search and query formulation are also discussed. In particular, query reformulation assistance, which focuses on understanding users' dynamic and versatile needs and providing more intuitive searches, reflects the current research goal.

From user perspective, users' information searching behavior can be apprehended as a problem-solving or goal directed activity. Different levels of goals are constructed and conceptualized to be reflected in users' queries. Users' search intents are influenced by various factors that are cognitive, affective, and situational but a retrieval system can only detect the search intent at interface level (i.e. queries submitted to the system). Hence the current study focuses on query formulation/reformation process and aims to develop context-aware query formulation assistance. In particular, users' *current search goal* can be captured by consistent concepts appeared in users' consecutive queries. The concept terms extracted from the changes between queries should typically represent users' *interactive intention*. Five major types of query reformulation strategies will be utilized to discover the relationship between users' information needs and the strategies adopted. New reformulation strategies may also emerge from Grounded Theory approach in user study data analysis.

In next section, we discuss our methodology to study general Web image users' query formulation/reformulation behaviors and construct the contextual image searching model from Web log analysis and user study in detail.

# CHAPTER 3: RESEARCH DESIGN

This chapter presents the research design and methodology for the current research. Two sub-studies contributed to the main findings in this research. First, Web multimedia search logs were analyzed and compared in the pre-study to ensure the plausibility of a new log analysis method which investigates consecutive in-session query changes. This pre-study also pinpointed the key focuses of the query reformulation process in the subsequent user study, such as the selected query reformulation and result reviewing behaviors that needed to be quantified in the analysis. The user study complemented the understanding of users' Web image searching from log analysis as it provided more comprehensive search contexts that are missing in Web logs, such as search goals, search requirements, and outcomes.

This research does not focus on reporting key Web image searching behaviors, but rather on the relationship or the connection between users' search goal, search task, search skill, and corresponding search strategies. Hence the analysis of search strategies from Web logs and user studies is particularly important. Due to the lack of literature suggestions on Web image searching strategies, especially in regards to query reformulation behaviors, the current study needs to first identify the frequent search patterns for in-depth investigation and analysis. The categorization of query reformulation patterns discovered from the Dogpile log analysis pre-study thus facilitated gaining more insights into the search patterns that users frequently exhibit. By further investigating these patterns while allowing the discovery of new patterns from the subsequent user study, a comprehensive user model can be constructed to help understand general users' Web image searching, especially the relationships between different search strategies and different stages of searching.

## *Organization of the chapter*

In this chapter, *Section 3.1* introduces the three important aspects that influenced our Web searching user study design: the choice of task types that would influence the adoption of different search strategies, the sole focus on query reformulation process, and the limitations of the log analysis approach in understanding users' search intents and underlying behaviors. *Section 3.2* proposes the study assumptions which form the fundamental beliefs in answering the research questions. *Section 3.3* provides an overview of the entire study design, beginning with the selection of multiple research methodologies used in the current study. The overall structures and data analysis procedures of the two sub-studies are presented later in this section. *Section 3.4* provides details of the Dogpile log analysis pre-study, including the usable information from the log records, the log pre-processing methods, and the generation of search strategies appeared from these analyses. *Section 3.5* presents details of our data collection method for the user study, including the participant recruitment process, the user-initiated search tasks, the questionnaires used in the study, and users' search session monitoring. Data analysis methods for the user study data are presented in Section *3.6*, including the think aloud transcript and the Grounded Theory approach for qualitative analysis, as well as the query term categorization and statistical tests used for quantitative analysis. The quality of the study findings, such as the validity and reliability of the adopted research methods, as well as their limitations, are discussed in *Section 3.7*. Finally, *Section 3.8* provides a brief summary of the research methodologies and design discussed in the chapter.

## 3.1 Introduction

### *Task type vs. search strategy and outcome*

In order to study Web users' image searching behaviors and search strategies, the first critical decision is to define the types of tasks that are being studied. Many researchers have conducted user studies to learn about user's information search strategies based on different types of search tasks. The broadest task categorization splits in two: whether or not the search targets are known to the searcher (Weedman, 2002). The general implications from these studies are that browsing is more preferred by novice users or users who have exploratory goals, whereas querying is perceived as more suitable for experts or specific retrieval tasks (Frost, et al., 2000; Westman, et al., 2008).

In particular, research has discovered some significant effects that search task type has on user's search strategies and outcomes (Fukumoto, 2006; Kim & Allen, 2002). For example, Kim and Allen (2002) found that a known-item search yields high recall and precision, whereas a subject search results in more search activities, more time, and using more embedded links and jump tools. Similarly, Fukumoto (2006) also found that open search tasks showed significant increase in users' search processes (e.g., number of pages reviewed, the overall search time) and querying activities (e.g., the number of inputting keywords and the use of unique keywords) than in closed tasks. In image search studies, Weedman (2002) identified two kinds of searches from analyzing a social scientist's use of images in her research: *search for pre-existing information* and the *search for the synthesis of new information from relevant documents*.

The decision of how many task types should be incorporated in the current research will affect the potential findings. If the study is constrained to some specific tasks, more detailed search behaviors are expected to be discovered, but with limited applicability to the broad and versatile Web image searching. On the contrary, if the study investigates every Web image searching, it faces the danger of not being able to find any significant behaviors, as samples are diverted into many different categories (i.e. the different types of search tasks for the current study) without any coherent patterns. Hence, determining search tasks that balance the open and closed nature of the information being sought is crucial to the intended findings. However, no literature has suggested to which extent the openness or specificity of search tasks suits such purposes. As a result, the current study did not specify the types of tasks participants will perform. Instead, participants were asked to come up with their own search topics because the research goal is to understand their searching behaviors in general, not under any specific search contexts. The types of visual information, however, are strategically constrained to *news*, *travel*, and *commercial products* because of the significant proportion of search terms/interests related to people, location, event, and particular objects found in previous studies.

After the user study data collection has been completed, search tasks are broadly categorized as *retrieval* and *exploratory tasks* during the analysis stage to compare any behavioral difference. Retrieval tasks are similar to the known-item searches or close tasks in which the search target is a *tangible set of images* known to exist on the Web, despite whether the participants have seen them or not. Exploratory tasks are comparable to subject searches or open tasks in which participants' search needs are more dynamic and less specific, and thus do not involve a tangible set of images as search targets.

### *Focus on query reformulation strategies*

As mentioned in *Section 2.1.2*, user studies of Web image searching primarily focused on either the different aspects of images utilized in formulating queries (Chen, 2001; Fukumoto, 2006; Westman & Oittinen, 2006), the purpose of image searching and its usage (Conniss, et al., 2000; Fidel, 1997; Othman, 2005; Weedman, 2002), or the different search modalities (Frost, et al., 2000; McDonald & Tait, 2003; Westman, et al., 2008). While these studies provided valuable insights into user perspective of image searching, little attention was given to query reformulation strategies. Query reformulation, as suggested by many Web log studies, now makes the major part of Web searching activities (Youngok Choi, 2010). In fact, most of users' interaction with the retrieval system takes place during query reformulation. Investigating searching behavior with an individual's motivation and outcome but ignoring the querying activity seems to be missing the nexus connecting the start and end. On the other hand, investigating query reformulations without a clear start and end (e.g., Web log analysis) misses the context for reasoning the whole picture of users' searches. The only way of solving this puzzle is a user study that observes users' real searching activities while explicitly recording their needs and goals for searching.

### *Shortcomings of log analysis and reasons for user study*

Recent studies on multimedia Web search logs have revealed that image search users have the highest proportion of query reformulation, as well as the longest search sessions and queries (Youngok Choi, 2010; Jorgensen & Jorgensen, 2005; Spink, et al., 2001; Spink & Jansen, 2006). While these findings signified difficulties in Web image searching, little was known about the kinds of difficulties users were facing. Because search logs can reflect only fractions of users' external behaviors, internal aspects such as intentions and thoughts were absent in the collected data, thus prohibiting the understanding of reasons behind each action. Most importantly, search log findings also lacked of search contexts, such as users' purpose of search or intention of use, especially when the analysis was based on a single query reformulation (Youngok Choi, 2010; Rieh & Xie, 2006).

As a result, there is an emerging body of research that attempts to elicit contextual information about users' search from series of query reformulations (D. He, et al., 2002; H. C. Ozmutlu & Cavdur, 2005; Seda Ozmutlu, 2006; Rieh & Xie, 2006). In particular, some attention is given to search strategies that characterized the whole search session. Despite the dynamic characteristics of Web searching strategies, research found that most users adopted a top-down approach. Users usually started with a general idea about their topic, and gradually narrowed down to some more specific concepts or topics during their interactions with the retrieval system (Rieh & Xie, 2006). Such an approach also reflected the concern of search precision over recall among general Web users. However, because these findings were primarily based on Web searches, their applicability to image searching was uncertain, as search strategies were found to be affected by different search tasks or information collections (Youngok Choi, 2010; Fukumoto, 2006; Bernard J Jansen, 2008; Pu, 2003; Tseng, et al., 2009). A Web image searching user study thus not only provides a rich search context for analyzing users' behaviors, but also testifies to the applicability of general Web searching strategies in image searches, and potentially explores new strategies that are specific to image searching.

## 3.2 Study Assumptions

In this study, users' querying behaviors, including formulating initial queries, reviewing results, and reformulating subsequent queries, are the focus of research interest because only these activities are 'visible' from the system perspective. Users' mental processes before the actual searching (e.g., problem identification, need articulation) are beyond the scope of this study because they vary a lot among individuals and are not feasible for systems to implement assistance on. However, since typical Web searching interactions are brief and provide only limited information about users' behaviors, a more in-depth investigation is needed to go beyond traditional Web transaction log analysis methods. Hence **the first challenge for the current study is how to extract more information, particularly users' search contexts from the records of Web searching logs.** By utilizing Web log analysis methods, this research emphasizes the ability to automatically and systematically process large amounts of user data, which is crucial for Web retrieval system implementation. A feasible solution is to look into the sequence of users' query reformulations rather than at the queries one by one. From previous studies, as stated in *Section 2.7.3*, syntactic and semantic changes in the sequences of users' consecutive queries are useful in providing information about users' search interests, especially in detecting topic shifts within sessions.

**The second challenge in the current study arises from the limited user sample data used in understanding the vast and diverse Web users' searching behaviors**. Due to the research timeframe constraint, only a limited number of users (i.e. forty) participated in this study, so the reliability and representativeness of the findings may not be generalizable enough. However, as real-world Web log data was first analyzed as the pilot study to lead the findings from the user study, the reliability and representativeness are therefore assumed. In addition, the mixed method data analysis approach should further ensure the quality and credibility of the user study findings because they are triangulated from different analysis perspectives. Next, the two main challenges are discussed in greater detail.

### 3.2.1 Web image searching behaviors and query reformulation activities

By analyzing the syntactic and semantic changes in users' query reformulation sequences, it is assumed that the concepts appearing in the modified terms would give more clues about the important aspects of users' current search needs. Because online users' interests are very dynamic, it is not appropriate to assume that a search interest will be consistent throughout the search session. Without taking the changes in queries into account, it would be impossible for the system to know what a user really looks for without asking the user explicitly. Conventional Web log analysis provides automated procedures to investigate users' behavior but little research has been dedicated to understanding the evolving search interests from consecutive queries. Hence, the current research emphasizes the new method of consecutive query log analysis, which should particularly help achieve:

- Identifying the key concepts in user's current search goal
- Modeling the reformulation strategy under different types of visual needs (e.g., search for people, location, object, or event)
- Reflecting the weakness of current retrieval system (to see what is lacking from the results)

For example, if the user modifies color descriptors in consecutive queries, it is reasonable to assume color feature is more important to the user's current search goal and the retrieval system should therefore give more weighting to the color feature. This approach can be used in conjunction with relevance feedback information using click-through data to enhance the accuracy of capturing users' intention. Specifically, three hypotheses are constructed for the reformulation analysis:

- If all modified terms can be mapped to the same concept class (e.g., replacing terms with synonyms), it is assumed that the user is really concentrating on that particular concept, and thus more weighting should be given to that concept in the retrieval ranking algorithm.

- If the modified terms belong to different concept classes but may be connected by a higher level concept (e.g., subsequently search for iPhone, iPod, iPad under the concept of 'iOS devices'), this may indicate a more general or explorative search where the higher level concepts (e.g., Apple iOS products) should be included in the search as well.

- If no semantic connection can be detected between concepts (i.e. no direct match in the existing concept ontology or dictionary), a statistical model (i.e. the concept co-occurrence) may still help to identify other relevant information.

### 3.2.2 The combined approach of quantitative Web log analysis and qualitative user studies

In this research, users' intention and their interaction with the search engines were studied by two major means, namely Web log analysis and think aloud data from real users. The main purpose is to leverage the benefits of combining both types of analysis techniques and complement the aspects that cannot be covered by a single method alone. This approach, called 'triangulation', has been widely adopted for studying complex phenomena such as user's information seeking and retrieval behaviors (Ingwersen & Jarvelin, 2005). The triangulation approach increases a study's reliability and validity by cross checking data from multiple resources (Malterud, 2001). However, it does not seek to validate any existing theories. Our approach is to use qualitative means (i.e. content analysis of Web logs and visual search think aloud data) to strengthen the findings from quantitative analysis (i.e. statistical analysis of query logs), towards constructing a contextual visual search model.

Specifically, the Web log analysis approach should provide a good way of quantifying users' behaviors. Target behaviors are recorded during a search session, and are later quantified for statistical analysis. By conducting the statistical analysis on the frequencies of each behavior under investigation, it is possible to identify the common searching behaviors that users perform, and discover new factors that may induce other related behaviors. The statistical evidence and the qualitative think aloud data will provide new insights into both the patterns of the user's searching behavior, and the corresponding search strategies. Because these findings arise from both qualitative and quantitative evidence, it is regarded as being more valid and reliable than the findings from either of the data analysis method alone, thus enhancing the quality of the entire study.

## 3.3 Study Overview

This overview of the study includes the rationale for the selection of the current research methodology, the overall study structure, and the general procedures for the Dogpile search log analysis pre-study and the Web image searching user.

### 3.3.1 Research methodology selection

#### *Web log analysis*

Web transaction logs (shortened as 'Web logs') provide server side records of users' interaction with the search engine. The biggest benefit of Web logs is the vast amount of data they store, usually with millions of user interactions in a daily search engine dataset. They provide structured information which can be easily quantified and systematically analyzed. They also represent unobstructed user behaviors because the logs are recorded in the background during searching without being noticed by users (for detail attributes of Web search logs, see *Section 2.7.1 - Overview of Web logs*).

The major drawback of Web logs is the depth or richness of the collected data. Because they record only limited attributes of the interaction, typically the IP address of the client computer, the time of an action, the query content, and the links that were clicked by a user, the user's thoughts and other client side activities (e.g., opening other browser windows concurrently, browsing other information resources other than the links from the search result) are inherently absent (for details of the Dogpile Web logs utilized in the current study, see *Section 3.4.2 - Overview of the*

*Dogpile data set*). Hence, in this study, the Web logs were used solely in the pre-study to test the new consecutive log analyzing method, and were complemented by the user study data to verify and support the findings.

### *Questionnaire*

A questionnaire is an effective means to collect in-depth qualitative data, compared to other common study instruments such as interviews and observations (Ingwersen & Jarvelin, 2005). The questionnaire requires less training for administration and less time for the analyzing process because of the standardized answers it provides. Much research studying human behavior has used this approach to obtain respondents' thoughts and cognitive data. In this study, questionnaires were used in conjunction with think aloud recording to collect participants' thoughts and opinions during their search activities. This data collection method provided in-depth views on participants' cognitive transitions during query formulation and reformulation activities.

### *Think aloud protocol*

Think aloud is a frequently used method for collecting data on users' thoughts in information seeking studies or human computer interaction research (Ingwersen & Jarvelin, 2005; Jaspers, Steen, Bos, & Geenen, 2004; Nielsen, Clemmensen, & Yssing, 2002). This method typically asks participants to verbalize their thoughts, feelings, what they see, or what they are doing while solving their information problems. This allows the observer to gather the first-hand information of participants' genuine response and to make the implicit cognitive process explicit. Despite the variations in terminology by which think aloud has been referred, Ericson and Simon (1993) distinguished three kinds of verbal reporting techniques:

- Talk aloud – the verbalization of thoughts that have already been orally encoded
- Think aloud – the verbalization of a sequence of thoughts that was not held in verbal form, such as visual

- Retrospective report – the verbalization of thoughts that were not held in the subject’s short-term memory

Thus it is primarily talk aloud and think aloud that researchers have typically employed. One disadvantage of think aloud is its obtrusiveness (Ingwersen & Jarvelin, 2005) and training is often required in order to obtain more information. Several researchers have investigated the effects of additional cognitive load caused by think aloud activities (Haak, Jong, & Schellens, 2003; Rogers, Sharp, & Preece, 2002). Some found that users probably find it difficult to speak when the task becomes demanding (Haak, et al., 2003; Rogers, et al., 2002). Specifically, Karsenty (2001) pointed out that think aloud should not be used in tasks involving dialogue as it may compete or interfere with subject’s cognitive process required by the task. However, some researchers did not find significant problems associated with the double cognitive load of users doing think aloud concurrently (Katalin, 2000).

Although think aloud is a dominant technique in usability studies which usually focus on task performance and user’s experience (Haak, et al., 2003; Nielsen, et al., 2002), our objective was to discover the process of Web image searching activity, rather than to evaluate the differences between participants’ performance or strategies. Thus the effects that think aloud may introduce to participants’ performance should not cause the validity of the current study’s findings to deteriorate.

## ***Searching activity recording and logging***

In addition to using think aloud protocol, participants’ searching activities were automatically recorded using *Camtasia software* to provide the means to reconstruct/recall the searching situation for later analysis. This is essential for qualitative data analysis as the researcher needs to match participants’ think aloud data with the actual searching activity in order to ensure the accuracy and integrity of the think aloud transcript. The searching activity recording also helps construct the user study search logs, which are the simplified and structured activity logs for quantitative data analysis. Because such logs were constructed on the client side, activities that cannot be captured by search engines can still be included in the log record, such as browsing other websites or switching between several search tasks concurrently. This is an important feature for the current study as the research focus is user perspective rather than the system perspective of the searching process. Similarly, in 2005, Google and Keynote Systems conducted a study of users' Web searching behavior using client side recording (Grimes, et al., 2007).

### *Grounded Theory approach*

Grounded Theory is the fundamental analysis approach in many qualitative studies (Corbin & Strauss, 2008; Ingwersen & Jarvelin, 2005; Mansourian, 2008a, 2008b; Mansourian & Ford, 2007). It uses an inductive approach to develop new theories from empirical data, and thus makes the theory close to the original data or observed phenomenon (Corbin & Strauss, 2008; Barney G. Glaser, 2008; B. G. Glaser & Strauss, 1977; Heath & Cowley, 2004). One distinct characteristic of the Grounded Theory approach is that it does not begin with a hypothetical theory, but begins by collecting data in the field (Backman & Kyng , 1999). Since there are no well-established theories or models for general Web image searching and the current study aims to construct such a new model, the Grounded Theory approach suits this purpose, particularly for analyzing qualitative user data.

The vital process in Grounded Theory is the *coding* phase, which means categorizing segments of user data (i.e. the think aloud transcript in this study) into short labels that summarize and explain what the data represents (Charmaz, 2006). Coding thus becomes the link between the data collected and the emergent theory. Details of the coding procedures in Grounded Theory and their applications to the current study data are presented in *Section 3.6.2 – Qualitative data analysis*.

## 3.3.2 The research structure

As depicted in *Figure 3.1*, the entire research was divided into two major phases, namely the Dogpile Web log analysis pre-study, and the Web image searching user study. Based on the preliminary user models proposed in *Section 2.6*, Dogpile multimedia search logs were first analyzed to find the basic query reformulation patterns. Findings from the Dogpile pre-study helped consolidate the set of query reformulation behaviors that needed further investigated in the following Web image searching user study. These two phases of the study are closely connected, as the user study utilized the log analysis methodology developed from the Dogpile pre-study, while the findings from Dogpile pre-study resonated with the user study results. Summaries of the purposes in both studies are presented next.

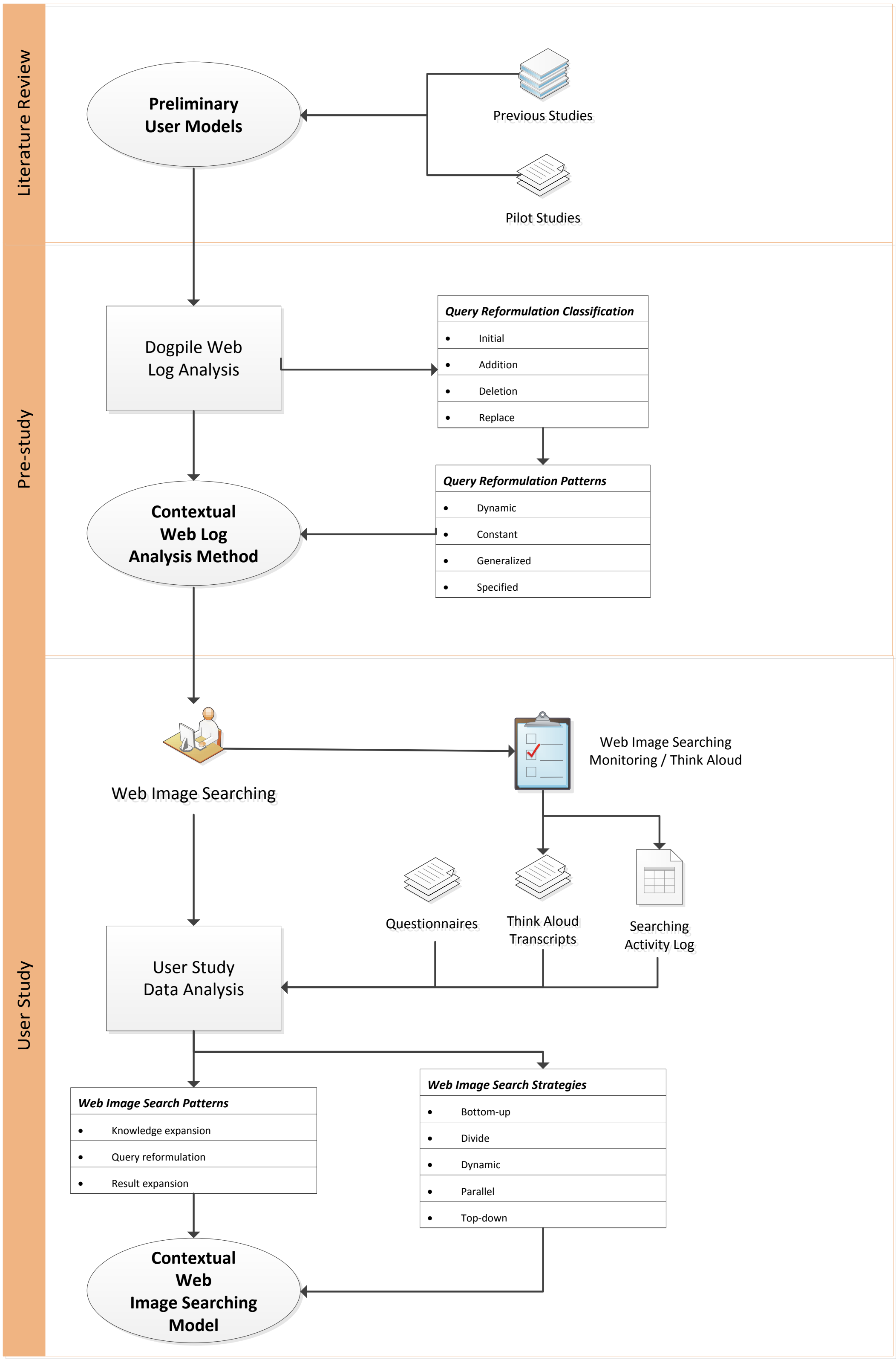



Figure 3.1 The overall research structure

## *Pre-study: Dogpile Web log analysis*

The first phase was to develop a feasible method for analyzing online users' query reformulation patterns and search strategies from consecutive queries. Conventional Web log analysis approaches consider only single queries and have limited ability in identifying users' search contexts, such as the search intents and the corresponding search strategies. Our consecutive log analysis method took a step forward by taking the entire search session into account, and thus was able to identify some preliminary search strategies from the contextual changes in query terms. The query reformulation patterns and search strategies identified in the pre-study also helped determining and confining the behaviors of focus in the user study.

The new method proved to be effective in extracting more search context information from a large data set like Web search logs. However, as with the limitations of other log analysis techniques, user information that does not appear in the query, is inaccessible form this approach, particularly the search intents and reasons for different kinds of query reformulations. Hence a user study with in-depth qualitative search data is needed to extend our understanding of users' Web image search context and behaviors.

### ***User study: Web image searching***

The Web image searching user study contributed to the main findings of the current research. Although Web log analysis can provide information about users' visual searching behavior on a large-scale basis, users' cognitive activity cannot be directly measured by such approach. The only way to have a closer look at users' actual behavior while remaining informed of user's thoughts is to observe the users performing their searches alongside, and ask users to reflect their thoughts and feelings concurrently. Hence a user study is needed which utilizes a lab setting for participants searching Web images individually. The researcher then sits beside the participant, observing and prompting the participant to reflect her thoughts when necessary.

Questionnaires were used to collect participants' thoughts and opinions before and after searching activities, and thus provided in-depth reviews on participants' cognitive transitions during searching. Two types of questionnaires were administrated in this study: *pre-search* and *post-search* questionnaires. The pre-search questionnaire collected background information about participants and their motivations to search such as search experience, the preference for search engines (e.g., Google image search or Yahoo), and descriptions of each search task.

During searching, the researcher observed participants' behavior while recording participants' computer screen for data analysis later. Participants were asked to search images in *News*, *Travel*, and *Product* domains while constantly think aloud (i.e., to speak out what goes on in their mind) during searching, particularly for important search moves, such as the changes in search direction, the strategy chosen, and the query reformulations.

Upon completing the search tasks, participants were asked to reflect on their search experience, the effectiveness of their search tactics, and their satisfaction in the post-search questionnaire so that we could assess the subjective aspects of the search outcomes. The questionnaires, as well as the think aloud data, were later analyzed for common search patterns using the Grounded Theory approach. The identified common search patterns were further statistically tested for their significance to ensure their reliability. Finally, the significant patterns were integrated into our contextual user model, which is presented in Chapter 5. In the following sections, detailed procedures of the log analysis pre-study and user study are discussed.

## 3.4 Dogpile Web Log Analysis

### 3.4.1 Study goals

In this pre-study, our focus is users' Web multimedia searching behavior which can be revealed by consecutive query reformulations. We investigated the entire session of users' query reformulations to infer their searching behavior. The three main questions that we attempted to answer were:

1. What are the frequent reformulations in Web multimedia queries and do they

differ among the multimedia searches?

2. What can the sequence of query reformulations tell us about user's query reformulation behavior?
3. What search strategies can be inferred from query reformulation sequences?

We now present the detailed procedures for our Web log analysis pre-study.

### 3.4.2 Overview of the Dogpile data set

Among 1,228,330 records of the Dogpile data set taken on 15 May 2006, a total of 597,760 transaction records were attributed to be image searches as users clicked the image option during their search. From these image transaction logs, the query reformulation analysis was conducted against 315,793 reformulation records, and a total of 60,699 different user sessions were identified. After eliminating records without any user session cookie, 311,487 reformulation records were used for further analysis, which consisted of 188,378 (60.5%) initial queries, 77,957 (25.0%) replace reformulations, 29,279 (9.4%) addition reformulations, and 15,873 (5.1%) deletion reformulations. Based on the session sequence analysis (i.e. the number of independent queries/topics within a user session), there were 172,094 different session sequences in total and users submitted an average of 2.84 independent queries during their search, varying from only one query to 145 queries per user session (SD=4.44). The statistics of maximum session sequence showed that more than 95% of user sessions had only 10 session sequence (topic) or less. These results are comparable and consistent with other studies in general web search transaction records.

#### *Dogpile transaction log fields*

The original Dogpile transaction log contains seven fields that were utilized in this study:

- *IP*: the IP address of the computer submitting the query
- *Cookie*: the unique identifier which the Dogpile system sends to a

particular computer with a pre-defined valid period

- *Time*: time of the day when a user submits the query
- *Query*: the original search text submitted to the system
- *Vertical*: the search type option a user selected on Dogpile's search page: for this study, we use only the logs with 'images' option selected
- *Sponsored*: the number of sponsored links the user has clicked on
- *Organic*: the number of non-sponsored links the user has followed. In our analysis, we combine the number in both sponsored and organic fields to calculate the total number of results viewed by the user

### 3.4.3 Contextual query reformulation analysis

Our query reformulation analysis follows the general procedures stated in *Section 2.7.2 - General procedures for log analysis*. By query reformulation pattern we refer to the classification of different types of query changes, which is determined by the search terms that have been modified. In addition, we address the query level analysis which investigates the reformulation sequences between the queries that the user submitted to Dogpile search engine. In the next section, we present the detailed methodologies of our analysis.

#### ***Session aggregation***

In order to conduct the reformulation pattern analysis, the Dogpile transaction logs are first sorted based on different sessions in chronological order. User session identification has been a concern in the Web log studies (Bernard J. Jansen, Spink, Blakely, et al., 2007) and many different approaches have been proposed to define user sessions (Bernard J. Jansen, Goodrum, et al., 2000; B. J. Jansen & Spink, 2003, 2005; Bernard J. Jansen, Spink, & Narayan, 2007). In this study, we define session as a continuous time span which consists of one or more different queries submitted by a user. We adopt the method presented in Jansen et al.'s (2007) work using IP and browser cookies as the means for session identification. One difference between our session definition and Jansen et al.'s (2007) is the introduction of search topics within a session. Because we assume that users may search several different yet conceptually related topics in a session, the use of query reformulation pattern to classify a new topic into another new session is not compatible with our view of a session. In other words, a session would have only one search topic if Jansen et al.'s (2007) session identification method three (i.e., using IP, cookie, and query reformulation pattern to identify session) was being applied. However, this is not compatible with our session definition. As a result, we use query reformulation patterns to identify each new search topic (termed as a new '*session sequence*'), that shares no common search terms with its preceding query. Our views on session are consistent with Ozmutlu and Cavdur's (2005) definition, with one terminology difference that the '*session sequence*' in our study is equivalent to their '*topic*' within a session.

### *Browsing record aggregation*

Consecutive log records with identical queries (i.e. browsing records) are aggregated with the first log of the same query. This collapsed log record represents the whole span of the browsing activity and the numbers of the viewed results are accumulated across the aggregation. The duration of such browsing activity is constructed as the period from the first log in the current aggregation to the first log in the next aggregation if they belong to the same *session sequence* (i.e. current aggregation shares at least some terms with next aggregation). Otherwise the duration will be the time difference between the first and last log in the current aggregation. Due to the limitation of Web transaction logs in identifying the time when users depart from the search engine, if the last log has the same time record as the first log in the current aggregation, the duration will have to be recorded as zero length (e.g. the last aggregation in *Table 3.1 and Table 3.2*). Because relevance feedback mechanism is not shown in Dogpile logs, no information can be analyzed in this regard. *Table 3.1* and *Table 3.2* illustrate the original log and aggregate log respectively.

| IP | Cookie | Time | Query | Vertical |
|---|---|---|---|---|
| 64.105.73.70 | 2187RDPA47YLJOB | 6:05:33 PM | pod of dolphins | Images |
| 64.105.73.70 | 2187RDPA47YLJOB | 6:06:03 PM | group of dolphins | Images |
| 64.105.73.70 | 2187RDPA47YLJOB | 6:06:18 PM | group of dolphins | Images |
| 64.105.73.70 | 2187RDPA47YLJOB | 6:06:18 PM | group of dolphins | Images |
| 64.105.73.70 | 2187RDPA47YLJOB | 6:08:56 PM | dolphins | Images |
| 64.105.73.70 | 2187RDPA47YLJOB | 6:08:56 PM | dolphins | Images |
| 64.105.73.70 | 2187RDPA47YLJOB | 6:08:56 PM | dolphins | Images |

*Table 3.1* Original Dogpile search logs with browsing records

| Session No. | Current query | Modified terms | Reformulation pattern | Duration |
|---|---|---|---|---|
| 1 | pod of dolphins | | I | 0:00:30 |
| 1 | group of dolphins | pod,group | R | 0:02:53 |
| 1 | bottlenose dolphins | group of,bottlenose | R | 0:00:00 |

*Table 3.2* Query reformulation table with aggregated reformulation records

## *Reformulation pattern classification*

Each aggregated transaction record is classified into a query reformulation pattern based on the content of the current query and the previous query. We use four reformulation patterns for our classification. The definitions for each reformulation pattern are:

- *Initial query (I)*: current query has no terms in common with the previous query
- *Addition reformulation (A)*: current query contains all search terms from the previous query, as well as some new terms
- *Deletion reformulation (D)*: current query omits some terms from the previous query
- *Replacement reformulation (R)*: deletion and addition of terms happen simultaneously to form the current query

Thus an initial query represents a new search topic since no search terms are carried over from the previous query. This is consistent with Jansen's (2006) definition of an initial query. Each initial query reformulation introduces a new *session sequence*, resulting in an increased session sequence number. Our classification for query reformulation patterns is originally adapted from Ozmutlu (2005) and He et al.'s (2002) studies with some terminology difference. Many other researchers have proposed slightly different yet comparable classifications (Bernard J. Jansen, Spink, Blakely, et al., 2007; Bernard J. Jansen, Spink, & Narayan, 2007; Park, et al., 2005; Rieh & Xie, 2006). The algorithm for session aggregation and query reformulation pattern classification is presented in *Figure 3.2*. Details of the classification algorithm can be found in He et al., (2002). We built a program to automatically classify queries by their reformulation patterns and aggregate the consecutive browsing records in *Table 3.2*.

Some studies classify the replacement of search terms and the changing of term orders as 'reformulation' (D. He, et al., 2002; H. C. Ozmutlu & Cavdur, 2005; Seda Ozmutlu, 2006). However, as users can freely reorder the query terms without affecting the search results on most search engines (e.g., Google searches), we use the terminology *'replacement'* to clearly indicate the substituting of terms. A comprehensive comparison of the taxonomies of query reformulations in various studies is provided by Huang and Efthimiadis (2009).

**Input:**
Current query $Q_i$ , previous query $Q_{i-1}$
Cookie of current query $C_i$ , cookie of previous query $C_{i-1}$
IP of current query $P_i$ , IP of previous query $P_{i-1}$
Initial reformulation pattern $I$
Replace reformulation pattern $R$
Deletion reformulation pattern $D$
Addition reformulation pattern $A$

**Let**
$\phi$ be the empty set
$t$ be query terms in query
$CO$ be the set of terms common to $Q_i$ and $Q_{i-1}$, such that
$CO = \{t \mid t \in Q_{i-1} \quad and \quad t \in Q_i\}$

$U0$ be the set of unique terms in $Q_{i-1}$, such that
$U0 = \{t \mid t \in Q_{i-1} \quad and \quad t \notin Q_i\}$

$U1$ be the set of unique terms in $Q_i$, such that
$U1 = \{t \mid t \notin Q_{i-1} \quad and \quad t \in Q_i\}$

$MPi$ be the Reformulation Pattern of $Q_i$, such that $MPi \in \{I, R, D, A\}$

**IF** ( $C_i = C_{i-1}$ and $P_i = P_{i-1}$ ) **THEN**
//current query from same session
**IF** ( $Q_i = Q_{i-1}$ ) **THEN**
//browsing or click-through record
//merge with previous log and accumulate result count
**ELSE IF** ( $Q_i \neq \phi$ and $CO = \phi$ ) **THEN**
//initial reformulation
$MPi = I$
**ELSE IF** ( $CO \neq \phi$ and $U0 = \phi$ and $U1 \neq \phi$ ) **THEN**
//addition reformulation
$MPi = A$
**ELSE IF** ( $CO \neq \phi$ and $U0 \neq \phi$ and $U1 = \phi$ ) **THEN**
//deletion reformulation
$MPi = D$
**ELSE IF** ( $CO \neq \phi$ and $U0 \neq \phi$ and $U1 \neq \phi$ ) **THEN**
//replace reformulation
$MPi = R$
**END IF**
**ELSE**
//beginning of a new session, reformulation pattern is Initial
$MPi = I$
**END IF**

*Figure 3.2* The algorithm for the session aggregation and the reformulation pattern classification

### *Query reformulation analysis*

We built a program to automatically classify queries by their reformulation patterns and to aggregate browsing logs into a single record in a query reformulation table (*Table 3.2*). The session sequence signifies that consecutive modified queries share some search terms in common, presumably representing some related current search goals. In Lau and Horvitz's (1999) study, they have demonstrated some achievement in predicting users' search goal by using the first two search actions and time intervals as conditional variables. Thus it is reasonable to assume that by investigating the consecutive reformulations in users' search session sequences, we can possibly infer more information about users' current search goal. Each single session sequence can be regarded as an individual search topic since there is no apparent textual relationship between session sequences. In other words, the beginning of each session sequence is always an initial query indicating the start of a new search topic. However, inter-session sequences may not always be semantically independent, as two syntactically different terms can still refer to some similar idea. An incremental sequence number is assigned to each session sequence within a session. If a new session is encountered (i.e., if the combination of current IP and cookie changes), the program will reset the sequence number back to one to indicate the first sequence in the new session. With this aggregation, we ensure each session sequence is a closer representation of independent search topics. By calculating the highest sequence number in each session, we are able to identify the average number of search topics per user session.

### *Reformulation sequence (session sequence) analysis*

Once the query reformulation table has been generated, series of reformulation patterns within each session sequence can be classified into several predetermined reformulation sequences. We used our program to identify the occurrence of a total of 36 different reformulation sequences, incorporating from 2 to 3 reformulations. Because our intention is to study users' query reformulation behavior from these reformulation sequences, session sequences with fewer than 2 reformulations are discarded as they provide little information from which to infer users' behavior. As a result, there are nine possible reformulation sequence of 2 reformulations which all start with an initial query (I), denoted as {I, #, #} where # signifies either of the addition (A), deletion (D) or replace (R) reformulation patterns. Similarly, twenty-seven reformulation sequences of 3 reformulations (3*3*3) have been formulated, denoted as {I, #, #, #}. When the program finds a session sequence matching the chosen reformulation sequence, it records the starting log of that session sequence as the reference to the entire session sequence in the reformulation pattern table. The main purpose of this analysis is to discover typical reformulation sequences that users follow, thus providing some insights into users' query reformulation behavior for in-depth analysis.

### 3.4.4 Search strategies based on reformulation sequences

When typical reformulation sequences emerge from our analysis, we calculate the changes in the number of query terms within each sequence. Such changes can determine if users adopt some particular search strategies. We construct our strategy classification based on the higher level categorization of Rieh and Xie (2006). The list of reformulation strategies used in the log analysis pre-study, as well as the detail descriptions of our analysis assumptions, are:

#### *Generalized reformulation*

A user may begin with several search terms and subsequently drop some of the terms to include more results. This generalized reformulation is often manifested by consecutive term deletion changes (Rieh & Xie, 2006). It can also be characterized by replacing the query with fewer terms. Reformulation sequences in which subsequent queries always have fewer or equal terms to the precedent queries belong to this category.

#### *Specified reformulation*

When a user persistently specifies a query by adding more terms or changing to more specific phrases, we classify this approach as specified reformulation. In our analysis, reformulation sequences in which a subsequent query always has more or equal terms to its preceding query belong this category.

### *Dynamic reformulation*

When a user inconsistently switches between generalized and specified reformulation, we characterize this approach as the dynamic reformulation. Such reformulation pattern manifests the unplanned nature of users' search process. Users who adopt this search strategy generally have the most unconsolidated search problems, and require more interaction with the retrieval system. Reformulation sequences in which subsequent queries can have either fewer or more terms than precedent queries exhibit the dynamic search strategy.

### *Constant reformulation*

A constant search occurs when a user modifies terms at the same concept level which shares some common characteristics, for example when substituting with related objects (e.g. from PC to Mac) or synonyms. This strategy is characterized by having a constant number of query terms across the entire reformulation sequence, regardless of the existence of replacement reformulations. The same query specificity suggests a one-to-one relationship between the new terms and the original terms being replaced. We used the term '*constant reformulation*' to reflect this unique characteristic.

In the following sections, we present our methodologies for the user study, starting with the user study data collection procedure.

## 3.5 Web Image Searching User Study Data Collection

### 3.5.1 Participants

A total of 40 participants was recruited from Queensland University of Technology. As the current study did not include participants' backgrounds, the areas of study, and their genders as research variables, participants were not differentiated by their demographical data. Instead, participants were heuristically grouped by their Web image searching experience, their prior knowledge level about the search tasks, their search task specificity, and the tangibility of each task, as these were the important aspects that we consider may have an effect on task completion and search satisfaction.

Hence our study adopted the mixed approaches of *convenience sampling* and *purposeful sampling* in Grounded Theory studies (Morse, 2007). Recruitment for our participants adopted the convenience sampling method, as our participants were approached based on accessibility (i.e. via emails and friends in university) and were not categorized by any aspect of their backgrounds. This ensured we maximized our sample size for the study.

The three search domains (i.e. *news*, *travel*, and *commercial products*) were purposefully chosen to reflect mainstreams in Web image searching (Bernard J Jansen, 2008) and thus were attributed to purposeful sampling method. All participants performed search tasks in the three domains (i.e. 120 search sessions in our user study pool) and no search session was discarded as our focus was the heuristic nature of Web image searching.

### 3.5.2 Search tasks (defining leading search goals)

Participants were asked to prepare one image search task for each of the three domains before commencing their search sessions. The three search domains, *news*, *travel*, and *commercial product* images, reflected most Web image users' search interests on people, event, location, and named objects (Bernard J Jansen, 2008). To ease participants' cognitive load, we did not specify the search topic so participants should not be overwhelmed by task difficulty. The user-initiated search tasks also better reflected real-world Web image searching compared to predefined tasks or search scenarios. We also allowed a maximum of one-hour searching for participants to freely employ different search strategies and to perform their searches in any order. No explicit instruction on task completion was given as long as participants felt satisfied with their results.

Two major benefits were expected from this domain-specific approach. First, by restricting the image problem domains, it was more likely to get more equally distributed respondents from each of the frequent image search categories. For instance, news contents are basically event driven and usually involve famous people, travel topics often include scenery images of famous locations, and product pictures are always about a particular named object. This helped us to collect valuable and representative data regarding each task domain and to control the risk of introducing biased samples. Second, while restricting task domains gave users some structure to construct their image problems, it was not too narrowly defined so different types of search needs could still be shown in the sample data (e.g., either known-item/factual retrieval search or exploratory search; visual content oriented or semantic oriented). Such degree of freedom was important as we aimed to utilize the study findings to expand and refine our user model, rather than to confirm or validate some pre-existing theory or previous findings.

### 3.5.3 Questionnaire

There were two types of questionnaires used in this study, namely the *pre-search* and *post-search* questionnaires. Pre-search questionnaires collected participant's demographic data such as the degree they are currently studying or have completed, the years of experience they had in Web image searching, and their preferred search engine and corresponding familiarity level. Descriptions of each search task and corresponding search concepts were also given in the pre-search questionnaire. For quantitative respondent data, participants were asked to rate their own *personal knowledge*, *task specificity*, and the *tangibility* of each search task using the Likert scale ranging from 1 to 5.

When participants completed their search tasks, they were asked in the post-search questionnaire to reflect on the *completion level* of their search tasks, their search experience (e.g., the overall *satisfaction*, the *difficulty* encountered, and the *usefulness* of the search engine), as well as the *effectiveness* of their search strategy and possible improvements for future searches. The subjective aspects of the entire image searching process can thus be assessed by analyzing these qualitative data (i.e. participant's own comments) collected by the post-search questionnaire.

### *Likert type scale*

To measure the degree of participants' responses and attitudes towards a given question statement, we used the Likert type scale to obtain the quantitative scores. Likert (1932) proposed a five-point scale for the assessment of survey respondents' attitudes which has been widely used in studies involving human responses (Clason & Dormody, 1994; Roberts, Laughlin, & Wedell, 1999). The five-point alternatives discretely classify the continuum from strongly approve to strongly disapprove and ask the respondents to select which of these ordered alternatives they feel appropriate. The number of alternatives may vary depending on the needs of a study. Some research used an even number of scaling, without the option of a neutral response (Clason & Dormody, 1994). The Likert scale is the summation of the scores for each question (i.e. the Likert item). A similar scale used in psychometrics is the Thurstone scale, which asks respondents to rate their favorability or unfavorability of a given attitude statement. Unlike the Likert scale, in which each item clearly represents a positive or negative opinion, the Thurstone scale always allows neutral responses (Roberts, et al., 1999).The Thurstone scale also differs from the Likert scale as it is calculated based on each item (i.e. using mean score to assess the attitude). Although there is some argument of the validity produced by the Likert scale in extreme attitude cases, both scales produce relatively high correlated scores ($.60<=r<=0.95$) in moderate attitude measurements, thus are suitable for our research purposes (Roberts, et al., 1999).

### ***Pre-search questionnaire***

The pre-search questionnaire served the following purposes:

- Collecting participant's search experience background and demographic data for quantitative analysis and participant group comparisons
- Identifying participant's leading search goal, which is the highest level intent of each search session in our user modeling (for further definitions of different types of search goals, refer to *Section 2.5.2 - The information goal perspective*)
- Providing background information on participant's own search tasks
- Helping participant develop a more consolidated plan for search
- Modeling participant's search term selection strategies for initial queries

### *Participant's Web image searching background information*

Prior to the statement/descriptions of participant's search problems, relevant demographic data (e.g., participant's education background, domain knowledge, discipline of study, and prior experience with Web image search systems) were collected first. Sample questions were:

- What degree are you currently studying?
- What faculty are you from?
- How many years have you been using Web search engines to retrieve images?
- What is your preferred image search engine?
- Why do you choose this particular search engine?
- Please rate your familiarity with the image search engine nominated above.

(totally new to me) 1 --- 2 --- 3 --- 4--- 5 (very familiar)

To identify participant's leading search goal, as well as the important concepts for search, the pre-search questionnaire also asked:

- What is your search problem regarding your visual information need in news/travel/commercial product domains; please give explicit descriptions of your problem.
- For each of your search problems, please identify some important/core concepts (e.g., people/object/location/event/action, visual descriptions, or authorship of the image) that you plan to include as search keywords.

For example, looking for an image to match a food article, retrieving a set of Egypt photos to decide an interesting place to visit, or finding the detailed photos of the new iPhone product were regarded as leading search goals. Our assumption was that the leading search goal should typically reflect the initial query, especially when participant adopts a top-down problem solving approach (Y.-H. Liu & Belkin, 2008). This can be verified by checking whether the participant's image problem description matched the concepts in the initial query. Identification of leading search goals helped us understand the participant's core concepts for the search, and the information problem/task behind.

### *Task (problem) complexity*

Task complexity can be constructed in many ways, such as the pre-determinability or the uncertainty of the task (Vakkari, 1999). Dimensions of pre-determinability involve the information requirement, process, and outcome of a task. The elements of task complexity, person's knowledge, and information actions are depicted in *Figure 3.3*. As the knowledge about the task's information requirement, process, and expected outcome increases, the task becomes more structured and less complex, thus easier to accomplish.

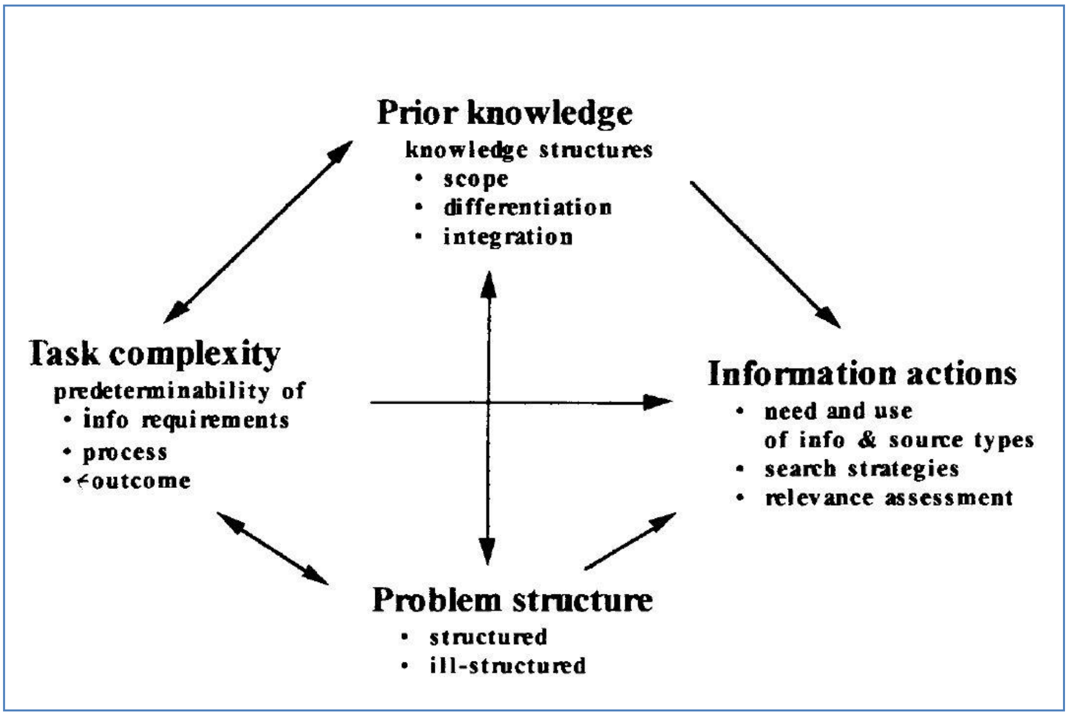



*Figure 3.3* Task complexity and related elements (Vakkari, 1999, p.830)

For example, if participants know what specific information is needed, they can focus on sources that are more likely to contain the information. On the other hand, if participants only vaguely know what the information problem is, or only form a broad search need, it is more likely they will be searching on general information sources first in order to articulate or consolidate a more specific/structured need. A number of researches have demonstrated the connections between search strategies and task structures in the information retrieval field (Hsieh-Yee, 2001; Vakkari, 1999).

Markkula and Sormunen (2000) also concluded that general search tasks easily lead to multiple queries and more browsing, based on the study of image illustration tasks among journalists. However the willingness to browse multiple items is dependent not only on time constrains, but also on the motivation of tasks at hand (Markkula & Sormunen, 2000).

Because task complexity is difficult to measure by simple means, we asked participants to rate three aspects of their searches: their personal knowledge about the problem, the specificity of the search task, and the tangibility of the target images being sought. Some sample questions are:

- Please rate your personal knowledge about each of your search problems:

Problem 1: (little/general knowledge) 1 --- 2 --- 3 --- 4--- 5 (specific knowledge)

- Please rate the specificity of each your search problem:

Problem 1: (very general) 1 --- 2 --- 3 --- 4--- 5 (very specific)

- Does your search problem aim to find a particular/a set of tangible images?

(Please circle the answer)
Problem 1: (YES) / (NO)

Research has found domain knowledge and search experience influence users' search strategies (Youngok Choi, 2010; Debowski, 2001; Frost, et al., 2000; Westman, et al., 2008). Task specificity can also affect search strategies as specific tasks are usually more structured and require more specific knowledge to complete (Vakkari, 1999). The tangibility of target images is measured to be compared with the task type classification for exploratory or retrieval tasks (e.g., the open and closed tasks in Fukumoto (2006)). When users have a clear set of images in mind, the search task becomes finding the matching images, whereas in exploratory tasks, users generally need to 'see as they search' in order to further consolidate their search needs.

### *Concept construction and search term selection for initial query*

Having constructed their image search problems, participants were asked to translate each of the image problems into an initial search query regarding to the concepts they nominated.

- Given the search concepts stated above, please construct the search queries for each of your image search problems

Search Query 1: ______________________________________________

Listing the important concepts and initial query for each problem facilitates participants' selection of relevant search terms, as well as provides a trace for analyzing how participants translate their concepts into queries. For example, if participants want to find images about some famous scenic spots in France, they would probably utilize semantic terms like 'famous scene' or 'popular spot' rather than visual feature descriptors. We investigated participants' thoughts and concerns when translating their conscious but vague image needs into concrete and explicit queries, especially the compromises they make when choosing representative terms for their search concepts.

### ***Post-search questionnaire***

The post-search questionnaire was administrated straight after the search session to review the outcome of the search tasks and the effectiveness of participants' search strategies. Overall, the post-search questionnaires served the following purposes:

- Reviewing the search process from participants' perspective, particularly on the completeness and satisfaction level of the search outcome, as well as the problems experienced during search activity
- Assessing the effectiveness of participants' search strategy and the search engine
- Collecting participants' comments on possible improvements of search functionalities

#### *Open-ended vs. closed questions*

Open-ended questions allow respondents to express their opinions in their own words. They are particularly useful if the purpose is to discover unanticipated answers and to gather data about individuals rather than groups (Fink, 2003). In our study, feedback on the effectiveness and usefulness of search strategies and search engines was difficult to anticipate and pre-categorize; thus questions in regards to these aspects were open-ended questions. Closed questions, on the other hand, require knowledge of possible answers or response categories. Respondents may prefer closed questions because they are easier to answer. The standardized response items are also more reliable and easier to be analyzed statistically (Fink, 2003).

Hence in our questionnaire, we utilized closed questions for most of the measured variables wherever suggestions on the possible response categories could be found in the relevant literatures.

In particular, we asked participants to give ratings on:

- The completeness of their image search tasks
- The satisfaction level of the retrieved results
- The levels of difficulty experienced during searching activities
- The accuracy of query interpretation by the search engine
- The overall perceived time pressure

We also asked participants to indicate the types of problem they encountered during searching. For example:

- Please tick the types of problems you have encountered during your search (can be more than one, whichever you feel suitable for your situation):

  Problem 1/Problem 2/Problem 3

  ☐ Difficulty in interpreting search problem as query terms
  ☐ Difficulty in finding the correct search term
  ☐ Misinterpretation of queries by search engine
  ☐ Too many results
  ☐ Too few results
  ☐ Unable to consolidate my problem
  ☐ Other: (please specify)

  ____________________________________________

Finally, we asked participants to reflect on their thoughts about the effectiveness of the adopted search strategies as well as on any tactics that they thought could help improve their search efficiency. We also asked participants to give their thoughts on the usefulness of the chosen search engine, and to suggest any possible functionalities that they thought would improve the overall search experience.

### 3.5.4 Web image searching session

Once the pre-search questionnaire had been completed, participants commenced their searching. Participants performed their searches individually in a laboratory setting where a computer with internet connection was provided. The computer used in this study has a standard Microsoft Windows XP operating system with different versions of internet browsers installed (i.e., the Internet Explorer, FireFox, and Safari) to suit participants' personal preference. Camtasia Studio software was also installed to record participants' computer screens and voice. There was no face recording in the study as participants' facial expressions were irrelevant to our measurement; also it helped participants stay relaxed if they maintained anonymous during the study.

#### ***Searching activity monitoring***

We used Camtasia Studio software to record the entire searching activity such as inputting queries, browsing and following result links, changing websites or downloading images. In addition to screen recording, Camtasia Studio can record voice input concurrently, which suited our think aloud data collection. Overall, we focused on monitoring participants' query formulation and reformulation activities during the course of their searching, particularly for:

- Identifying participants' current search goal and interactive intentions
- Reasoning the changes in participants' search need or search direction
- Modeling participants' query reformulation and search strategies

Participants' current search goals and interactive intentions were measured on individual query reformulation basis. For example, if participants were interested in images about football matches (i.e. the **leading search goal**) in general, then the images of a particular match between certain teams would become their **current search goal.** However if the retrieved results could not fully satisfy the participants, they may want to narrow down the search based on the players who were in the match. Such a change in the search direction would be an instance of **interactive**

**intention**. It was conceptualized that the current search goal should be reflected in each initial query of any new search topic, and interactive intention should correspond to the reasons for query reformulation actions. These two cognitive factors can be captured by multiple data collection methods to ensure the coverage of all aspects under investigation (i.e. triangulation). Hence two major tools were utilized, namely the *think aloud protocol* and *search query logging*.

## *Think aloud protocol*

During the searching activity, we used think aloud protocol to gather information on participants' opinions regarding the retrieved results. This is a direct way of gathering first-hand information about what goes on in a participant's mind immediately in respond to the search results (for a detailed discussion on think aloud protocol, refer *Section 3.3.1 – Think aloud protocol*).

To ease participants' cognitive load, we did not constrain the difficulty for their search topics so they would not be overwhelmed by the search task at hand. Neither had we require participants to complete all their search tasks. The Camtasia Studio software only ran in the background during search session recording, so the obtrusiveness was kept at minimal.

Some think aloud samples were shown to participants before the search session as the guideline for how to verbalize their thoughts and reasons for action. Participants were encouraged to express their reasons for replacing, adding, or deleting search terms in query reformulation actions.

### Think aloud samples

- *I want to see the inside components of iPhone, since "inside" does not give me any relevant results, maybe I should try "broken apart" or "taken apart".*

- *I have seen enough landscape pictures of Egypt, I want to focus on the people and clothes they are wearing, so I add "people" and "dress" to my query*

In addition to cognitive loads, the search session may be up to one hour long, which further raised the concern about participants' ability to recall important incidents in a retrospective think aloud (Haak, et al., 2003). Because it would be more difficult for participants to recall their thoughts after the whole search session, think aloud data collected alongside the searching activity was more accurate than retrospective think aloud. After each querying round (i.e., the completion of submitting a query and retrieving corresponding results), participants were required to speak up their thoughts and feelings towards the current result, and to provide some brief comments to assess the effectiveness of their query reformulation strategies. For instance, participants were asked to reflect their thoughts on:

- The relevance and usefulness of current retrieved results
- What was missing/ what was expected to be more in the results
- Whether they felt too few or too many search conditions/terms used
- How they were going to modify the query to incorporate their concerns towards current results

Hence the think aloud protocol provided us with valuable data for analyzing the relationship between participants' intention and query reformulation strategies, which in turn contributed to the construction of our contextual Web image search model.

### *Search query logging*

The search query logging utilized in this study was similar to general Web search engine logs. However, since this is a client-side logging which was manually done by the researcher with the help of the screen recording in Camtasia Studio, actions that were not captured by the search engine (e.g., browsing on other websites by following the result links, searching multiple search engines or other resources concurrently) were also recorded, thus providing a more holistic view on participants' behavior. *Table 3.3* shows the sample search log.

| Search Engine | Query | Query_Change | Content | Change Type | Results Viewed | Page Viewed | Duration |
|---|---|---|---|---|---|---|---|
| Google Image | air canada plane recent crash | | All Images | I | 1 | 4 | 0:02:35 |
| Google Web | wikinews | | All Web | I | 1 | 1 | 0:00:27 |
| Wikinews | air canada | | All News | I | 0 | 1 | 0:00:20 |
| Wikinews | air canada crash | crash | All News | A | 0 | 2 | 0:00:58 |
| Google Web | air canada crash | | All Web | C | 0 | 1 | 0:01:36 |
| Google Image | air canada plane recent crash | plane recent | All Images | AC | 0 | 1 | 0:00:57 |
| Google Web | air canada crash | plane recent | All Web | DC | 0 | 1 | 0:00:10 |
| Google Web | air canada crash recent | recent | All Web | A | 1 | 1 | 0:02:25 |
| Google Web | air france crash | canada recent, france | All Web | R | 0 | 1 | 0:00:17 |
| Google Image | air france plane recent crash | plane recent | All Images | A | 0 | 4 | 0:00:53 |
| Google Image | air france plane recent crash wreckage | wreckage | All Images | A | 1 | 2 | 0:00:25 |
| Google Web | air france crash | plane recent wreckage | All Web | DC | 1 | 1 | 0:00:32 |
| Google Image | air france plane recent crash wreckage | | All Images | C | 0 | 2 | 0:00:26 |
| Bing Image | air france crash | plane recent crash wreckage | All News | DC | 3 | 1 | 0:03:06 |
| Bing Image | air france recent crash inside | recent inside | All Images | A | 0 | 1 | 0:01:21 |
| Bing Image | air france recent after crash inside | after | All Images | A | 0 | 1 | 0:00:18 |
| Google Image | air france recent after crash inside | | All Images | C | 1 | 3 | 0:01:31 |

*Table 3.3* The sample user study search log

### *Time constrains*

Time is an important aspect in information seeking studies because it affects subject's expectations, predictions, choices of actions in the process, and the final outcomes (Kuhlthau, 2004). Time also acts as an important external factor on subject's *perceived behavior control*, or *behavioral self-efficacy* (Ajzen, 1991). The perceived behavioral control will in turn act as an important determinant of users' behavior in the use of information systems (Liaw, 2002). Generally people alter their search strategies to suit the amount of time allocated for their search problems. In this study, we intended to control this factor while allowing enough time for participants to freely choose different search paths. The maximum search time for all three visual search problems was one hour in total, excluding the time needed to answer the pre-search and post-search questionnaires. Participants could allocate any amount of time to each search problem and perform the searches in any order, as long as all search activities were performed within this one-hour period.

# 3.6 Web Image Searching User Study Data Analysis

In this study, participant behaviors were analyzed both qualitatively and quantitatively. Qualitative data analysis is a primary approach in many user studies focusing on understanding users' behavior beyond the description and phenomenon level (Frost, et al., 2000; Westman & Oittinen, 2006). Because the reasons behind participants' behaviors were difficult to convey in quantitative data, qualitative data analysis was adopted first in order to discover the common problems or process that participants underwent during their Web image searching.

We first adopted the Grounded Theory approach to qualitatively categorize participants' searching behavior into broad search patterns, and the significant behaviors within each pattern. This was done by carefully analyzing the problem statements in participants' think aloud transcripts and the searching activities in corresponding search logs. Common search patterns emerged when a few participants encountered similar problem situation and adopted similar actions to solve the problem. After the identification of common search patterns, each search pattern was then quantitatively compared based on the observed behaviors. Behaviors that showed significant difference from a particular search pattern characterized that pattern. The statistical analysis thus ensured the reliability of the identified search patterns and the corresponding significant behaviors.

## 3.6.1 Think aloud data

As participants constantly expressed their thoughts in think aloud data, the foremost step in the qualitative analysis was transcribing the think aloud data into search transcripts for each participant. This search transcript recorded each participant's specific utterance for the transition of each query reformulation, as well as the reasons behind (example search transcript is shown next).

## *Example of transcript – Participant 10, Product*

Task description:
Participant wants to find images of the latest Google phone because he have heard it from friends but has not been able to see how it looks like. The images should focus on the phone itself, some disassembled parts would be interesting.

Search log summary:
(Google Image) Google phone -> Google phone parts -> Google phone parts disassemble -> “Google phone” parts disassemble -> “Google phone” parts disassemble separate -> “Google phone” disassemble separate -> (Google Web) “Google phone” disassemble separate -> ” Google phone” disassembly separate -> how to “Google phone” disassemble -> how to G1 “Google phone” disassemble

Searching activity summary and think aloud:
The participant was looking for the disassembled parts of the Google phone. He expected the images of this particular need would not appear in the top results, so he browsed up to page five and decided to reformulate the query. New keywords such as “parts”, “disassemble” and “Google phone” were subsequently used to reformulate the query, but still no highly relevant images were shown.

*But Google phone itself is not what I’m looking for, I’m looking for some images about its parts [29:28]*
*Such images would definitely not be the first couple of pages of search engines because those searches or those images are usually not popular…especially we give such a general query [30:02]*
*We found something for the parts, but it’s not Google phone [32:16]*

Participant then added “separate” to his query because he thought the word “disassemble” may be too formal for general Web users. He also dropped “parts” as it was unnecessary to have it in the query. Participant later on switched to Google Web search because no images found that were likely to be relevant.

*Sometimes people may not use disassemble because this word is too formal [35:17]*
*If I can’t find what I want from Image search, I may just go to Web search to see if I can get some links there which leads to some images, sometimes that happens [38:08]…because I believe image search engine has much limited search range comparing to Web search engine [38:20]*

The participant believed that the image search is more limited by its indexed data and searching on Web content should give him better chance in finding what he wanted. After reviewing the results from either “disassemble” or “disassembly”, the participant added “how to” to his query and found some discussion threads in some mobile forums. From the forum he found the a cached page that show a tutorial on how to disassemble the phone step by step, which was exactly what the participant wanted to find for this task. He also discovered the particular model “G1” from the Web search and subsequently used the term to find more relevant discussions.

*Let’s change the query as “how to disassemble the Google phone” [40:54]*
*We got the forum for Google phone, I think we’re closer and closer to the result [41:09]*
*Watch how to disassemble G1…it’s a tutorial! I love it [41:54]*
*This is a YouTube video of how to disassemble the phone…oh this guy doesn’t disassemble that, just a tutorial showing how to use that…too bad [44:39]*
*So let’s put the particular model in (query) [45:44]*
*(Went back to previous Web search result and followed a link which was previously neglected) trace it up…haha…I think that’s the one [46:17]…Finally, we got it…so let’s confirm this is the G1 [46:22]*
*The lesson I learnt from this is that sometimes Google image didn’t provide what I want…the exact result I’m looking for…I may need to go to other search engine to trace or browse the text information…what I found is from some forums…gave me the link to another site and finally found what I want, so only relying on image search engine is not good enough for me [47:30]*

The researcher then reviewed the search transcripts to find the common search patterns among participants, particularly the relationship between search intention and query reformulation strategies. For example, when analyzing the circumstances that participants needed to use textual information (i.e. Web search results) to complement their image searches, searches that utilized both Web and image collections (i.e. searches with either Switch to Web or Switch to Image behaviors in the log) were reviewed for the identification of common search patterns. Once a common pattern emerged from several searches, this particular pattern was summarized in a brief paragraph that states its context and typical behaviors. As more searches were analyzed, similar searches reinforced the search pattern and amendments were made when necessary. For example, in cases where participants utilized textual Web searches to expand their knowledge about a search topic, their searching behaviors were further differentiated based on their interactive intents as exploratory intents usually lead to intensive browsing for new ideas or related information, and retrieval intent usually results in brief scanning for proper nouns or useful keywords to reformulate queries.

The think aloud transcripts, as well as the descriptions about participant's search tasks collected in pre-search questionnaire, helped us determine the nature of participants' search tasks (i.e. exploratory or retrieval tasks), and more importantly, the search contexts for query reformulations. Participants' search strategies were analyzed at query formulation/reformulation level. Although the term 'strategy' has sometimes been used interchangeably with 'tactic', we follow the Bates' (1979) definition:

*Search tactic*: a move made to further a search
*Search strategy*: a plan for the whole search

Hence it is clear that tactic refers to the single move in the searching activity, while strategy is the overall approach of a search. In the context of our study, *query reformulation tactic* refers to the type of single change to a query, such as adding/deleting/replacing search terms. *Query reformulation strategy* indicates the pattern of sequential query reformulations according to participants' current search goal. Participants' search sessions were primarily classified into five main strategies:

*Bottom-up*, *Top-down*, *Dynamic* (*Trial-and-error), Divide-and-conquer* and *Parallel* (for detailed definitions of the strategies, see *Section 2.8.3 - Web query reformulation strategies*).

As depicted in *Section 2.6.2 - Figure 2.4 The activity theory based query reformulation model*, while query reformulation and result evaluation activities can be recorded by software, only think aloud data can provide access to participants' various intents. For example, when one participant used 'Nokia N95', 'iPhone GPS', 'iPhone Map' as a series of search queries, it was reasonable to infer that the participant might be interested in smart phones that have built-in navigation functions. From each individual query, however, no such inference could be derived. In addition, only think aloud data can provide the clue to how and why the search query has evolved from 'Nokia' to 'Map', and how participant came up with these terms. In order to fully exploit the richness of such qualitative data, we adopted the Grounded Theory approach to discover participants' query formulation/reformulation strategies.

### 3.6.2 Qualitative data analysis

Grounded Theory approach was the primary method for our qualitative data analysis. After participants' think aloud data had been transcribed, the researcher coded the behaviors and the related search contexts in these transcripts. General coding procedures involve three stages: *open coding*, *axial coding*, and *selective coding* (Ingwersen & Jarvelin, 2005; Sarker, Lau, & Sahay, 2001). Open coding is to categorize and classify properties that identify significant concept labels. This typically involves naming each user's own utterance towards an incident and the actions associated with it (Charmaz, 2006). Axial coding focuses on constructing the individual categories and their attributes for identifying connections between categories. As open coding fractures the data into pieces, axial coding brings the data back together in a coherent manner by checking the *conditions*, the *actions and interactions*, and the *consequences* of the coded category. The purpose of axial coding is to link categories with subcategories, while asking how they relate to each other (Charmaz, 2006). The last stage (selective coding) involves consolidating the core category and its relations to other categories. Finally, the new theory will emerge around the core theory (Backman & Kyng , 1999). Because Grounded Theory emphasizes using a heuristic approach to construct new theories rather than to verify existing theories, it is suitable for our purpose of discovering underlying rules for adopting a particular strategy, as well as new strategies that may emerge from the think aloud data (Backman & Kyng , 1999; Sarker, et al., 2001).

### *Searching behavior coding*

To start coding, we began with tangible behaviors/actions that were apparent in the raw data, thus avoiding the introduction of subjective-prone codes. These behavioral codes also facilitated our analysis for participants' common search patterns in the next stage. Since our focus is the query reformulation process, the coding theme includes two aspects: *result reviewing* and *query reformulation* actions.

#### *Result reviewing*

**Serendipity Browsing (SB):** participants appeared to skim through the results, possibly looking for particular keywords or new terms. The criteria for this activity is 30 seconds per page for an image search, and 1 minute per page for a Web search

**Intensive Browsing (IB):** participants appeared to carefully browse through results, possibly indicated by sequential scrutiny or prolonged browsing time (i.e. browsing duration > browsing duration in SB)

**Term Discovery (TD):** participants discovered new terms from reviewing the current result and used the terms to modify queries

**Idea Discover (ID):** participants discovered new ideas and subsequently generated new search terms for query reformulation

#### *Query reformulation*

**Replace with Related term (RR):** participants replaced current query with some terms that are related to terms being replaced; the new terms also related to participants' original concepts

**Replace with Synonym term (RS):** participants replaced current query with some synonyms of the replaced terms

**Replace with New term (RN):** participants replaced current query with some new terms which are not related to their original concepts, in other words, such term replacement may indicate a topic shift to a varying degree

**Replace with term in Original construct (RO):** participants replaced current query terms with other terms stated in their search concept list in the pre-search questionnaire

**Delete Newly added term (DN):** participants deleted the term that was just added in the previous query, manifesting that the term was used as a trial to see the difference in results

**Delete Original concept term (DO):** participants deleted the term that was in the original concepts or previous queries

**Add New term (AN):** participants added a term that was not listed in the original concepts and was not related to current search topic either

**Add Related term (AR):** participant added the term that was not listed in the original concepts but still related to the current search topic

**Add Original concept term (AO):** participants added the term that was stated in the original concept list in the pre-search questionnaire

**Switch to Image search (SI):** participants switched to image search mode

**Switch to Web search (SW):** participants switched to Web search mode

**Switch Search engine (SS):** participants switched to another search engine

**Switch search Content (SC):** participants selected a particular content (e.g., news, blog) in the advance search function

**New query with Related topic (NR):** participants formulated a new query with no textual relationship with the previous query but still semantically related

**New query with New topic (NN):** participant formulated a new query that had no textual or semantic relationship with the previous query

**Domain-specific Search (DS):** participants utilized some domain specific websites to search (e.g., BBC.com for news, Flickr.com for photos)

**Localized Search (LS):** participants changed to a localized content for searching (e.g., switch to *Google.com.tw* for Taiwan's news)

Once participants' querying activities were translated into search log records, we manually coded each query reformulation with this categorization. The entire search activity is presented as a coded search sequence below.

| Participant | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Q1 | SB | RS | Q2 | IB | RR | Q3 | IB | DN | Q4 | IB | RO | Q5 | IB | RR | Q6 | SB | AO |
| 2 | Q1 | IB | AO | Q2 | IB | Q3 | IB | RO | Q4 | IB | AN | Q5 | IB | RO | Q6 | IB | RO | Q7 |
| 3 | Q1 | IB | AR | Q2 | IB | DN | Q3 | IB | | | | | | | | | | |
| 4 | Q1 | SB | DS | IB | DS | IB | SS | SI | SB | | | | | | | | | |
| 5 | Q1 | IB | RS | Q2 | IB | SW | DS | IB | LS | SB | RR | Q3 | SB | SI | SB | | | |
| 6 | LS | Q1 | IB | RR | Q2 | SB | SI | SB | | | | | | | | | | |
| 7 | Q1 | SB | SI | IB | AO | Q2 | IB | RS | Q3 | SB | SS | DO | Q4 | IB | AO | Q5 | IB | |
| 8 | Q1 | SB | SI | IB | SW | IB | DO | Q2 | IB | SI | IB | | | | | | | |
| 9 | Q1 | IB | SI | SB | AO | Q2 | SB | AO | Q3 | SB | SS | RS | Q4 | SB | SS | SW | RS | Q5 |
| 10 | Q1 | IB | AO | Q2 | IB | SW | DO | Q3 | SB | TD | RR | Q4 | IB | TD | SI | AR | Q5 | IB |
| 11 | LS | Q1 | IB | RR | Q2 | IB | TD | RR | Q3 | IB | RO | Q4 | IB | | | | | |
| 12 | Q1 | IB | SI | IB | RO | Q2 | IB | | | | | | | | | | | |
| 13 | Q1 | IB | RO | Q2 | IB | ID | RR | Q3 | IB | AO | Q4 | IB | RO | Q5 | IB | AO | Q6 | IB |
| 14 | Q1 | SB | AO | Q2 | IB | RO | Q3 | IB | SI | IB | DS | RO | Q4 | SB | DO | Q5 | IB | SI |
| 15 | DS | IB | TD | SS | Q1 | SB | SI | SB | | | | | | | | | | |
| 16 | Q1 | IB | SW | RN | Q2 | SB | DS | RO | Q3 | SB | AO | Q4 | SB | SS | IB | SI | AO | Q5 |
| 17 | Q1 | IB | SS | RO | Q2 | IB | DN | Q3 | SB | SS | IB | SS | TD | RR | Q4 | IB | | |
| 18 | Q1 | IB | SI | IB | | | | | | | | | | | | | | |
| 19 | Q1 | IB | TD | RS | Q2 | IB | LS | AO | Q3 | IB | SS | IB | | | | | | |
| 20 | Q1 | IB | SS | IB | | | | | | | | | | | | | | |

*Table 3.4* Coded news search sequences

## *Interactive intent coding*

The second type of coding related to participants' interactive intents during searching. Although participants would have a rather consolidated leading search goal at hand before starting the search, their interactive intents were constantly changing depending on the information encountered, or the sub-task underneath each search task. Hence interactive intent is very dynamic and situation-dependent, which could not be captured in the pre-search questionnaire and only appears in the think aloud transcript. The categorization of interactive intent involves three major states during searching, namely *knowledge state*, *search state*, and *review state*:

### *Knowledge state*

**Knowledge Expansion for new Ideas (KEI):** participants indicated that they needed to perform more searches to get more information or ideas about the search task and may thus refine the current search goal

**Knowledge Expansion for new Keywords (KEK):** participants indicated that they needed to perform more searches to get more information or useful keywords to reformulate the search query, but usually did not change the current search goal

### *Search state*

**Query Reformulation for Exploration (QRE):** participants constantly used some terms as the core concept and reformulated queries with different terms related to the core concept to explore a topic

**Query Reformulation for Retrieval (QRR):** participants continuously reformulated queries with synonyms or terms that have similar meanings to retrieve a particular target

### *Review state*

**Result Expansion due to inAccurate results (REA):** participants developed another search plan or direction due to the low accuracy of the current results

**Results expansion due to inSufficient results (RES):** participants developed another search plan or direction due to the limited results

The interactive intent categorization manifested the axial coding phase in Grounded

Theory because the series of coded behaviors can be associated with particular interactive intent codes. These interactive intents were identified based on the incidents that participants explicitly expressed such intents, or retrospectively reflected after the search. For example, when participants expressed the need to explore for new ideas (the KEI intent as the *pre-condition* in axial coding), they may then switch from image search to Web search (SW) and reformulated queries using some related terms (RR) as the *set of subsequent actions*, and therefore discovered some new ideas (ID), which in turn reformulated the query with some newly acquired terms (RN) as the *consequences of this coded intent*. The association between coded behaviors and interactive intents was discovered during quantitative analysis.

### 3.6.3 Query term categorization

In order to determine whether participants utilized different types of terms to search different domains, we constructed a term categorization for each query term in the search log. The categorization was based on various user studies in image searching (Chen, 2001; Youngok Choi & Rasmussen, 2003; Jorgensen, 1998; Markkula & Sormunen, 2000), with some extensions to reflect the diversity of Web image searches (e.g., the format of the target images) and the current study domains.

**People**: entity refers to a particular person, group of people, occupation, or position (e.g., president, government member, pilot)

**Location**: entity refers to a country, a geographic place, or a named building (e.g., USA, beach, resort, place, the great barrier reef, Eiffel tower)

**Object**: entity is a tangible thing, a product, or a generic term of a certain type of things (e.g., car, iPod, landmark, building, hotel)

**Organization**: entity refers to a company/brand name, an institute, or a named group of people (e.g., Apple, Toyota, University of Sydney, government)

**Event**: a particular circumstance that typically involves a certain group of people doing something at a particular time (e.g., Milan fashion, Queen's Birthday, bushfire, nuclear test, bombing)

**Time**: temporal constrains for the information being sought (e.g., now, current, 2009)

**Subject/attribute**: a generic term for some kind of knowledge or area of interest, a property that specifies an aspect of the entity term, or the proper noun that cannot be classified otherwise (e.g., soil science, climate change, ecotourism, design, overview, attraction, landscape, transport, after service, lomography)

**Format**: the terms that define the type of image or the source of the information (e.g., diagram, graph, map, current affair, news)

Once we tagged every query term in participants' search logs, we calculated the frequency of each term category within each search domain. By summing up the total frequency of each term category, we can determine the percentage of different term types within the search domain, and thus compare the composition of term categories across the news, travel, and product domains.

### 3.6.4 Quantitative data analysis

Statistical analysis was conducted on the quantitative data collected from both pre-search and post-search questionnaires. In particular, we gave attention to the relationship between various contextual factors and the search strategies, as well as the relationship between the search strategies and the search outcomes. For example, it may be that when participants possess higher domain knowledge (measured by the number of concept terms utilized for search, and the specificity of the search task), the more likely a bottom-up search strategy will be adopted. It was conceptualized that knowledge factors may influence participants' choice of search strategies, and this strategy may in term influence the outcome of search task (measured by participant's self-ratings on the completeness and satisfactory toward the search results). The significance of these relationships was confirmed by the analysis of variance and correlation tests (e.g., non-parametric t-test).

In addition, we also investigated the association between different task types (i.e. exploratory and retrieval) and domains (i.e. news/travel/product domains) with participants' query reformulation processes. The findings from both qualitative and quantitative analyses were utilized to refine the contextual visual search model with more detail and to develop the contextual query recommendation tool (detailed in *Section 5.7* and *Section 5.8* respectively).

The global user model (see *Figure 2.3* in *Section 2.6.1*) depicts the interaction between various knowledge resources and users' different information retrieval stages. However, this is just the highest level representation of the analysis; a more detailed model is constructed as the relationships are being discovered. For detail definitions of each type of knowledge, please refer to *Section 2.6.1 - Knowledge resources*. The quantitative factors measured by pre-questionnaire were twofold, including *Knowledge factors* and *Task factors*:

### *Knowledge factors*

- *Domain knowledge*, which comprises participant's own knowledge rating of each task (KNO), the number of key concepts (up to five per task) nominated for search (CON), and the number of concepts used to formulate initial queries (INI)
- *Device knowledge*, which is the familiarity (FAM) of a particular Web search engine
- *Search experience*, which is assessed by the years of Web image searching experience (EXP)

### *Task factors*

- *Task domains*, which is the subject areas participants were told to search images upon (i.e. News, Travel, and Product)

- *Task specificity* (SPE), which is participants' self-ratings of how specific the search task is on a 1 to 5 scale
- *Task tangibility* (TAN), which is whether participants can imagine or has seen how the target images should look
- *Task type* (Exploratory / Retrieval), which is a post-search categorization based on participants' task description and explanation of their actual searching behaviors

The *IR knowledge*, which is another important type of knowledge in information retrieval process (see *Section 2.6.1 - Knowledge resources*), is difficult to measure directly in the current study, as each participant performed different search topics and may require different levels of IR knowledge. Instead, we used *search experience* and *education level* to assess participants' proficiency in general information searching skills and as the potential variables that have effects on the search outcomes.

### *Outcome factors*

Quantitative information regarding the search outcomes were collected in the post-search questionnaire:

- *Levels of task completion* (COM)
- *Participant's subjective satisfaction* (SAT)
- *Overall task difficulties* (DIF)

We manually coded participants' searching behavior and query reformulations into a search sequence representing the entire search session. *Table 3.5* shows the sample behavioral coding from the original search logs. After all search logs were coded as in *Table 3.5*, the number of times for each coded behavior was then summed up to derive a behavioral score (as shown in *Table 3.6*), indicating how many times a participant had exhibited such behavior within the session.

All ratings collected in the questionnaires had a maximum score of 5, except for task tangibility, which was measured in a Boolean fashion representing whether the participant had a tangible set of images in mind to start a search (see examples of coded search logs and summary of behavioral scores below). The means of behavioral scores and participants' image search ratings (i.e. SPE, KNO, CON, INI, FAM, COM, SAT, and DIF) were statistically compared to find significant differences. A similar analysis approach can be found in Choi's (2010) recent study in college students' Web image searching behavior.

| Search Engine | Query | Page Viewed | Duration | Query No. | Coded Behavior | | | | |
|---|---|---|---|---|---|---|---|---|---|
| *Participant 2, News* | | | | | | | | | |
| Google Image | storm Brisbane 2008 | 1 | 0:01:14 | Q1 | IB | AO | | | |
| Google Image | storm Brisbane November 2008 | 1 | 0:01:01 | Q2 | IB | | | | |
| Google Image | "storm" AND Brisbane AND "November 2008" | 1 | 0:00:37 | Q3 | IB | RO | | | |
| Google Image | "storm" AND Brisbane AND flood | 2 | 0:01:14 | Q4 | IB | AN | | | |
| Google Image | storm hits Brisbane | 2 | 0:04:20 | Q5 | IB | RO | | | |
| Google Image | storm Brisbane 2008 | 4 | 0:02:34 | Q6 | IB | RO | | | |
| Google Image | flood Brisbane 2008 | 2 | 0:00:43 | Q7 | SB | SW | SC | RO | |
| Google News | storm Brisbane 2008 | 1 | 0:05:49 | Q8 | IB | TD | SI | RR | |
| Google Image | flooding Brisbane 2008 | 1 | 0:00:29 | Q9 | SB | SW | | | |
| Google Web | flooding Brisbane 2008 | 3 | 0:07:56 | Q10 | IB | LS | RO | | |
| ourbrisbane.com | storm | 5 | 0:02:01 | Q11 | SB | | | | |
| *Participant 10, News* | | | | | | | | | |
| Google Image | french airline crash | 1 | 0:01:03 | Q1 | IB | AO | | | |
| Google Image | french airline crash brazil | 1 | 0:01:15 | Q2 | IB | SW | DO | | |
| Google Web | french airline crash | 1 | 0:00:16 | Q3 | SB | TD | RR | | |
| Google Web | air france crash | 1 | 0:01:24 | Q4 | IB | TD | SI | AR | |
| Google Image | air france crash Flight 358 | 1 | 0:00:49 | Q5 | IB | SW | RO | | |
| Google Web | air france crash brazil | 1 | 0:00:34 | Q6 | SB | SI | TD | RR | |
| Google Image | air france crash Flight 447 | 1 | 0:06:25 | Q7 | IB | SW | RR | | |
| Google Web | air france crash brazil black box | 1 | 0:01:46 | Q8 | IB | TD | SI | RR | |
| Google Image | french airline crash brazil wreckage | 1 | 0:00:14 | Q9 | SB | TD | RR | | |
| Google Image | french airline jet brazil wreckage | 1 | 0:00:17 | Q10 | SB | AO | | | |
| Google Image | french airline jet brazil wreckage 447 | 1 | 0:01:15 | Q11 | IB | SS | | | |
| Yahoo Image | french airline jet brazil wreckage 447 | 1 | 0:00:32 | | IB | TD | SS | AN | |
| Google Image | french airline jet brazil wreckage 447 crash storm | 1 | 0:00:09 | Q12 | SB | DN | | | |
| Google Image | french airline jet brazil wreckage 447 storm | 1 | 0:00:26 | Q13 | SB | DN | | | |
| Google Image | french airline jet brazil wreckage 447 | 1 | 0:01:09 | Q14 | IB | | | | |
| *Participant 14, News* | | | | | | | | | |
| Google Web | queen's birthday 2009 australia | 1 | 0:00:22 | Q1 | SB | AO | | | |
| Google Web | queen's birthday 2009 australia picture | 1 | 0:01:58 | Q2 | IB | RO | | | |
| Google Web | queen's birthday 2009 UK picture | 1 | 0:01:09 | Q3 | IB | SI | | | |
| Google Image | queen's birthday 2009 UK picture | 1 | 0:02:28 | | IB | DS | RO | | |
| BBC UK | queen's birthday 2009 australia picture | 1 | 0:00:16 | Q4 | SB | DO | | | |
| BBC UK | queen's birthday 2009 | 1 | 0:01:33 | Q5 | IB | SI | SS | TD | AR |
| Google Image | queen's birthday 2009 official celebration | 1 | 0:04:14 | Q6 | IB | SW | DS | | |
| BBC UK | queen's birthday 2009 official celebration | 1 | 0:02:29 | | IB | LS | DN | | |
| ABC News | queen's birthday 2009 | 1 | 0:01:46 | Q7 | IB | | | | |
| *Participant 15, News* | | | | | | | | | |
| DW-World.de | (browsed for world news section) | | 0:01:43 | DS | IB | TD | SS | | |
| Google Web | Air France Crash in Brazil | 1 | 0:00:39 | Q1 | SB | SI | | | |
| Google Image | Air France Crash in Brazil | 1 | 0:00:17 | | SB | | | | |
| *Participant 16, News* | | | | | | | | | |
| Google Image | air canada plane recent crash | 4 | 0:02:35 | Q1 | IB | SW | RN | | |
| Google Web | wikinews | 1 | 0:00:27 | Q2 | SB | DS | RO | | |
| Wikinews | air canada | 1 | 0:00:20 | Q3 | SB | AO | | | |
| Wikinews | air canada crash | 2 | 0:00:58 | Q4 | SB | SS | | | |
| Google Web | air canada crash | 1 | 0:01:36 | | IB | SI | AO | | |
| Google Image | air canada plane recent crash | 1 | 0:00:57 | Q5 | IB | SW | DO | | |
| Google Web | air canada crash | 1 | 0:00:10 | Q6 | SB | AO | | | |
| Google Web | air canada crash recent | 1 | 0:02:25 | Q7 | IB | TD | RR | | |
| Google Web | air france crash | 1 | 0:00:17 | Q8 | SB | SI | AO | | |
| Google Image | air france plane recent crash | 4 | 0:00:53 | Q9 | SB | AR | | | |
| Google Image | air france plane recent crash wreckage | 2 | 0:00:25 | Q10 | SB | SS | DN | | |
| Google Web | air france crash | 1 | 0:00:32 | (merged by multi-tasking) | | | | | |
| Google Image | air france plane recent crash wreckage | 2 | 0:00:26 | (merged by multi-tasking) | | | | | |
| Bing Image | air france crash | 1 | 0:03:06 | Q11 | IB | | | | |
| *Participant 28, News* | | | | | | | | | |
| Yahoo Finance | (browsed for exchange rate graphs) | | 0:02:53 | DS | IB | | | | |
| HSBC HK | (browsed for exchange rate graphs) | | 0:02:16 | DS | IB | SS | | | |
| Google Web AU | exchange rate diagram | 1 | 0:01:36 | Q1 | IB | SS | | | |
| Yahoo Finance | (browsed for exchange rate graphs) | | 0:02:31 | DS | IB | SI | SS | | |
| Google Image | exchange rate diagram | 1 | 0:00:51 | | IB | | | | |
| *Participant 36, News* | | | | | | | | | |
| Google Image | maclaren recall parts | 1 | 0:00:42 | Q1 | IB | SW | | | |
| Google Web | maclaren recall parts | 1 | 0:01:23 | | IB | TD | RR | | |
| Google Web | maclaren recall stroller's hinge mechanism | 1 | 0:00:36 | Q2 | SB | SI | | | |
| Google Image | maclaren recall stroller's hinge mechanism | 3 | 0:01:24 | | SB | TD | SW | RR | |
| Google Web | maclaren recall stroller hinge cover | 1 | 0:01:38 | Q3 | IB | RO | | | |
| Google Web | news maclaren stroller recall | 2 | 0:04:18 | Q4 | IB | SI | RR | | |
| Google Image | maclaren stroller hinge dangerous | 1 | 0:00:39 | Q5 | IB | SW | | | |
| Google Web | maclaren stroller hinge dangerous | 3 | 0:01:32 | | SB | | | | |
| *Participant 13, Product* | | | | | | | | | |
| Google Web | jeans new york outlet | 1 | 0:02:43 | Q1 | IB | LS | ID | RN | |
| Google Web TW | jeans new york 養褲 | 1 | 0:03:50 | Q2 | IB | TD | RR | | |
| Google Web TW | jeans new york Hysteric Glamour | 1 | 0:02:31 | Q3 | IB | AR | | | |
| Google Web TW | jeans new york Hysteric Glamour 原褲 | 1 | 0:00:44 | Q4 | SB | RO | | | |
| Google Web TW | jeans new york Hysteric Glamour 磅數 | 1 | 0:00:30 | Q5 | SB | AR | | | |
| Google Web TW | jeans new york Hysteric Glamour 高磅數 | 1 | 0:01:15 | Q6 | IB | DO | | | |
| Google Web TW | jeans new york 高磅數 | 1 | 0:01:58 | Q7 | IB | AR | | | |
| Google Web TW | jeans new york 高磅數 推薦 | 1 | 0:00:46 | Q8 | SB | RS | | | |
| Google Web TW | 牛仔褲 高磅數 紐約 | 1 | 0:02:29 | Q9 | IB | AN | | | |
| Google Web TW | 牛仔褲 高磅數 紐約 經典 | 1 | 0:01:08 | Q10 | IB | TD | RN | | |
| Google Web TW | Thee Hysteric XXX new york | 1 | 0:04:54 | Q11 | IB | | | | |
| crownjewel.co.jp | (browsed for product images) | 1 | 0:01:44 | | IB | | | | |
| selectism.com | (browsed for product images) | 1 | 0:02:42 | | IB | | | | |

*Table 3.5* Search pattern example logs with behavioral codings (color coded transactions indicate multi-tasking searching)

| Participant | EXP | FAM | KNO | SPE | TAN | CON | INI | TQS | Reviewing | | | | Content Switch | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | IB | SB | TD | ID | SW | SI | SS | SC |
| **1** | 4 | 4 | 2 | 3 | 0 | 4 | 4 | 13 | 11 | 2 | 1 | 0 | 1 | 1 | 0 | 0 |
| **2** | 10 | 3 | 5 | 5 | 1 | 4 | 3 | 11 | 8 | 3 | 1 | 0 | 2 | 1 | 0 | 1 |
| **3** | 3 | 3 | 2 | 5 | 1 | 3 | 3 | 3 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **4** | 10 | 5 | 4 | 5 | 1 | 5* | 5 | 1 | 2 | 2 | 0 | 0 | 0 | 1 | 1 | 0 |
| **5** | 10 | 4 | 2 | 2 | 1 | 2 | 3 | 3 | 3 | 3 | 0 | 0 | 1 | 1 | 0 | 0 |
| **6** | 10 | 4 | 4 | 4 | 1 | 5 | 3 | 2 | 1 | 2 | 0 | 0 | 0 | 1 | 0 | 0 |
| **7** | 14 | 4 | 2 | 5 | 1 | 3 | 3 | 5 | 4 | 2 | 0 | 0 | 0 | 1 | 1 | 0 |
| **8** | 0 | 1 | 1 | 5 | 0 | 1 | 3 | 2 | 4 | 1 | 0 | 0 | 1 | 2 | 0 | 0 |
| **9** | 10 | 4 | 2 | 3 | 1 | 3 | 2 | 8 | 4 | 6 | 0 | 0 | 1 | 1 | 3 | 0 |
| **10** | 5 | 5 | 3 | 5 | 1 | 4 | 3 | 14 | 9 | 6 | 6 | 0 | 2 | 3 | 2 | 0 |
| **11** | 7 | 5 | 5 | 3 | 1 | 4 | 3 | 4 | 4 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| **12** | 8 | 4 | 4 | 3 | 1 | 2 | 2 | 2 | 3 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |

*Table 3.6* Example summary of news search ratings and behavioral scores

# 3.7 Quality of the Study

## 3.7.1 Validity and reliability

The validity and reliability of this study were ensured by the following approaches:

- Multiple data collection method (i.e. triangulation)
- Tangible behavior based analyses
- Think aloud based interactive intent coding
- Statistical tests on qualitative findings

In this study, multiple data collection methods (i.e. the questionnaires, searching activity recording, think aloud protocol, and post-search interviews) were adopted to ensure the richness and cohesiveness of the data gathered. Participants' searching activities were monitored and recorded by computer software, which was used to generate the think aloud transcript and Web searching log. These two types of participants' search records were analyzed together to ensure the observed behaviors always matching participants' intentions.

The consistency of the coding theme is a major issue in qualitative studies, especially when using a Grounded Theory approach, because new categories of codes are to be constructed from the analysis process, rather than applying pre-existing codes. However, since this study mainly applied coding to tangible behaviors that were explicitly defined, the consistency was assured. The only codes developed from the study were interactive intents, which explicitly reflected participants' intentions in the think aloud transcript. All qualitatively discovered search patterns were associated with the interactive intent behind, thereby ensuring the validity of these patterns.

Finally, statistical tests were conducted to further ensure the reliability of our qualitative analysis results, as most of the target behaviors discovered from each pattern were significantly different from the rest of the population. This largely eliminated the possibility of our findings being discovered 'by chance'. The statistical analysis also helped us unveil some interesting behaviors which were not originally included in our research design.

### 3.7.2 Methodological limitations

As with any research methodologies, particularly qualitative studies involving human participants, the current research has several limitations regarding to:

- The coverage of general Web image search topics
- The veracity of participants' image searching behavior
- Difficulties for participants to elaborate all thoughts during searching
- The selective query formulation/reformulation behaviors investigated

Firstly, the current study investigated participants' Web image searching only in *news*, *travel*, and *commercial product* domains. Although participants could freely develop their own specific search topics, such constraints in the topic domains inevitably introduced some limitations on the coverage of the search topics investigated. Such a refined research scope is necessary because this study aims to discover common patterns in participants' searching behaviors. Without any limitations on the problem domains, it endangered the research of not able to find any coherent patterns which can be utilized in constructing the user model. In addition, the problem domains were selected based on the popular image searching topics suggested in many papers. Hence the coverage, or the representativeness, of the current study findings should be at least indicative of most real-world Web image searching.

In the user study, participants' searching behaviors were closely observed by the researcher. The mere presence of an observer may have introduce some effects and influence participants' behavior, as many psychological studies have suggested (Hazel, 1978; Zajonc, 1965). Since the observation is essential for the think aloud protocol, and sometimes interactions with participants are necessary, some measures were taken to minimize the obtrusive effects. The searching environment was in normal lab settings, which our participants should have been familiar with. The Camtasia software was run in the computer system background without any interference with participants' searching or cognitive loads. To keep the stress on performance concerns minimal, specific search tasks were not imposed to participants. Similarly, the searching time constraint was set generously, so that there should be more than enough time for participants to complete their tasks even though the study did not require the completion of all search tasks. The researcher also prompted participants to think aloud only when necessary to minimize interference on the searching behavior. Finally, the research assured the anonymity of participants' individual identities, as there was no face recording during the user study, and all searching records such as the observation memos and activity recording files were stored by participant number only.

Regarding the ability to elaborate all thoughts relevant to the current study goals, an simplified version of think aloud protocol was adopted. Instead of having extra equipment such as a voice recorder or video camera to record participants' activities, the Camtasia software was run on the same computer that participants used to serve this purpose. Some think aloud examples were shown to the participants prior to the search session to facilitate their thinking about what to verbalize during searching. The researcher also prompted the participants seeking for clarification on particular action when necessary. All these measures were believed to ease participants' anxiety towards the unfamiliar think aloud protocol and to collect more useful data.

As mentioned in *Section 3.2 – Study Assumptions*, query formulation and reformulation behaviors were intentionally chosen as the study focus. Obviously, such behaviors do not cover all aspects of the complex Web image searching problems, and more future studies should be considered to provide a more holistic view. However, based on literature findings, the query formulation and reformulation process is regarded as the main source of the image searching problems. Hence this is the most important issue that should be solved first. In addition, because of the applicability aims of the current study, our analysis needs to be based on more tangible factors so that the study findings can be easily verified or compared in the future. It would also be more beneficial for the existing image search engines as the current findings are ready for implementation. Constructing abstract theories which focus on the internal factors (e.g., stress, anxiety, or the *Anomalous State of Knowledge, ASK*) may be difficult to be incorporated in systems. Other general limitations regarding the qualitative research methods also exist for the current study, such as the potential experimenter's bias or sample selection bias. These biases generally exist inherently from the research method adopted and can only be minimized, but not eliminated, through rigorous research design (e.g., triangulation for data collection and analysis), which was discussed in previous sections.

## 3.8 Chapter Summary

This chapter reviews the methodologies for our Dogpile log analysis pre-study and Web image searching user study. We investigated users' consecutive query reformulations in the Dogpile multimedia search logs. By investigating the changes in the syntax and the number of query terms between consecutive queries, some primary search strategies can be inferred from the sequences of query reformulations (i.e. dynamic, constant, specified, generalized search strategies). However, the log data analysis still lacks users' search context information, such as the search problems, the difficulties encountered during searching, and the reasons for any strategy adopted to overcome the problems. A Web image searching user study is thus designed to complement the drawbacks in the log analysis pre-study.

In our Web image searching user study, the contexts of participants' searching were captured by the pre-search questionnaire, the searching activity monitoring and query reformulation logs, and the post-search questionnaire. We adopted think aloud protocol to gather participants' reasons for searching moves, particularly during result reviewing and query reformulation. Think aloud data and search logs were transcribed and qualitatively analyzed using the Grounded Theory approach. Grounded Theory was useful in discovering new search strategies and query reformulation patterns from participants' coded behaviors and their interactive intents. Query terms in the search logs were also categorized for quantitative analysis. The quantitative factors measured by both pre-search and post-search questionnaires (e.g., search experience, task specificity, knowledge level, task completion and satisfaction level), as well as the frequency of coded behaviors, were statistically tested for their significance among different search patterns. Six interactive intents also emerged through the Grounded Theory analysis. In the next chapter, we present our results on the Dogpile log analysis pre-study and the Web image searching user study.

# CHAPTER 4: RESULTS

The findings of this study are presented in this chapter. *Section 4.1* reviews the results from our Dogpile log analysis pre-study, with short discussions on the log analysis findings in *Section 4.2*. *Section 4.3* provides the overview of participants' demographic data, including their search experience, education background, and search tasks ratings. *Section 4.4* provides the findings of participants' Web image searching behavior from the search sequence analysis. *Section 4.5* presents the classification of task types and search strategies in the three search domains. *Section 4.6* presents the findings of different types of terms utilized among search domains. Important search strategies and query reformulation patterns are presented in *Section 4.7*, with corresponding search transcript examples. *Section 4.8* presents factors that have effects on search satisfaction and outcomes, as well as the common problems participants encountered during searching. Finally, *Section 4.9* summarizes the findings presented in this chapter.

Key research questions answered by the log analysis pre-study and the user study are:

- What are the common query reformulation patterns in different multimedia searches? (*Section 4.1.2*)
- What are the search strategies that can be automatically inferred from query reformulation sequences? (*Section 4.1.3*)
- How do users search Web images in different domains? (*Section 4.4*)
- How do search domains affect the type of users' search tasks? (*Section 4.5.1*)
- What are the strategies users adopted in different search domains and task types? (*Section 4.5.2 and 4.5.3*)
- What are the terms users utilized to formulate queries in different domains? (*Section 4.6*)
- What are the important search strategies and query reformulation patterns in Web image searching? (*Section 4.7*)
- Are there any important behaviors associated with the strategy and patterns we found? (*Section 4.7.2 to4.7.8*)

- Are there any predetermined factors associated with users' search outcomes? (*Section 4.8.1*)
- What are the common problems users encountered during searching? (*Section 4.8.2*)

# 4.1 Dogpile Log Analysis Findings

We present the findings from our Dogpile log analysis pre-study in this section. This study aims to discover multimedia query reformulation behavior and search strategies by applying novel log analysis procedures. To our knowledge, this is the first study to automatically analyze contextual information beyond two consecutive log records. This approach also allows us to compare the search strategy characteristics among different types of multimedia searches and to provide insights for future system development.

## 4.1.1 Query reformulation

From *Table 4.1*, image searches are the dominant type of multimedia search in our dataset, with more than 50% of sessions and users attributed to image searches. Audio is the second popular type of multimedia search, while video is the least popular. As *Table 4.2* shows, initial queries are the majority of query reformulation across all multimedia searches. Replacement reformulation occurs more than twice of the addition reformulation in visual searches (i.e. image and video searches), but much less frequently in audio searches. Deletion is the least type of reformulation in all searches.

Comparing the distribution of the four reformulations in multimedia searches, audio search users are more likely to formulate new search topics as they have a larger proportion of initial queries and more topics per user than image and video searches. The number of topics submitted by both image and audio users varies widely

(SD=21.60 and 22.39 respectively), while video users show a much uniform pattern (SD=8.33). Image and video users have the same amount of reformulations (1.71 reformulations on average), while audio users show slightly fewer reformulations per session (1.63 on average). Overall, image and video search users were very similar in terms of query reformulations.

| Dogpile Log Statistics | | | | | | |
|---|---|---|---|---|---|---|
| | **Image** | **%** | **Video** | **%** | **Audio** | **%** |
| Log records | 597,760 | 48.7 | 231,941 | 18.9 | 398,609 | 32.5 |
| Sessions | 183,825 | 52.9 | 52,405 | 15.1 | 110,945 | 32.0 |
| Users | 60,701 | 52.1 | 21,677 | 18.6 | 34,088 | 29.3 |

*Table 4.1* Statistics of image, video, and audio search logs in Dogpile dataset

| Query Reformulation Statistics | | | | | | |
|---|---|---|---|---|---|---|
| | **Image** | **%** | **Video** | **%** | **Audio** | **%** |
| Initial | 183,825 | 58.6 | 52,405 | 58.5 | 110,945 | 61.2 |
| Replacemen | 82,292 | 26.2 | 22,225 | 24.8 | 33,645 | 18.6 |
| Addition | 30,716 | 9.8 | 8,817 | 9.8 | 22,553 | 12.4 |
| Deletion | 16,757 | 5.3 | 6,124 | 6.8 | 14,176 | 7.8 |
| Total | 313,590 | 100.0 | 89,571 | 100.0 | 181,319 | 100.0 |
| **Topics per user** | | | | | | |
| Average | 3.03 | | 2.42 | | 3.25 | |
| SD | 21.60 | | 8.33 | | 22.39 | |
| **Modifications per session** | | | | | | |
| Average | 1.71 | | 1.71 | | 1.63 | |
| SD | 1.68 | | 1.68 | | 1.42 | |

*Table 4.2* Statistics of query reformulation records

## 4.1.2 Reformulation sequence

### *Two-reformulation-sequence analysis*

The frequencies of each reformulation sequence pattern (in percentages) are presented in *Table 4.3* and *Table 4.4*. *Table 4.3* signifies the popularity of replacement reformulation in all types of multimedia searches, as evidenced by the dominance of *I-R-R* and *I-A-R* sequences. On the contrary, the unlikelihood of consecutive deletion reformulation is manifested by the low occurrence of *I-D-D* sequences (i.e. less or equal to 1% in all multimedia searches).

*Figure 4.1* shows that both image and video searches have prominently more *I-R-R* sequences than audio searches. The audio searches have many more *I-A-D* sequences than the other two types of searches, thus making it more evenly distributed in the top three reformulation sequence patterns. All multimedia searches show a similar distribution beyond the top three patterns.

**Two-reformulation-sequence Comparison**

| Pattern | Image | Video | Audio |
|---|---|---|---|
| I-R-R | 41.2% | 39.2% | 26.8% |
| I-A-R | 24.9% | 22.2% | 23.6% |
| I-A-D | 10.9% | 13.4% | 21.9% |
| I-R-A | 5.6% | 5.3% | 6.2% |
| I-R-D | 5.4% | 6.8% | 6.9% |
| I-D-A | 5.1% | 6.2% | 7.1% |
| I-A-A | 3.9% | 3.3% | 4.3% |
| I-D-A | 2.3% | 2.6% | 2.1% |
| I-D-D | 0.6% | 1.0% | 1.0% |

*Table 4.3* Comparison of the frequencies in two-reformulation-sequence patterns

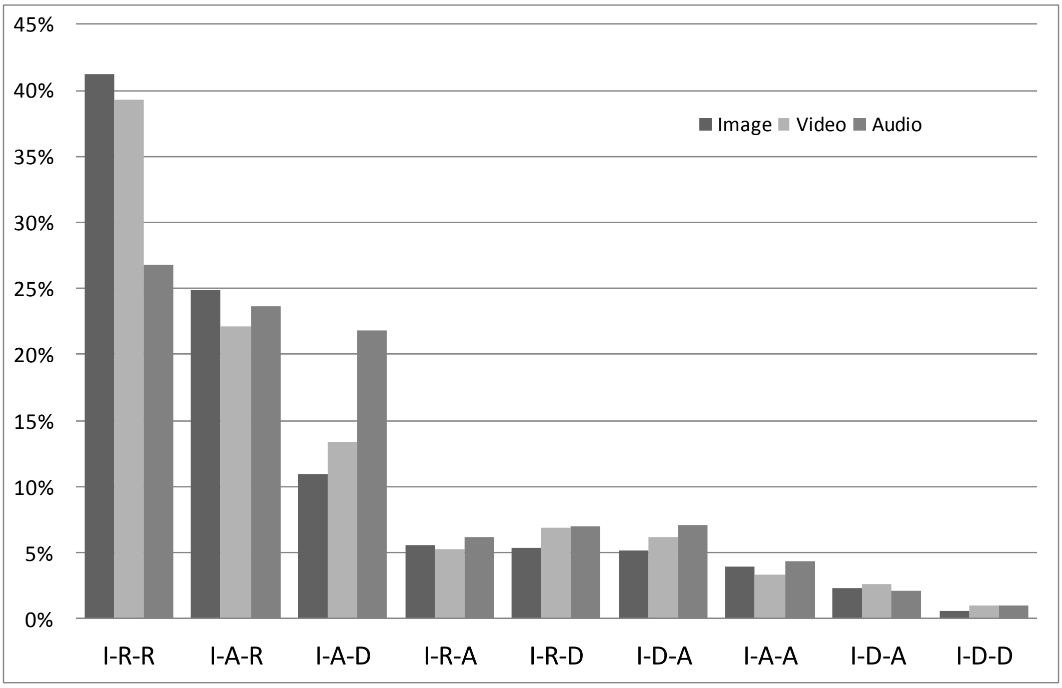



*Figure 4.1* The distribution of the two-reformulation-sequence patterns among Image, Video, and Audio searches

## *Three-reformulation-sequence analysis*

The dominance of replacement and addition reformulation continued in the analysis of three-reformulation-sequences. As shown in the high frequencies of both *I-R-R-R* and *I-A-R-R* sequences in *Table 4.4*, about 50% of all three reformulation sequences in image and video searches are associated with replacement and addition reformulations. Similarly to the distribution in two-reformulation-sequence analysis, both image and video searches have much higher proportion of consecutive replacement reformulations (i.e. the *I-R-R-R* sequences) than audio searches. The top three reformulation sequence patterns distribute more evenly in audio searches, with slightly more *I-A-D-A* sequences than in the other two types of searches. For reformulation sequence patterns beyond the top five, all multimedia searches demonstrate a similar distribution, thus providing little information for characterizing different types of multimedia searches. *Figure 4.2* shows that *I-R-R-R* sequences are more prominent in both image and video searches, as the distribution decreased more in the top three reformulation sequence patterns than audio searches. The top five patterns account for over half of the three-reformulation-sequence in all multimedia searches, with only one pattern contains the deletion reformulation. When we further differentiate *I-R-R* sequence into *I-R-R-R*, *I-R-R-A*, and *I-R-R-D* sequences, the prevalence of replacement over addition and addition over deletion continued (*I-R-R-D* not shown in *Table 4.4*). Hence, users' preference for replacing terms, and the unlikelihood of deletion reformulation, in the early stage of query reformulation can be confirmed.

| Top 5 Three-reformulation-sequence Comparison | | | |
|---|---|---|---|
| **Pattern** | **Image** | **Video** | **Audio** |
| I-R-R-R | 35.3% | 32.4% | 21.6% |
| I-A-R-R | 20.1% | 17.3% | 16.7% |
| I-A-D-A | 5.3% | 6.3% | 11.1% |
| I-R-A-R | 4.5% | 4.1% | 3.6% |
| I-R-R-A | 3.9% | 3.5% | 2.6% |
| Total | 69.1% | 63.7% | 55.6% |

*Table 4.4* Comparison of the top 5 frequencies in three-reformulation-sequence patterns

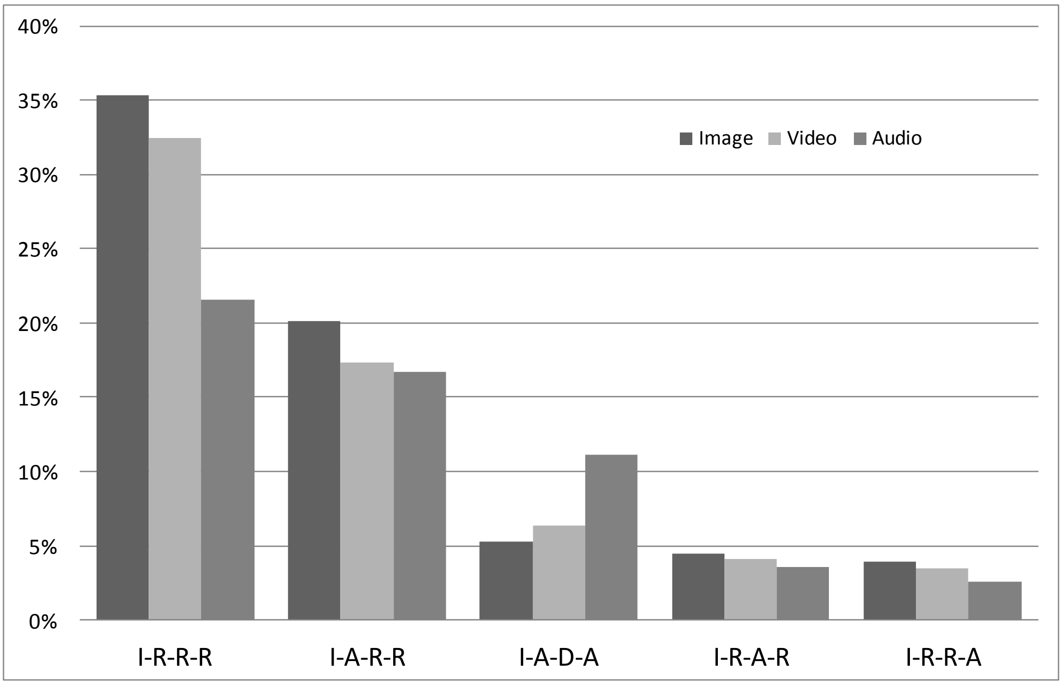



*Figure 4.2* The distribution of the top 5 three-reformulation-sequence patterns among Image, Video, and Audio searches

### 4.1.3 Search strategies based on reformulation sequence

We investigated search strategies based on the consecutive replacement sequences (i.e. the *I-R-R* and *I-R-R-R* sequences) because of their prominence in the reformulation sequence analysis. As *Table 4.5* shows, about 40% of all *I-R-R* sequences exhibit a dynamic search strategy. From *Table 4.6*, the proportion for dynamic search increases to more than 50% in *I-R-R-R* sequences. While this large proportion for dynamic search can be anticipated, constant search, which accounts for nearly one-third of all consecutive replacement sequences, is more revealing. Because the query length is held at constant within each session in constant searches, it appears to be a one-to-one relationship between the replaced term pairs. A reasonable explanation is the interchange of synonyms or associated terms of the same construct (e.g. ‘PC’ to ‘Mac’, ‘UK’ to ‘USA’, or ‘girls’ to ‘boys’). Both *Table 4.5* and *Table 4.6* show more specified searches than generalized searches, but the difference is noticeable only in image searches. This indicates that image users are more prone to adopt the specified strategy (i.e. gradually adding more search terms as the searching progresses) than other types of multimedia users. In other words, image users progressively consolidate or learn more information about their problems through the interaction with the Web search engine. The percentages for the search strategy analysis from *I-R-R* and *I-R-R-R* sequences are presented in *Table 4.5* and *Table 4.6* respectively.

| ***I-R-R*** **Search Strategy Comparison** | | | |
|---|---|---|---|
| **Strategy** | **Image** | **Video** | **Audio** |
| Dynamic | 40.1% | 40.6% | 42.7% |
| Constant | 34.8% | 34.3% | 28.5% |
| Specified | 15.2% | 12.8% | 15.2% |
| Generalized | 9.9% | 12.3% | 13.5% |

*Table 4.5* The percentages of search strategies from *I-R-R* reformulation sequences

| ***I-R-R-R*** **Search Strategy Comparison** | | | |
|---|---|---|---|
| **Strategy** | **Image** | **Video** | **Audio** |
| Dynamic | 52.9% | 52.9% | 58.3% |
| Constant | 27.2% | 25.7% | 22.1% |
| Specified | 11.9% | 11.3% | 10.1% |
| Generalized | 8.0% | 10.1% | 9.4% |

*Table 4.6* The percentages of search strategies from *I-R-R-R* reformulation sequences

As shown in *Figure 4.3* and *Figure 4.4*, both strategy analyses from *I-R-R* and *I-R-R-R* sequences suggested the highest constant search strategy in image searches. Thus image searches require more synonym or related term replacement reformulation than other types of multimedia searches, and such characteristics should benefit image searches more from term suggestion functionalities when refining the search queries. While video searches have a slightly less proportion of constant searches than in image searches, they shared very similar distribution across the four types of search strategies. On the other hand, audio search users are more prone to adopt a dynamic search strategy.

In order to verify the replaced terms in constant search sequences, we implemented a

Brill tagger[3] (Brill, 1992) to identify the part-of-speech of the replaced term pairs (i.e. the terms from the original query paired with the terms from the replacement query). Among the randomly selected 1,465 constant *I-R-R-R* reformulation sequences, a total of 3,003 replaced term pairs have been successfully tagged using the Brill tagger. More than 70% of these term pairs (2,125 in total) have the same part-of-speech, reassuring our explanation of interchanging between synonyms or associated terms of the same construct in these constant search sequences.

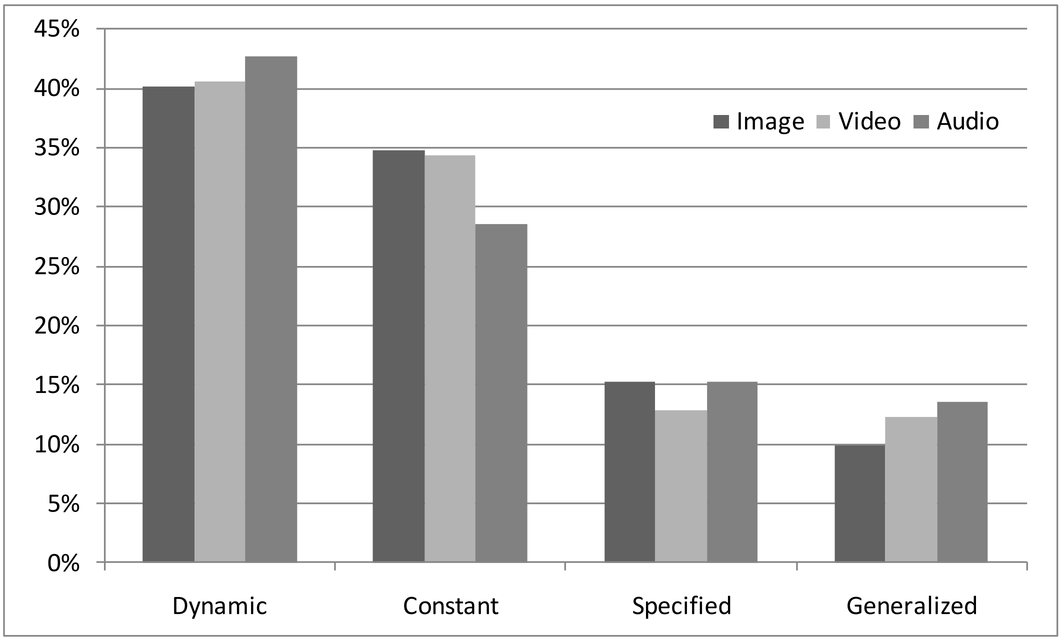



*Figure 4.3* Comparison of the search strategies from *I-R-R* reformulation sequences

[3] Details on the tagger implementation can be found in Simpson (2005).

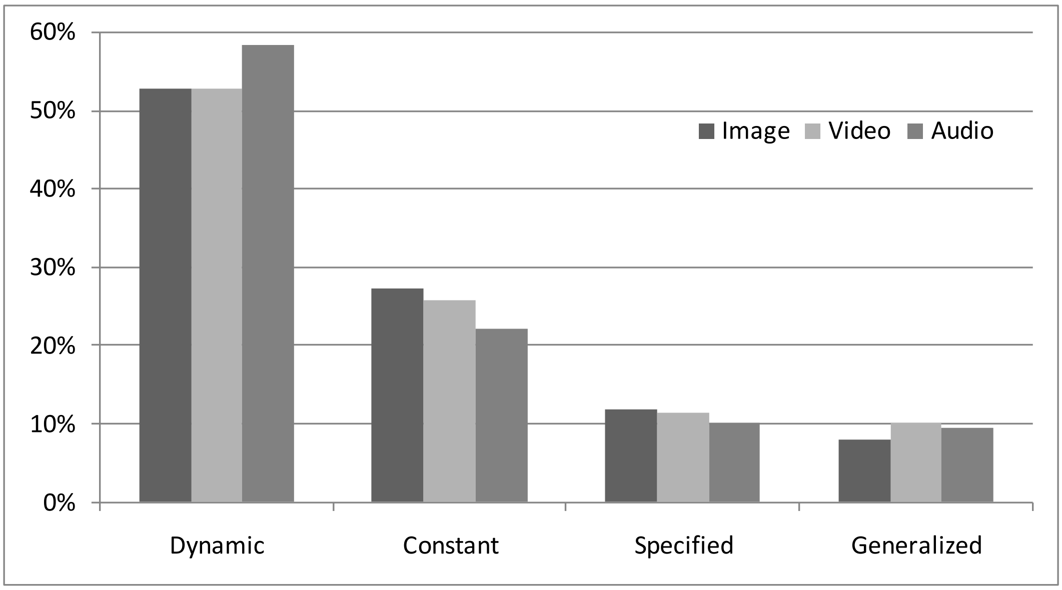



*Figure 4.4* Comparison of the search strategies from *I-R-R-R* reformulation sequences

# 4.2 Discussion on the Pre-study

## 4.2.1 Characteristics of Web multimedia searching

The statistics of query reformulation revealed that all multimedia search users shift their search topics more often than refining their queries. This phenomenon is most evident in audio searches as initial queries are more than triple the replacement queries. The replacement queries are more than twice the addition queries in both image and video searches, whereas audio searches have notably more addition queries. Deletion queries are the least frequent type of reformulations in all multimedia searches, especially in image searches. Overall, when users do modify their queries, they tend to replace their search terms rather than adding or removing them. Such reformulation tendency is more prominent for visual searches (i.e. image and video searches). Although the number of topics searched by one user varies widely, users searched around two to three different topics on average. In terms of in-session reformulation analysis, the majority of users perform only few reformulations to their queries, and visual search users modify their queries slightly more than audio users.

The analysis of reformulation sequence patterns suggests the tendency to replace and add search terms when modifying visual queries. The distribution of reformulation sequences shows a tendency toward the consecutive replacement reformulation sequences (i.e. the *I-R-R* and *I-R-R-R* sequences) in visual searches. This tendency also distinguishes visual searches from audio searches and suggests the need for interchanging related search terms. In other words, visual search users are more willing to interact with the system than audio search users are.

In terms of search strategies, the changes in number of terms within *I-R-R* and *I-R-R-R* sequences reveal that about 40% to 50% of users engage in dynamic searches. This typically reflects the unplanned nature of Web multimedia searching, which manifests the need for initiating several guessing runs to consolidate the search problem, or to find the appropriate search terms. Nevertheless, about one third of users adopt a constant search strategy in which they replace search terms with an equal number of terms, suggesting the high likelihood of interchanging with synonyms or related terms. This constant search strategy also differentiates visual searches from audio searches. While visual searches always have a higher proportion of constant searches, image users adopt the most constant search strategy among all multimedia searches. Hence it can be assumed that image users should benefit most from knowledge or ontology based query expansion or term suggestion assistance. The reason for a less constant search strategy in audio searches may be that audio searchers tend to use the song title or singer's names in their queries (Tjondronegoro, et al., 2009), resulting the replacement of these proper nouns rather than the interchanging of similar terms in visual searches.

When the change of terms shows a unidirectional pattern, all multimedia searchers are more prone to adopt the specified approach. This finding is consistent with prior studies' conclusion on users' primary concern of retrieval precisions (B. J. Jansen & Spink, 2006). In particular, image search users show a stronger preference for adopting this approach than other types of multimedia users. A typical scenario would be that image search users need to see widely before they know exactly what they are searching for or how their target images should look. This characteristic implies the importance of a browsing tool that helps users compare different results and thus consolidate their problems quicker. A hierarchy arrangement of the results or term suggestions should also be useful.

Compared with general Web search studies, the current study findings are consistent with Jansen and Spink's (B. J. Jansen & Spink, 2005) conclusion on the complexity of user's Web search behavior as one-query sessions increased over the years and users modify their queries less and less. This is to say that general Web users share the same characteristics as our user pool. Hence the effectiveness of the interaction between the user and the system is substantial to the improvement of the query reformulation process. Future work should include a user study to understand the reasons behind each reformulation, as well as the corresponding search strategies. A semantic level analysis of replaced terms would also help to discover the aspects of multimedia content that users modify most, such as the visual descriptors or the semantic meanings of the retrieved objects.

The prevalence of consecutive replacement reformulations implies the need for an effective relevance feedback mechanism that would help users refine the importance of their query terms, perhaps with advanced search term suggestions based on the replaced terms (e.g. automatically displays synonyms or associated terms when user deletes a term). In terms of search strategies, the current study confirms the preference for the specified approach among image searchers. An interactive retrieval system that can gradually obtain more information about users' image problems would be helpful in guiding users to explore the entire collection, and hence improve the query reformulation effectiveness.

## 4.2.2 Study summary

The current study investigated users' multimedia searching behavior based on their query reformulation methods. Our analysis showed that around 60% of query reformulations are to formulate new search topics. Image and audio users searched more topics on average than video users. Our approach to analyzing Web multimedia query reformulations went beyond two consecutive queries. The analysis of session reformulations revealed that visual search users (i.e. both image and video users) modify their queries slightly more than audio users do. Visual search users also tend to replace search terms with other related terms rather than merely narrowing or broadening their searches. Generally speaking, visual searches showed similar reformulation patterns with many more consecutive replacement reformulations than in audio searches. In terms of search strategies, the relatively high proportion of constant search strategy in visual searches indicates the importance of term suggestion assistance that helps users find the synonyms or related terms more easily. Our search strategy analysis also showed the tendency of adopting a specified approach in image searches, which suggests a need for query formulation assistance to help users gradually specify their problems.

We present an automatic analysis method in this pre-study, thus maximizing the ability to apply the same analysis to different data sets, as well as allowing comparisons with general Web user's searching behavior. By adopting the analysis method, it is possible to extract more information about user's query reformulation behavior, especially the search strategies based on the statistical evidence. Future multimedia retrieval systems can utilize these different search characteristics to improve query formulation process and search efficiency.

### *Dogpile log study findings*

From the pre-study, we discovered that users constantly modify their queries with some sort of trial-and-error approach to compare the difference between results returned by the variations of original query. Among all four types of reformulations (initial, addition, deletion, replace), replace took the majority (more than 63%) of all reformulations excluding the initial queries. Thus when users modify their queries, they tend to substitute search terms with other keywords rather than simply narrowing or widening their search conditions (i.e. the addition or deletion of search terms). This finding manifests the situation that users need to initiate a preliminary search query so that they can know how the system will interpret their initial construct and react accordingly (i.e. modifying their queries upon the aspects that were missing or misinterpret by the system). To this point, the initial query should merely reflect user's own construct towards the information problem while subsequent reformulations are shaped by the interaction between the system and the user.

Furthermore, based on reformulation pattern analysis, most users modify their queries only once, with 95% of searched topics having fewer or equivalent to five reformulations. Our further analysis on the reformulation sequences of two and three reformulations found that users generally keep replacing search terms rather than simply adding or removing terms, as *I-R-R* and *I-R-R-R* sequences occurred most in two and three reformulation sequences respectively. Such interesting findings indicate the need for a term level analysis in order to discover the types and the relationships among these terms in the consecutive replacement sequences, hence knowing the important concepts that are center to users' image needs.

### 4.2.3 Limitations

With our aim of using an automatic approach to discover users' query reformulation behaviors, the pre-study performs only the part-of-speech analysis of replaced terms in constant search sequences. This limits our understanding of the types of terms being modified during the reformulation process. Although we have successfully discovered some unique characteristics and broad search strategies among different types of multimedia searches, in-depth studies are needed in order to understand and investigate the contextual factors that influence users' searching behaviors and strategies. In the next sections, we present our findings of the Web image user study, and unveil the relationships between users' search contexts and the corresponding searching behaviors.

## 4.3 User Study Participants' Demographic Data

*Table 4.7* summarizes participants' demographic data collected in the pre-search questionnaire. Participants' education levels and background are presented in *Table 4.8* and *Table 4.9* respectively. Our participant pool consisted of an even distribution of education levels (N.B. one participant with MCSA certificate was treated as Master degree level) and a variety of faculties. Information Technology was the majority discipline of our participants (52.5%), followed by Business (20%), Engineering (10%), Creative Industry (5%), and various others.

| Participant | Degree | Faculty | Experience | Search Engine | Familiarity | Personal Knowledge | | | Specificity | | | Tangible | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | News | Travel | Product | News | Travel | Product | News | Travel | Product |
| 1 | PhD | IT | 4 | Google | 4 | 2 | 1 | 2 | 3 | 5 | 4 | 0 | 0 | 1 |
| 2 | PhD | IT | 10 | Google | 3 | 5 | 1 | 2 | 5 | 1 | 4 | 1 | 0 | 1 |
| 3 | Master | IT | 3 | Google | 3 | 2 | 1 | 2 | 5 | 2 | 2 | 1 | 0 | 0 |
| 4 | Master | Business | 10 | Google | 5 | 4 | 3 | 4 | 5 | 3 | 5 | 1 | 0 | 1 |
| 5 | Bachelor | Engineering | 10 | Google | 4 | 2 | 4 | 5 | 2 | 3 | 5 | 1 | 0 | 1 |
| 6 | Bachelor | Business | 10 | Daum.net | 4 | 4 | 3 | 4 | 4 | 3 | 4 | 1 | 1 | 1 |
| 7 | PhD | IT | 14 | Google | 4 | 2 | 4 | 3 | 5 | 4 | 5 | 1 | 0 | 1 |
| 8 | PhD | BEE | 0 | Google | 1 | 1 | 1 | 1 | 5 | 5 | 5 | 0 | 0 | 0 |
| 9 | Master | IT | 10 | Google | 4 | 2 | 3 | 3 | 3 | 4 | 3 | 1 | 1 | 0 |
| 10 | PhD | IT | 5 | Google | 5 | 3 | 3 | 1 | 5 | 4 | 5 | 1 | 1 | 1 |
| 11 | Bachelor | Chemistry | 7 | Naver | 5 | 5 | 4 | 4 | 3 | 2 | 2 | 1 | 1 | 1 |
| 12 | PhD | Creative Industries | 8 | Google | 4 | 4 | 2 | 2 | 3 | 3 | 3 | 1 | 1 | 1 |
| 13 | Bachelor | Business | 7 | Google | 5 | 2 | 2 | 4 | 4 | 4 | 4 | 1 | 1 | 0 |
| 14 | PhD | IT | 8 | Google | 3 | 4 | 4 | 2 | 5 | 4 | 2 | 1 | 1 | 0 |
| 15 | Bachelor | German | 10 | Google | 5 | 1 | 4 | 3 | 4 | 5 | 4 | 1 | 1 | 1 |
| 16 | PhD | IT | 10 | Google | 4 | 2 | 2 | 3 | 4 | 2 | 3 | 1 | 1 | 1 |
| 17 | PhD | IT | 8 | Google | 5 | 5 | 4 | 1 | 5 | 4 | 2 | 0 | 1 | 1 |
| 18 | Bachelor | Engineering | 8 | Google | 4 | 2 | 3 | 4 | 4 | 2 | 4 | 1 | 1 | 1 |
| 19 | Master | Business | 10 | Yahoo | 4 | 2 | 2 | 2 | 4 | 2 | 5 | 0 | 1 | 0 |
| 20 | Bachelor | IT | 5 | Naver | 5 | 3 | 4 | 5 | 4 | 4 | 4 | 1 | 1 | 1 |
| 21 | Master | IT | 8 | Google | 3 | 5 | 4 | 4 | 5 | 5 | 5 | 1 | 1 | 1 |
| 22 | Master | Business | 10 | Google | 4 | 1 | 2 | 3 | 5 | 4 | 3 | 0 | 1 | 1 |
| 23 | Bachelor | Hospitality | 10 | Yahoo | 4 | 3 | 3 | 4 | 3 | 4 | 4 | 1 | 1 | 1 |
| 24 | Bachelor | Hospitality | 11 | Google | 3 | 1 | 1 | 3 | 4 | 2 | 5 | 1 | 1 | 1 |
| 25 | Master | IT | 9 | Bing | 3 | 2 | 2 | 4 | 3 | 4 | 2 | 1 | 1 | 1 |
| 26 | Master | IT | 3 | Google | 3 | 1 | 4 | 3 | 1 | 4 | 4 | 1 | 1 | 1 |
| 27 | MCSA | IT | 3 | Google | 3 | 3 | 4 | 4 | 3 | 3 | 3 | 1 | 1 | 1 |
| 28 | Master | IT | 10 | Google | 5 | 5 | 5 | 5 | 4 | 4 | 4 | 1 | 1 | 1 |
| 29 | Master | IT | 10 | Google | 2 | 2 | 2 | 1 | 1 | 1 | 3 | 1 | 1 | 0 |
| 30 | Master | IT | 4 | Google | 4 | 2 | 1 | 1 | 1 | 2 | 4 | 1 | 0 | 1 |
| 31 | Bachelor | Engineering | 9 | Google | 3 | 2 | 1 | 3 | 5 | 2 | 4 | 1 | 0 | 1 |
| 32 | Bachelor | Business | 9 | Google | 3 | 4 | 2 | 3 | 5 | 1 | 5 | 1 | 0 | 1 |
| 33 | PhD | IT | 5 | Google | 4 | 4 | 4 | 5 | 5 | 4 | 4 | 1 | 1 | 1 |
| 34 | Bachelor | Business | 7 | Google | 4 | 3 | 1 | 2 | 3 | 1 | 3 | 1 | 0 | 1 |
| 35 | Bachelor | Business | 10 | Google | 5 | 2 | 4 | 4 | 5 | 3 | 4 | 1 | 1 | 1 |
| 36 | Master | Creative Industries | 6 | Google | 3 | 4 | 2 | 3 | 5 | 1 | 4 | 1 | 0 | 1 |
| 37 | PhD | IT | 5 | Google | 3 | 3 | 3 | 3 | 2 | 1 | 4 | 0 | 1 | 0 |
| 38 | Bachelor | Social Science | 5 | Naver | 4 | 1 | 3 | 4 | 2 | 2 | 4 | 1 | 1 | 1 |
| 39 | PhD | IT | 10 | Google | 4 | 1 | 3 | 1 | 4 | 5 | 4 | 1 | 1 | 1 |
| 40 | PhD | IT | 5 | Google | 2 | 2 | 2 | 2 | 3 | 4 | 5 | 0 | 1 | 1 |

*Table 4.7* Participants' demographic data from the pre-search questionnaire

| Participants' Education Level | | |
|---|---|---|
| **Degree** | **No. of participant** | **%** |
| PhD | 13 | 32.5 |
| Master | 13 | 32.5 |
| Bachelor | 14 | 35 |

*Table 4.8* Participants' education level

| Participants' Education Background | | |
|---|---|---|
| **Faculty** | **No. of participant** | **%** |
| IT | 21 | 52.5 |
| Business | 8 | 20 |
| Engineering | 4 | 10 |
| Creative Industry | 2 | 5 |
| Hospitality | 2 | 5 |
| Chemistry | 1 | 2.5 |
| German | 1 | 2.5 |
| Social Sceience | 1 | 2.5 |

*Table 4.9* Participants' education background

In terms of the Web image searching background, our participants claimed to have 7 to 8 years (Avg=7.65, SD=2.91) of searching experience (EXP), except for one participant had never done any image searching before. All participants also claimed to have a moderate level (Avg=3.75, SD=0.95) of search engine familiarity (FAM). Participants' personal knowledge (KNO) and task tangibility (TAN) were at similar levels across the three search domains. Task specificity (SPE) was the highest in product domain with least variations (Avg=3.83, SD=0.96), and the lowest in travel domain with most variations (Avg=3.08, SD=1.31). *Table 4.10* shows the statistics of quantitative variables measured by the pre-search questionnaire. Details on the difference in personal knowledge, task specificity, and tangibility among search domains will be presented in *Section 4.7.6 – Effects of task domains on overall searching behavior*. Our participants came from a range of different backgrounds and searching experience, and thus should be representative of general Web users.

| Participants' Background Measurements | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Search Experience** | **Search Engine Familiarity** | **Personal Knowledge** | | | **Specificity** | | | **Tangibility** | | |
| | | | News | Travel | Product | News | Travel | Product | News | Travel | Product |
| **Avg** | 7.65 | 3.75 | 2.70 | 2.70 | 2.98 | 3.78 | 3.08 | 3.83 | 0.83 | 0.70 | 0.80 |
| **SD** | 2.91 | 0.95 | 1.30 | 1.18 | 1.23 | 1.25 | 1.31 | 0.96 | 0.38 | 0.46 | 0.41 |
| **Min** | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 0 | 0 | 0 |
| **Max** | 14 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 1 | 1 | 1 |

*Table 4.10* Statistics of participants' search background variables

*Figure 4.5* depicts the distribution of participants' searching experience in years. All participants have been searching images on Web for at least three years, despite one participant claiming to have never searched images online. Many participants have been searching online images for five to ten years. This timeframe corresponded to the popularity of commercial Web image search engines, as the study was conducted in year 2009. *Figure 4.6* shows the distribution of participants' familiarity with the nominated Web image search engine. Most participants claimed 3 to 5 out of five familiarity levels, suggesting a moderate to proficient level of using the search engine functions.

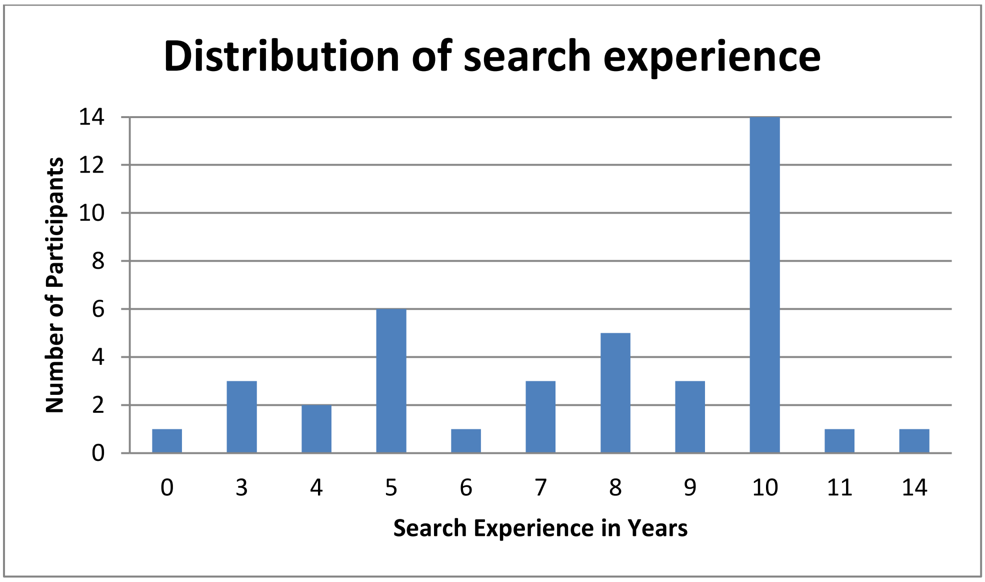



*Figure 4.5* Distribution of participants' Web image searching experience

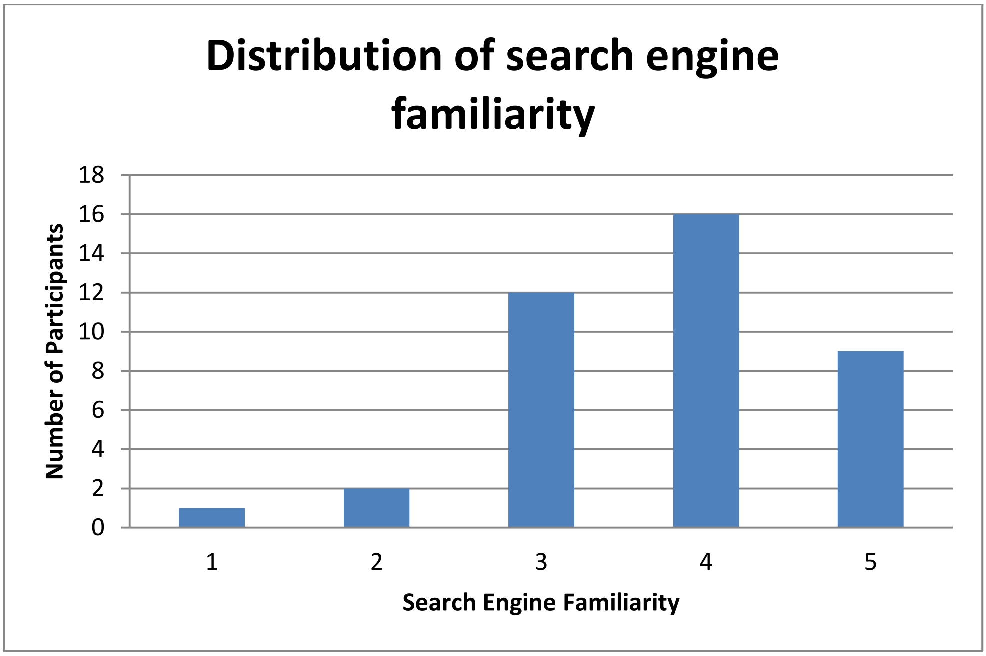



*Figure 4.6* Distribution of participants' search engine familiarity

## 4.4 Coded Search Sequence Analysis

Search sequence represented the sequential coded behaviors within a search session. In this study, a total of 120 search sequences (i.e. 40 participants with three search sessions per participants) were coded and analyzed. These 120 search sequences contained 1,950 behaviors/search moves that were identified during the open coding phase in the Ground Theory approach. The search sequence analysis is similar to the query analysis in Web log studies. The average sequence length provides information about participants' average number of searching activities in the studied domains. However, as with the limitations in Web log analysis, participants' search contexts and cognitive aspects (e.g., task type and search intent) were not considered in the search sequence analysis; thus the results provided little information on the reasons for the differences in searching activities.

*Table 4.11* shows the overall statistics for search sequences among the three search domains. Overall, news searches incurred the longest search sequence (Avg=18.15), followed by travel (Avg=16.45), and product (Avg=14.15) searches. This indicates the highest interactivity in news searches as shown by more search moves per session. The implications of the behavioral scores for each search domain are now discussed, based on the different aspects of the coded behaviors.

| | Coded Behavior - All | | | | | | | | | | | | | | | | | | | | | | | Avg. Sequence Length |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total Query | Reviewing | | | | Switching content | | | | New Query | | Replace | | | | Addition | | | Deletion | | Other | | | |
| | TQS | IB | SB | TD | ID | SW | SI | SS | SC | NR | NN | RR | RS | RN | RO | AN | AR | AO | DN | DO | DS | LS | | |
| News | 195 | 161 | 87 | 23 | 4 | 18 | 31 | 28 | 5 | 1 | 0 | 28 | 12 | 7 | 36 | 5 | 10 | 29 | 9 | 13 | 13 | 11 | | 18.15 |
| Travel | 217 | 155 | 55 | 14 | 16 | 14 | 13 | 15 | 4 | 1 | 2 | 29 | 9 | 16 | 36 | 4 | 7 | 23 | 5 | 8 | 8 | 7 | | 16.45 |
| Product | 168 | 131 | 65 | 15 | 5 | 15 | 5 | 10 | 1 | 1 | 1 | 26 | 12 | 9 | 25 | 1 | 16 | 23 | 3 | 9 | 18 | 7 | | 14.15 |
| Total | 580 | 447 | 207 | 52 | 25 | 47 | 49 | 53 | 10 | 3 | 3 | 83 | 33 | 32 | 97 | 10 | 33 | 75 | 17 | 30 | 39 | 25 | | 16.25 |

*Table 4.11* Frequencies of coded behaviors among search domains

## 4.4.1 Result reviewing and content switching

Intensive Browsing (IB) was more in news and travel searches and the least in product searches. Serendipity Browsing (SB) was more in both news and product searches and the least in travel searches. These suggested the need to browse intensively for information or ideas in travel searches, whereas product searches required more serendipity browsing for term discovery (TD). Unlike the other two, news searches were higher in both intensive and serendipity browsing. The more result reviewing activities in news searches seemed to contribute to the highest term discovery.

For content switching, news searches again exhibited most switching between Web and image (i.e. SW and SI), and switching between search engines (SS). This corresponded to the highest browsing activities in new searches. The much higher switching to image searches (SI) in news searches can be associated with the need or tendency in general Web searching for initial results, which will be discussed in greater detail as a knowledge expansion strategy in *Section 4.72*. Product searches showed the least SI, suggesting that the majority of product searches were performed only in image search mode.

## 4.4.2 Query reformulation

The total query per session (TQS) showed that travel searches required formulating the highest number of queries (Sum=217), followed by news (Sum=195), and product (Sum=168) searches. Replace was the most popular query reformulation type, followed by addition, then deletion, and with new query as the least type of reformulation. Among the four types of replace reformulation, replace with term in original concepts (RO), and replace with related term (RR), were the two most popular reformulations. This means that our participants formulated fairly focused searches, which is also shown by the rare use of new query with related topic (NR) and new query with new topic (NN). Interestingly, the replace with synonyms (RS) had higher use in news and product searches, suggesting the more focused searches in these two domains. Travel searches, on the other hand, were less focused and thus resulted in the more replace with new terms (RN).

# 4.5 Task Type and Overall Search Strategy Classification

## 4.5.1 Search domain and task type

All participants' search tasks were classified into two broad types: *exploratory* and *retrieval* tasks. Exploratory tasks are tasks that do not involve a clear or finite set of images as the search target. Retrieval tasks are tasks that have a tangible set of images as the search target, regardless of whether participants have seen the image before or can imagine how the images should look (i.e. the task tangibility, TAN). As a result, only 39 searches (32.5%) matched their task types with tangibility (i.e. retrieval tasks with tangible images in mind, exploratory tasks without tangible images).

The other 81 searches (67.5%) did not match task types with tangibility. Hence tangibility was not a good predictor of participants' task types. Overall, the total of 120 searches consisted of 94 exploratory tasks and 26 retrieval tasks. The frequencies of search domains in exploratory and retrieval tasks are presented in *Table 4.12* and *Table 4.13* respectively.

| Exploratory Task | | |
|---|---|---|
| Search Domain | No. of Searches | % |
| News | 26 | 27.66% |
| Travel | 38 | 40.43% |
| Product | 30 | 31.91% |
| Total | 94 | 100.00% |

*Table 4.12* Frequencies of search domains in exploratory tasks

| Retrieval Task | | |
|---|---|---|
| Search Domain | No. of Searches | % |
| News | 14 | 53.85% |
| Travel | 2 | 7.69% |
| Prodcut | 10 | 38.46% |
| Total | 26 | 100.00% |

*Table 4.13* Frequencies of search domains in retrieval tasks

While the three search domains distributed relatively equally in exploratory tasks, retrieval tasks consisted mainly of news and product searches. With the lowest retrieval task and highest exploratory task in the travel domain, it is clear that travel searches showed the most openness among the three search domains. *Table 4.14* shows the composition of the two task types within each domain. Among the three domains, news searches were the most balanced type of search with 65% exploratory and 35% retrieval tasks. Travel searches again showed the strongest tendency of 95% exploratory tasks. Product searches also favored exploratory tasks. Overall, participants preferred exploratory searches, although some differences among domains were observed. *Table 4.15* and *Table 4.16* list participant's task tangibility and search strategies in exploratory and retrieval tasks respectively.

| Task Type | Search Domain | | | | | |
|---|---|---|---|---|---|---|
| | News | | Travel | | Product | |
| | No. of Searches | % | No. of Searches | % | No. of Searches | % |
| Exploratory | 26 | 65% | 38 | 95% | 30 | 75% |
| Retrieval | 14 | 35% | 2 | 5% | 10 | 25% |
| Total | 40 | 100% | 40 | 100% | 40 | 100% |

*Table 4.14* Frequencies of task types in search domains

| Participant | Domain | Task Type | Tangibility | Overall Strategy |
|---|---|---|---|---|
| 4 | News | Exploratory | Yes | Nil |
| 5 | News | Exploratory | Yes | Top-down |
| 6 | News | Exploratory | Yes | Bottom-up |
| 7 | News | Exploratory | Yes | Top-down |
| 11 | News | Exploratory | Yes | Top-down,Divide |
| 12 | News | Exploratory | Yes | Parallel |
| 13 | News | Exploratory | Yes | Parallel |
| 14 | News | Exploratory | Yes | Top-down, Parallel |
| 15 | News | Exploratory | Yes | Top-down |
| 17 | News | Exploratory | No | Top-down |
| 18 | News | Exploratory | Yes | Top-down |
| 21 | News | Exploratory | Yes | Divide |
| 23 | News | Exploratory | Yes | Dynamic, Parallel |
| 24 | News | Exploratory | Yes | Top-down, Divide |
| 25 | News | Exploratory | Yes | Top-down |
| 26 | News | Exploratory | Yes | Nil |
| 29 | News | Exploratory | Yes | Top-down, Divide |
| 30 | News | Exploratory | Yes | Top-down |
| 31 | News | Exploratory | Yes | Top-down |
| 32 | News | Exploratory | Yes | Top-down |
| 33 | News | Exploratory | Yes | Top-down |
| 34 | News | Exploratory | Yes | Top-down, Divide |
| 35 | News | Exploratory | Yes | Dynamic, Divide |
| 37 | News | Exploratory | No | Top-down |
| 38 | News | Exploratory | Yes | Dynamic |
| 40 | News | Exploratory | No | Dynamic, Divide |

| | | | | |
|---|---|---|---|---|
| 3 | Product | Exploratory | No | Nil |
| 4 | Product | Exploratory | Yes | Top-down |
| 5 | Product | Exploratory | Yes | Top-down, Divide |
| 6 | Product | Exploratory | Yes | Top-down, Divide |
| 7 | Product | Exploratory | Yes | Top down, Divide |
| 8 | Product | Exploratory | No | Bottom-up, divide |
| 9 | Product | Exploratory | No | Nil |
| 12 | Product | Exploratory | Yes | Top-down, Divide |
| 13 | Product | Exploratory | No | Top-down, Divide |
| 14 | Product | Exploratory | No | Top-down |
| 15 | Product | Exploratory | Yes | Parallel |
| 16 | Product | Exploratory | Yes | Top-down |
| 17 | Product | Exploratory | Yes | Top-down, Parallel |
| 18 | Product | Exploratory | Yes | Top-down, Divide |
| 20 | Product | Exploratory | Yes | Top-down |
| 21 | Product | Exploratory | Yes | Top-down |
| 22 | Product | Exploratory | Yes | Top-down, Divide |
| 23 | Product | Exploratory | Yes | Top-down, Divide |
| 24 | Product | Exploratory | Yes | Bottom-up |
| 26 | Product | Exploratory | Yes | Dynamic, Divide |
| 27 | Product | Exploratory | Yes | Nil |
| 28 | Product | Exploratory | Yes | Nil |
| 31 | Product | Exploratory | Yes | Top-down, Parallel |
| 33 | Product | Exploratory | Yes | Parallel |
| 34 | Product | Exploratory | Yes | Divide |
| 35 | Product | Exploratory | Yes | Bottom-up |
| 36 | Product | Exploratory | Yes | Dynamic, Divide |

| | | | | |
|---|---|---|---|---|
| 37 | Product | Exploratory | No | Top-down |
| 38 | Product | Exploratory | Yes | Top-down |
| 40 | Product | Exploratory | Yes | Top-down, Divide |
| 1 | Travel | Exploratory | No | Dynamic, Divide |
| 2 | Travel | Exploratory | No | Nil |
| 3 | Travel | Exploratory | No | Top-down |
| 4 | Travel | Exploratory | No | Nil |
| 6 | Travel | Exploratory | Yes | Top-down, Divide |
| 7 | Travel | Exploratory | No | Bottom-up, Divide |
| 8 | Travel | Exploratory | No | Top down |
| 9 | Travel | Exploratory | Yes | Top-down, Divide |
| 10 | Travel | Exploratory | Yes | Dynamic, Parallel |
| 11 | Travel | Exploratory | Yes | Dynamic |
| 12 | Travel | Exploratory | Yes | Top-down, Parallel |
| 13 | Travel | Exploratory | Yes | Top-down, Divide |
| 14 | Travel | Exploratory | Yes | Top-down |
| 15 | Travel | Exploratory | Yes | Parallel |
| 16 | Travel | Exploratory | Yes | Top-down |
| 17 | Travel | Exploratory | Yes | Top-down, Divide |
| 18 | Travel | Exploratory | Yes | Dynamic, Parallel |
| 19 | Travel | Exploratory | Yes | Top-down |
| 20 | Travel | Exploratory | Yes | Divide |
| 21 | Travel | Exploratory | Yes | Dynamic, Parallel |
| 22 | Travel | Exploratory | Yes | Top-down, Divide |
| 23 | Travel | Exploratory | Yes | Parallel |
| 24 | Travel | Exploratory | Yes | Dynamic |
| 25 | Travel | Exploratory | Yes | Nil |
| 26 | Travel | Exploratory | Yes | Top-down |

| | | | | |
|---|---|---|---|---|
| 27 | Travel | Exploratory | Yes | Top-down, Divide |
| 28 | Travel | Exploratory | Yes | Parallel |
| 29 | Travel | Exploratory | Yes | Top-down, Divide |
| 30 | Travel | Exploratory | No | Top-down, Divide |
| 31 | Travel | Exploratory | No | Top-down, Divide |
| 32 | Travel | Exploratory | No | Dynamic |
| 33 | Travel | Exploratory | Yes | Top-down |
| 34 | Travel | Exploratory | No | Divide |
| 35 | Travel | Exploratory | Yes | Top-down, Divide |
| 36 | Travel | Exploratory | No | Top-down, Divide |
| 37 | Travel | Exploratory | Yes | Top-down, Parallel |
| 39 | Travel | Exploratory | Yes | Top-down, Divide |
| 40 | Travel | Exploratory | Yes | Top-down, Divide |

*Table 4.15* List of participants' task tangibility and search strategies in exploratory tasks

| Participant | Domain | Task Type | Tangibility | Overall Strategy |
|---|---|---|---|---|
| 1 | News | Retrieval | No | Dynamic |
| 2 | News | Retrieval | Yes | Dynamic, Divide |
| 3 | News | Retrieval | Yes | Dynamic |
| 8 | News | Retrieval | No | Bottom-up |
| 9 | News | Retrieval | Yes | Dynamic |
| 10 | News | Retrieval | Yes | Top-down, Divide |
| 16 | News | Retrieval | Yes | Top-down, Divide |
| 19 | News | Retrieval | No | Top-down |
| 20 | News | Retrieval | Yes | Parallel |
| 22 | News | Retrieval | No | Top-down |
| 27 | News | Retrieval | Yes | Bottom-up, Divide |

| | | | | |
|---|---|---|---|---|
| 28 | News | Retrieval | Yes | Nil |
| 36 | News | Retrieval | Yes | Divide, Dynamic |
| 39 | News | Retrieval | Yes | Top-down |
| 1 | Product | Retrieval | Yes | Dynamic, Divide |
| 2 | Product | Retrieval | Yes | Top-down |
| 10 | Product | Retrieval | Yes | Top-down, Divide |
| 11 | Product | Retrieval | Yes | Parallel |
| 19 | Product | Retrieval | No | Top-down |
| 25 | Product | Retrieval | Yes | Divide |
| 29 | Product | Retrieval | No | Bottom-up |
| 30 | Product | Retrieval | Yes | Divide |
| 32 | Product | Retrieval | Yes | Nil |
| 39 | Product | Retrieval | Yes | Divide |
| 5 | Travel | Retrieval | No | Nil |
| 38 | Travel | Retrieval | Yes | Dynamic, Parallel |

*Table 4.16* List of participants' task tangibility and search strategies in retrieval tasks

## 4.5.2 Single search strategy

Participants' searches were classified into five search strategies: *Bottom-up*, *Top-down*, *Dynamic*, *Parallel*, and *Divide-and-Conquer*. However, as participants may exhibit multiple strategies in one search session, some searches were classified as a combination of strategies. These search sessions were thus excluded from the single strategy searches. We first discuss searches that adopted only one single strategy through the entire session.

*Table 4.17* shows the frequencies of single strategy searches in exploratory and retrieval tasks. For exploratory tasks, participants adopted the top-down strategy most often (48%), followed by divide (11.5%), parallel (9.6%), dynamic (7.7%), and bottom-up (5.8%) strategies. Note that 9 out of 52 exploratory tasks (17.3%) did not exhibit any particular search strategy (Nil) because these participants either used only the initial query or relied on browsing to find their search targets. In retrieval tasks, top-down strategy was also the most popular strategy (27.8%), followed by divide and dynamic strategies (both on 16.7%). Bottom-up strategy was more popular (11.1%) with reduced parallel strategies (5.6%), which reflected the more focused nature of the retrieval tasks. An increased proportion of nil strategy (22.2%) in retrieval tasks also indicated the more specific queries which retrieved the search targets without further query reformulation.

| Task Type | Strategy | | | | | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Bottom-up | | Divide | | Dynamic | | Parallel | | Top-down | | Nil | | |
| | Frequency | % | Frequency | % | Frequency | % | Frequency | % | Frequency | % | Frequency | % | |
| Exploratory | 3 | 5.77% | 6 | 11.54% | 4 | 7.69% | 5 | 9.62% | 25 | 48.08% | 9 | 17.31% | 52 |
| Retrieval | 2 | 11.11% | 3 | 16.67% | 3 | 16.67% | 1 | 5.56% | 5 | 27.78% | 4 | 22.22% | 18 |

*Table 4.17* Frequencies of single strategy searches in task types

| Domain | Strategy | | | | | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Bottom-up | | Divide | | Dynamic | | Parallel | | Top-down | | Nil | | |
| | Frequency | % | Frequency | % | Frequency | % | Frequency | % | Frequency | % | Frequency | % | |
| News | 2 | 7.41% | 2 | 7.41% | 4 | 14.81% | 1 | 3.70% | 14 | 51.85% | 4 | 14.81% | 27 |
| Travel | 0 | 0.00% | 3 | 15.79% | 3 | 15.79% | 2 | 10.53% | 7 | 36.84% | 4 | 21.05% | 19 |
| Product | 3 | 12.50% | 4 | 16.67% | 0 | 0.00% | 3 | 12.50% | 9 | 37.50% | 5 | 20.83% | 24 |

*Table 4.18* Frequencies of single strategy searches in search domains

*Table 4.18* shows the frequencies of single strategy searches among the three search domains. Again, top-down strategy was the major strategy in all three domains. Parallel was the least frequent strategy in the news domain (3.7%), indicating more focused searches in news. On the other hand, none of the searches exhibited a bottom-up strategy in the travel domain, suggesting the openness and exploratory nature of travel searches. Product searches showed no dynamic strategy, but a large percentage of nil searches (20.8%), suggested that participants were specific when searching products without the need to try different reformulations of queries.

## 4.5.3 Multiple search strategies

A total of 50 searches demonstrated two search strategies within the search session. *Table 4.19* shows the frequencies of multiple strategy searches in the two task types.

The combination of top-down and divide strategies had the highest frequencies in both exploratory and retrieval tasks. Such strategy manifested that participants divided the search into several aspects around a core concept, and adopted a top-down approach to explore these aspects. The second frequent combination was the dynamic and divide strategies, which characterized searches with a clear core concept but were explored at different levels of specificity around the concept.

Dynamic and parallel combination strategies manifested searches with queries at different levels of specificity without clear core concept terms. However these queries were still related through a higher level concept, although such a concept was absent in the queries. The next frequent strategy was the top-down and parallel combination. This combination strategy occurred when participants gradually used more specific terms to reformulate queries without keeping any core concept terms in the query. The least frequent strategy was the bottom-up and divide combination, which represented searches that started from the most specific aspect of a core concept, and gradually broadened to more general aspects. As with single strategy searches, the bottom-up and divide combination strategy was rarely adopted with only two exploratory and one retrieval searches classified in this strategy. Example searches of each combination strategy are presented at the end of this section.

*Table 4.20* shows the frequencies of multiple strategy searches in search domains. Again, top-down and divide was the most frequent strategy combination in all three domains. Dynamic and parallel was the second frequent in travel searches, whereas dynamic and divide was the second frequent in news and product searches. This seemed to show a preference for the divide strategy in news and product searches, and a preference for the parallel strategy in travel searches. Such findings manifested the most openness in the travel domain, as participants may explore different aspects of the search task in parallel, without always having an obvious core concept in their queries. News and travel were more suitable for the divide strategy, as different aspects were searched around the explicit core concept terms.

| Task Type | Strategy | | | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Bottom-up, Divide | | Dynamic, Divide | | Dynamic, Parallel | | Top-down, Divide | | Top-down, Parallel | | |
| | Frequency | % | Frequency | % | Frequency | % | Frequency | % | Frequency | % | |
| Exploratory | 2 | 4.76% | 5 | 11.90% | 4 | 9.52% | 26 | 61.90% | 5 | 11.90% | 42 |
| Retrieval | 1 | 12.50% | 3 | 37.50% | 1 | 12.50% | 3 | 37.50% | 0 | 0.00% | 8 |

*Table 4.19* Frequencies of multiple strategy searches in task types

| Domain | Strategy | | | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Bottom-up, Divide | | Dynamic, Divide | | Dynamic, Parallel | | Top-down, Divide | | Top-down, Parallel | | |
| | Frequency | % | Frequency | % | Frequency | % | Frequency | % | Frequency | % | |
| News | 1 | 7.69% | 4 | 30.77% | 1 | 7.69% | 6 | 46.15% | 1 | 7.69% | 13 |
| Travel | 1 | 4.76% | 1 | 4.76% | 4 | 19.05% | 13 | 61.90% | 2 | 9.52% | 21 |
| Product | 1 | 6.25% | 3 | 18.75% | 0 | 0.00% | 10 | 62.50% | 2 | 12.50% | 16 |

*Table 4.20* Frequencies of multiple strategy searches in search domains

| Search Engine | Query | Duration |
|---|---|---|
| Google Web | ekka brisbane | 0:04:44 |
| Google Web | ekka photos | 0:00:11 |
| ourbrisbane.com | (browse ekka archival images) | 0:02:01 |
| Google Image | ekka photos | 0:02:48 |
| Google Image | ekka strawberry ice cream photos | 0:00:22 |
| Google Image | ekka show photos | 0:04:26 |
| Google Image | ekka Toyota V6 Hilux Heroes and Showtime FMX | 0:00:20 |
| Google Image | ekka showtime | 0:00:15 |
| Google Image | ekka car showtime | 0:00:35 |

Example Top-down, Divide search (Participant 29, News)

| Search Engine | Query | Duration |
|---|---|---|
| Google Image | sydney | 0:00:42 |
| Google Image | university of sydney | 0:00:20 |
| Google Image | university of sydney, women collage | 0:01:01 |
| Google Web | university of sydney, women college | 0:03:15 |
| Google Map | 15 Carillon Ave, Newtown 2042 | 0:05:24 |
| Google Map | blue mountain, sydney | 0:03:57 |
| Goolge Image | blue mountain | 0:02:08 |

Example Top-down, Parallel search (Participant 12, Travel)

| Search Engine | Query | Duration |
|---|---|---|
| Google Image | afghanistan war people victims 2010 | 0:07:17 |
| Bing Image | afghanistan war people victims 2010 | 0:01:39 |
| Bing Image | afghanistan war victims | 0:03:17 |
| Google Image | afghanistan war smile women | 0:01:07 |
| Google Image | afghanistan war women | 0:04:35 |

Example Dynamic, Divide search (Participant 40, News)

| Search Engine | Query | Duration |
|---|---|---|
| Google AU Web | the best job in the world | 0:00:49 |
| Google AU Video | the best job in the world | 0:00:46 |
| Google AU Web | the best job in the world | 0:00:17 |
| Flickr | | 0:04:53 |
| queenslandholidays.com.au | | 0:04:39 |
| Google AU Web | great barrier reef | 0:01:28 |
| Google AU Web | tourism queensland | 0:04:07 |

Example Dynamic, Parallel search (Participant 23, News)

| Search Engine | Query | Duration |
|---|---|---|
| Google Image | second hand car Toyota "good engine" "trading post" | 0:08:16 |
| Google Image | second hand car "good engine" "trading post" | 0:02:32 |
| Google Image | second hand car "engine reconditioned" "trading post" | 0:06:08 |

Example Bottom-up, Divide search (Participant 8, Product)

# 4.6 Search Term Categorization

A total of 1,609 terms was classified into 15 term categories. *Table 4.21* shows the statistics of each term category among the search domains. *Figure 4.7* depicts the comparison of term category distribution. Similar to other research findings, our participants utilized people, object/product, location, event and subject most to formulate their queries. The average number of terms per session was largest in news searches (17.18 terms), followed by travel (11.6), and product searches (11.45). Although the three search domains had a similar number of terms per session, the types of terms utilized in each domain differed significantly.

| | News | | Travel | | Product | |
|---|---|---|---|---|---|---|
| Term category | Total | Terms per session | Total | Terms per session | Total | Terms per session |
| People | 90 | 2.25 | 19 | 0.48 | 29 | 0.73 |
| Object / Product | 78 | 1.95 | 24 | 0.60 | 187 | 4.68 |
| Location/ Country | 136 | 3.40 | 250 | 6.25 | 22 | 0.55 |
| Organization | 49 | 1.23 | 8 | 0.20 | 53 | 1.33 |
| Event | 116 | 2.90 | 8 | 0.20 | 5 | 0.13 |
| Time | 39 | 0.98 | 4 | 0.10 | 8 | 0.20 |
| Action | 25 | 0.63 | 17 | 0.43 | 9 | 0.23 |
| Subject | 97 | 2.43 | 96 | 2.40 | 75 | 1.88 |
| Emotion | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| Adjective | 32 | 0.80 | 30 | 0.75 | 35 | 0.88 |
| Color | 0 | 0.00 | 0 | 0.00 | 2 | 0.05 |
| Shape | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| Texture | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| Format | 22 | 0.55 | 7 | 0.18 | 30 | 0.75 |
| Unclassify | 3 | 0.08 | 1 | 0.03 | 3 | 0.08 |
| Total | **687** | **17.18** | **464** | **11.60** | **458** | **11.45** |

*Table 4.21* Frequencies of term categories among search domains

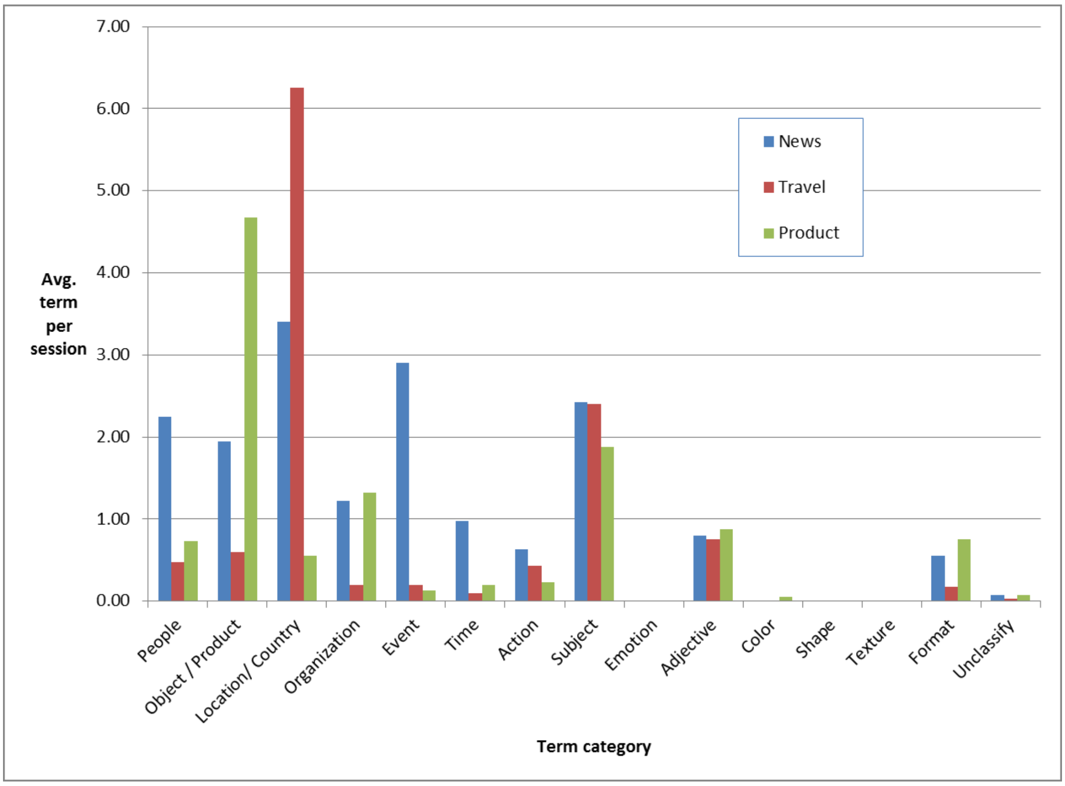



*Figure 4.7* Comparison of distribution of term categories

As *Figure 4.7* depicts, many more people, event, and time related terms were utilized in news searches. Travel searches contained mainly location and subject terms. Product searches clearly contained more object and organization (e.g., company names) terms, with slightly fewer subject terms than in news and travel searches. Interestingly, the only visual aspect utilized in our data sample was color, which appeared in only one participant's search session. This indicated the insignificant importance of visual aspects in Web image searching, which in turn provided one explanation of the low usefulness of content-based searches to general online users. Participants utilized a similar number of adjective terms to refine their queries in all three domains. Format terms (e.g., map, photo, vector) were most used in news and product searches, corresponding to the more specific needs in these two domains.

*Figure 4.8* to *Figure 4.10* illustrate the proportions of term categories within each search domain. News searches contained similar proportions of people (13%), object (11%), location (20%), event (17%), and subject (14%) terms. Travel searches were mostly location (54%) and subject (21%) terms. Product searches were prone to object (41%), organization (12%), and subject terms (16%). It is clear that participants utilized different types of terms in different domains. Hence system's term suggestion function should be able to recommend the types of terms according to users' current search domains.

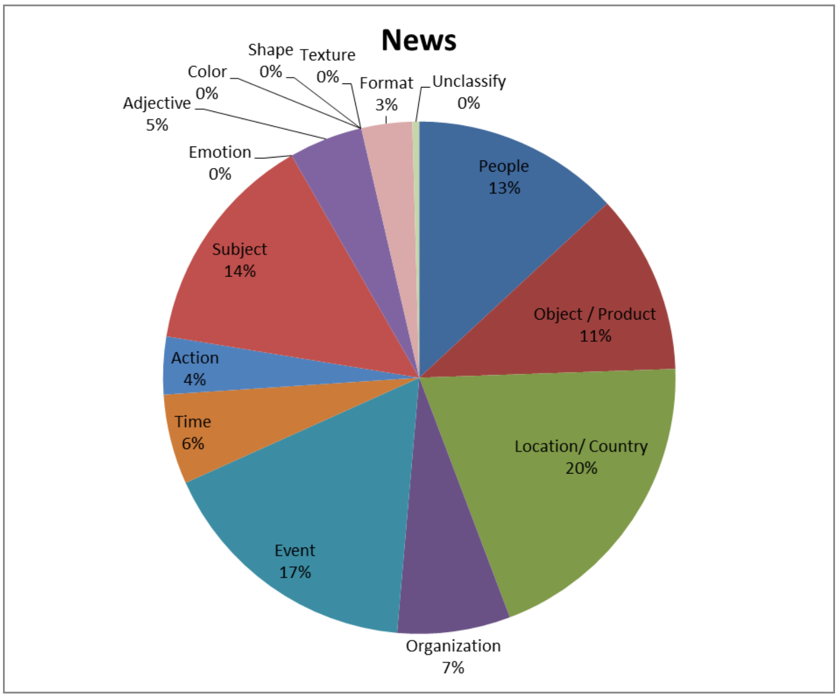



*Figure 4.8* Proportions of term categories utilized in news searches

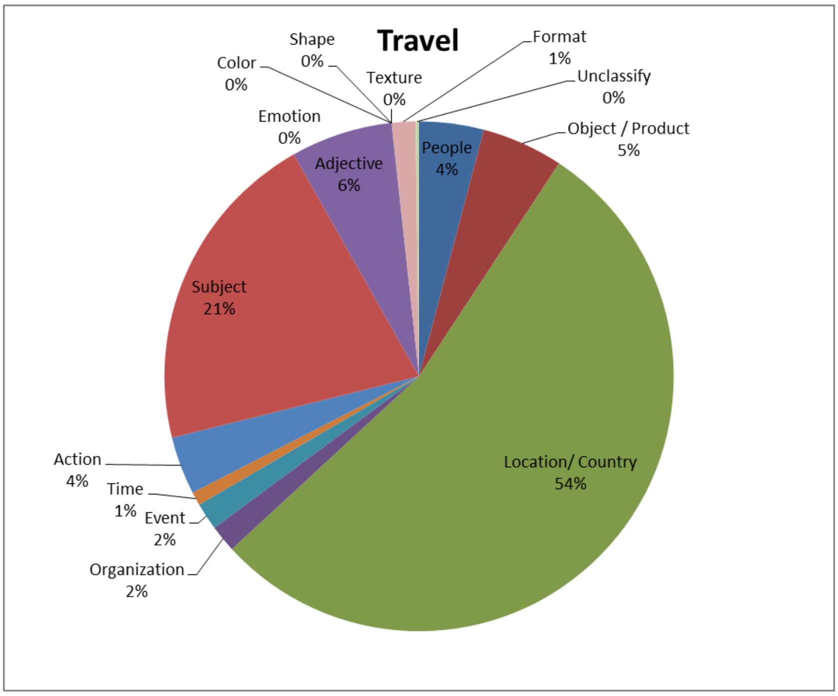



*Figure 4.9* Proportions of term categories utilized in travel searches

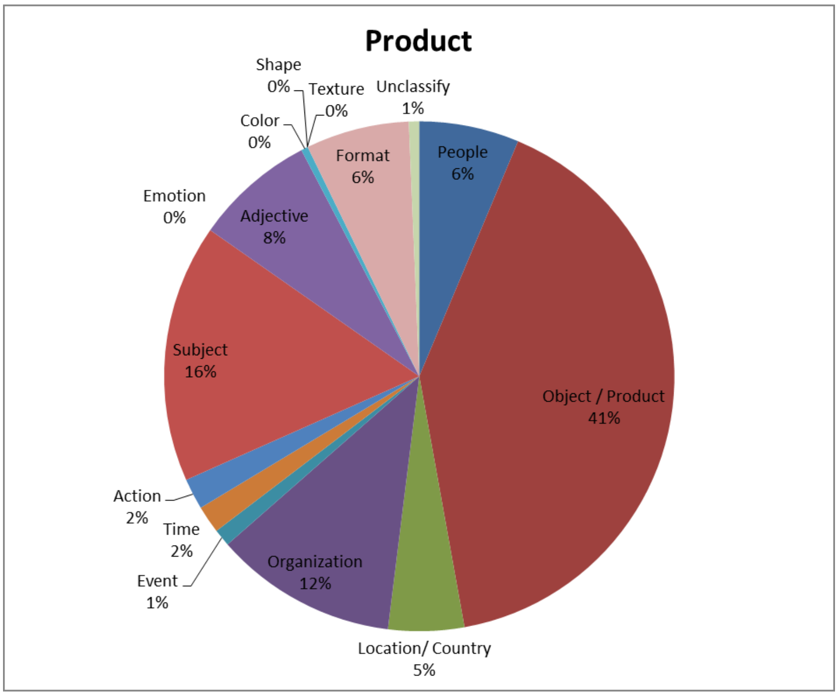



*Figure 4.10* Proportions of term categories utilized in product searches

# 4.7 Common Search Strategies and Query Reformulation Patterns

## 4.7.1 Overall search pattern demographic

By using the Grounded Theory analysis, six search patterns including four search strategies and two query reformulation patterns were categorized with regard to their coded interactive intents. Coded behaviors within each pattern were statistically tested against the rest of our data pool using the Wilcoxon-Mann-Whitney test (non-parametric t-test). *Table 4.22* to *Table 4.24* list the detailed search pattern metrics in news, travel, and product domains respectively. *Table 4.25* shows the frequencies of search domains in each search pattern. *Table 4.26* provides the descriptive statistics of participants' overall demographic, as well as the number of searches in each pattern and the corresponding statistics for contextual factors measured in the pre-search questionnaire.

| Participant | Task | Pattern 1 - Knowledge Expansion | Pattern 2 - Result expansion | Pattern 3 - Result expansion | Pattern 4 - Keyword Overcasting | Pattern 5 - Query Reformulation for Retrieval | Pattern 6 -Query Reformulation for Exploration |
|---|---|---|---|---|---|---|---|
| | | [KEI/KEK] | [RES] | [REA] | | [QRR] | [QRE] |
| 1 | News | | V | | V | | |
| 2 | News | V | V | | V | | |
| 5 | News | | V | V | | | |
| 6 | News | | V | | | | |
| 7 | News | V | V | | | | |
| 8 | News | | V | | | | |
| 9 | News | V | | | | | |
| 10 | News | V | V | | V | | V |
| 11 | News | | V | | | | |
| 12 | News | V | | | | | |
| 13 | News | | | | | | V |
| 14 | News | V | V | | | | |
| 15 | News | | V | V | | | |
| 16 | News | V | V | | | | |
| 17 | News | | | | V | | |
| 19 | News | | V | | | | |
| 21 | News | | V | | | | V |
| 22 | News | | | V | | | |
| 23 | News | | V | V | | | |
| 24 | News | | | | | | V |
| 25 | News | | V | | | | |
| 27 | News | | | | | | V |
| 28 | News | | V | V | | | |
| 29 | News | | V | | | | V |
| 32 | News | | V | | | | |
| 34 | News | V | V | | | | |
| 36 | News | V | V | | V | V | |
| 38 | News | | V | | | | |
| 40 | News | | V | | | | |

*Table 4.22* Search pattern metrics in news searches

| Participant | Task | Pattern 1 - Knowledge Expansion | Pattern 2 - Result expansion | Pattern 3 - Result expansion | Pattern 4 - Keyword Overcasting | Pattern 5 - Query Reformulation for Retrieval | Pattern 6 -Query Reformulation for Exploration |
|---|---|---|---|---|---|---|---|
| | | [KEI/KEK] | [RES] | [REA] | | [QRR] | [QRE] |
| 1 | Travel | | V | | | | |
| 7 | Travel | V | V | | | | |
| 9 | Travel | | | | | | V |
| 10 | Travel | | | | | | V |
| 13 | Travel | | | | | | V |
| 14 | Travel | V | V | | | | |
| 15 | Travel | | | V | | | |
| 16 | Travel | | V | | | | |
| 17 | Travel | | | | | | V |
| 18 | Travel | | | V | | | |
| 21 | Travel | | V | | | | |
| 22 | Travel | | | | | | V |
| 25 | Travel | | V | | | | |
| 26 | Travel | | V | V | | | |
| 27 | Travel | | | | | | V |
| 28 | Travel | | V | | | | |
| 29 | Travel | | | | | | V |
| 30 | Travel | | | | | | V |
| 37 | Travel | | | | | | V |
| 38 | Travel | | V | | | | |
| 39 | Travel | | | V | | | |
| 40 | Travel | | V | | | V | |

*Table 4.23* Search pattern metrics in travel searches

| Participant | Task | Pattern 1 - Knowledge Expansion | Pattern 2 - Result expansion | Pattern 3 - Result expansion | Pattern 4 - Keyword Overcasting | Pattern 5 - Query Reformulation for Retrieval | Pattern 6 -Query Reformulation for Exploration |
|---|---|---|---|---|---|---|---|
| | | [KEI/KEK] | [RES] | [REA] | | [QRR] | [QRE] |
| 6 | Product | | | | | V | |
| 7 | Product | V | | | | V | |
| 10 | Product | | V | | | V | |
| 12 | Product | V | | | | | |
| 13 | Product | V | V | V | | | V |
| 17 | Product | | | V | | | |
| 18 | Product | | | V | | | |
| 19 | Product | | | V | | | |
| 21 | Product | | | V | | | |
| 22 | Product | | V | | | | |
| 24 | Product | | | V | V | | |
| 25 | Product | | V | | | V | |
| 26 | Product | | | | | | V |
| 28 | Product | | | V | | | |
| 29 | Product | | | V | | | V |
| 30 | Product | | V | | | | |
| 31 | Product | | | V | | | V |
| 32 | Product | | | V | | | |
| 33 | Product | | | V | | | |
| 34 | Product | | | | | V | |
| 36 | Product | | | V | | V | |
| 38 | Product | | | | | V | |
| 39 | Product | | | | | V | |
| 40 | Product | V | | | | | |

*Table 4.24* Search pattern metrics in product search

| | Pattern 1 - Knowledge Expansion | | Pattern 2 - Result expansion | | Pattern 3 - Result expansion | | Pattern 4 - Keyword Overcasting | | Pattern 5 - Query Reformulation for Retrieval | | Pattern 6 -Query Reformulation for Exploration | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | [KEI/KEK] | | [RES] | | [REA] | | | | [QRR] | | [QRE] | |
| | Frequency | % | Frequency | % | Frequency | % | Frequency | % | Frequency | % | Frequency | % |
| News | 9 | 60.0% | 22 | 59.5% | 5 | 23.8% | 5 | 83.3% | 1 | 10.0% | 6 | 31.6% |
| Travel | 2 | 13.3% | 10 | 27.0% | 4 | 19.0% | 0 | 0.0% | 1 | 10.0% | 9 | 47.4% |
| Product | 4 | 26.7% | 5 | 13.5% | 12 | 57.1% | 1 | 16.7% | 8 | 80.0% | 4 | 21.1% |
| Total | 15 | | 37 | | 21 | | 6 | | 10 | | 19 | |

*Table 4.25* Frequencies of search domains in each search pattern

From *Table 4.25*, it is clear that news searches exhibited the most proportion of knowledge expansion (KEI/KEK), and the most proportion of result expansion for insufficient results (RES). Product searches required more result expansion for inaccurate results (REA) and more query reformulation for retrieval intent (QRR). Travel searches were prominent in only the query reformulation for exploration intent (QRE) pattern in which the news searches were also frequent.

| Search Pattern | | EXP | FAM* | KNO* | SPE | TAN* | CON* | INI | TQS |
|---|---|---|---|---|---|---|---|---|---|
| Pattern 1 | Mean | 8.93 | 3.73 | 3.20 | 4.20 | 0.87 | 3.40 | 2.73 | 7.00 |
| (N=15) | SD | 3.06 | 0.80 | 1.01 | 0.86 | 0.35 | 0.91 | 1.22 | 3.91 |
| Pattern 2 | Mean | 7.78 | 3.65 | 2.92 | 3.76 | 0.81 | 3.62 | 2.86 | 7.51 |
| (N=37) | SD | 2.98 | 0.98 | 1.34 | 1.12 | 0.40 | 0.95 | 1.21 | 6.28 |
| Pattern 3 | Mean | 8.67 | 3.90 | 3.05 | 3.95 | 0.81 | 3.29 | 2.95 | 5.43 |
| (N=21) | SD | 2.01 | 0.89 | 1.32 | 1.02 | 0.40 | 1.10 | 1.40 | 7.21 |
| Pattern 4 | Mean | 7.33 | 3.83 | 3.67 | 4.67 | 0.67 | 3.50 | 3.33 | 8.17 |
| (N=6) | SD | 2.80 | 0.98 | 1.21 | 0.82 | 0.52 | 0.84 | 0.52 | 5.12 |
| Total | Mean | 7.65 | 3.75 | 2.79 | 3.56 | 0.78 | 3.53 | 2.66 | 4.83 |
| (N=120) | SD | 2.89 | 0.95 | 1.24 | 1.22 | 0.42 | 1.00 | 1.23 | 4.37 |
| *data with no significant difference among patterns | | | | | | | | | |

*Table 4.26* Statistics of participants' demographic data in all patterns

As *Table 4.26* shows, there were no significant differences found in participants' search engine familiarity (FAM), personal knowledge (KNO), task tangibility (TAN), and nominated concepts for search (CON). Hence, participants in each search pattern did not seem to have search backgrounds that were different from others. In other words, it was their search contexts (i.e., search topic, task type, and the searching process) that resulted in different search patterns. Pattern 1, 2, and 4 participants significantly submitted more queries per session (TQS), and pattern 4 participants also had significantly higher task specificity (SPE).

### 4.7.2 Pattern 1 – Textual search for knowledge expansion [KEI/KEK]

*The indivisible part of textual and image searches, sometimes when the target images are specific but users only have limited ideas or lack of knowledge to describe their search target (e.g., knowing little about the terms that best represent the target images)*

When searching for a specific set of images with a limited set of concepts or keywords in mind, participants tended to start with Web searches because they presume a Web search should give them more ideas about the target. The Web search results are used to generate more ideas about their image problems or to expand their knowledge of the search topic, both of which can help consolidating their search needs. This search pattern is often characterized by intensive browsing or term discovery from the Web search results.

*Examples:*

Participant 14 wanted to find some news pictures of the Queen's birthday in UK and Australia but the first few Web and image search results were showing only irrelevant images. She went on to *BBC UK* website and read some more articles about this news, from which she found the term 'official celebration' and subsequently used that term to find a collection of Queen's birthday celebration images.

*I actually want to find the news…news agencies like ABC or BBC news to report Queen's birthday event…I need pictures, how people celebrate in UK and Australia [02:24] [KEI]*
*Yeah, I think maybe I found some keywords here, official celebration…maybe I can try that keyword [08:44] [TD]*
*I don't think this is this year…just to check…oh, yes, this is 2009 [11:46]…A lot of information in BBC News [14:00] [KEI]*

In other situations, even if users are clear about the target or the keywords for search, they may still want to check the Web first to see if there is something that they may not think of, or may take the unexpected results as a 'bonus' to their search tasks.

*Examples:*

Participant 7 started his all three searches in Google Web as he claimed this is his habit to start a search, as Google also includes image results in its Web search results. When the results are not sufficient or satisfying enough, he would then try Google Image.

*I usually start my search from Web, because Google also includes some images in Web search results [00:30]*
*If I cannot see what I want, I'll then switch to Image search [00:53]*
*So, as usual, I start with Web search [13:34]*

In cases that actually started with image searches, there may still be some stages in which users need to cross-check with Web content in order to confirm the validity of the retrieved images, or to find more useful terms for better search results.

*Examples:*

<u>Participant 10, News</u>
Participant searched on images of the recent crash of *AirFrance* in Brazil. However he accidentally picked up the wrong flight number but was able to find the correct one from Web search results later on.

*Most of the images seems to be related to the one that happened a few years ago…what's that called? The Continental? [01:30]…whatever, it's not the one I'm looking for, I'm looking for the one that only happened few days ago [01:39]*
*I think I need to go to Google Web search to find some keywords, some text information to help me reformulate my query [03:13] [KEK]*
*I'll start with my initial query…so that's the problem, it's not French airline, that means my initial query was not correct, it's "AirFrance"… [03:43] [TD]*
*So we can have the Flight 358 there, and see whether we can use this flight number to specify the query [05:10]*
*Good, this seems much better [05:20]…oh no, that's not the one…[05:50]*
*"Brazil confirms AirFrance jet crashed in ocean…" that's the correct news [06:20]…Ok, it's flight 447 [06:28] [TD]*

<u>Participant 16, News</u>
Participant mistakenly used "air Canada crash" in Google Image search to search for the news of the recent AirFrance airplane crash. It was not until he tried Google Web

search to find more information about the crash that he finally realized that it was actually the AirFrance which had crashed.

*I'm going to search about the Air Canada plane which just crashed [00:30]*
*Because I'm not sure about the news…I need to find the news first before finding the images [03:44] [KEI]*
*I'm looking for the dates only [09:24]…maybe I thought of wrong keywords [09:34]*
*Maybe it's not Air Canada [10:07]*
*Ok, so I made a mistake…should be Air France [10:24] [TD]*

<u>Participant 2, News</u>

After failing to retrieve useful images from Google Image search, the participant switched to Google News with the query identical to the initial query and specified 2008 archive in the date filter. She found a news headline of "Brisbane storm brings worst flooding in decades" and an image gallery which satisfied her search criteria for the storm in November, 2008. After reviewing the galley she went back to Google Image and replaced 'storm' with the newly acquired keyword 'flooding'. This time the results became much closer to what the participant had anticipated.

*Maybe I check news…storm news (switch to Google News) [12:39] [KEI]*
*(select "2008" archive from side menu) [13:05]*
*(clicked on one news titled "Brisbane storm brings worst flooding in decades") [13:15]*
(*participant checked the date of the news video and confirmed that the news happened in November 2008, and on the same page she finally found one news image archive containing pictures she wanted) [14:27]*
*I've found the keyword "worst flooding"…(used "flooding" in previous news search query and switched to image search)…now I will find pictures in this [18:04] [TD]*

<u>Participant 36, News</u>

Participant used Google Web to discover that it was the 'hinge' part of Maclaren strollers that was being recalled, and consequently found images of the problematic hinge mechanism; Google Web was then used to search for Maclaren stroller's recall news to verify the stroller's hinge image retrieved from Google Image

*I'm looking at the recall notice from Maclaren's official website [02:03]…so it is the stroller hinge mechanism, I'll copy it [02:21] [KEK] [TD]*
*Cover that hinge…would they have the image for it? [04:15]*
*I'll search for the (recall) news first [06:12] [KEI]*
*(clicked on news articles) No images…maybe I should focus on hinge, because every news mentioned about hinge [07:57]*
*There it is…but it's a video [08:08]*
*So…it's actually the images I've seen before [09:17]*
*I think there's none (relevant images)…maybe this is very recent news, the image search may not have been updated yet [11:03]*

In some extreme cases, participants did not utilize image search at all, merely browsing the images contained in the Web pages was enough to satisfy their needs. In these cases, conducting Web searches to find websites that potentially contained the target images was more important to their searches, despite that their search goals were still images. This usually happened when participants already had sufficient knowledge about the information source (i.e. particular websites in our user studies), and thus needed only to browse on the website to obtain the information they needed.

*Examples:*

<u>Participant 4, News</u>

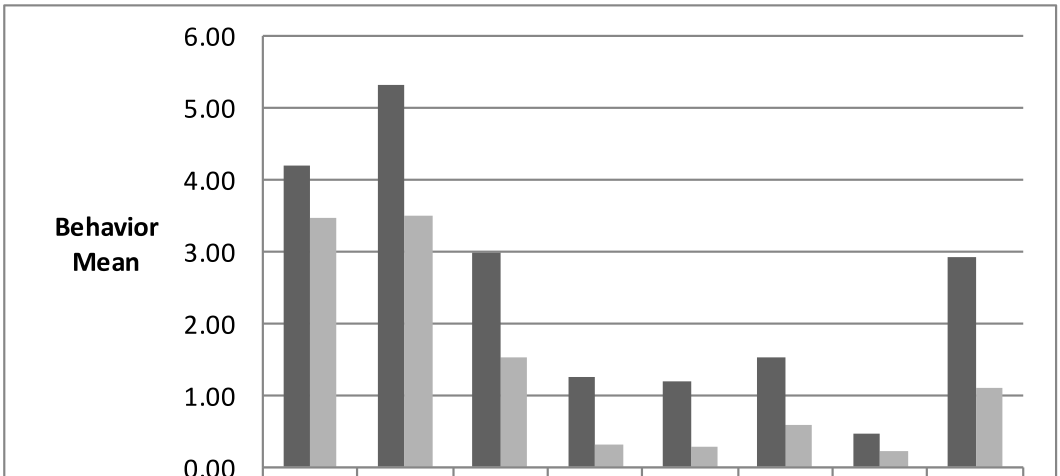
Participant first used Google Web to search for known car review websites, then navigated to *carsguide.com.au*, which is known for plenty of car information and reviews. He browsed three pages in the news section looking for sports cars that suit his need, predetermined by the look and the brand of the car. Participant then switched to *drive.com.au*, another website he knew.

*I know this website (carsguide.com.au), they have many car reviews, so I usually go to this site or carsales.com.au [01:02]*

*I also remember drive.com.au [05:56]*

The Wilcoxon-Mann-Whitney test results in *Figure 4.11* showed that pattern 1 participants had significantly higher task specificity (SPE), performed more browsing activity (IB and SB), and experienced more term discovery (TD) which all corresponded to our observation and assumptions. The more switching to image search (SI), and replacing with related terms (RR) while deleting the original terms (DO), were the new behaviors we did not expect when formulating the assumptions, and will be discussed next.

In order to facilitate the statistical analysis for significant behavior among search patterns, a new factor was also introduced, the Comparing Result (CR) score. This score is the sum of switching to image search (SI), switching to Web search (SW), switching search engine (SS), and switching search content (SC) values. The CR score presents the times of switching among search modes within a search session, regardless the specific types of switching. The significantly higher CR in pattern 1 participants manifested that participants constantly compared different results from different search modes, which further indicated the indivisible nature of image searches with other search modes.




| | SPE* | IB | SB | TD | SI | RR | DO | CR |
|---|---|---|---|---|---|---|---|---|
| Pattern 1 | 4.20 | 5.33 | 3.00 | 1.27 | 1.20 | 1.53 | 0.47 | 2.93 |
| Non-Pattern 1 | 3.47 | 3.50 | 1.54 | 0.31 | 0.30 | 0.58 | 0.22 | 1.10 |

*Figure 4.11* Significant behavior differences from pattern 1 (KEI/KEK)

### 4.7.3 Pattern 2 – Result expansion for sufficiency improvement [RES]

*The comparison of different search results from different search engines or collections due to limited results retrieved or localized search topics*

Sometimes participants need to compare the results from different search engines, not only because they are not satisfied with the current results, but also because different results may enrich their thinking toward the current search task.

*Examples:*

<u>Participant 15</u> initially used *DW-World.de* as the first choice search engine for the AirFrance crash news because she trusted the European media more, especially for European news. The participant then compared the results with Google Web and Image search due to the lack of images from *DW-World.de* news articles.

*I'm 100% sure I can find the news on this website…it's a Germany website…it provides news in about 20 different languages [02:48]*
*(In world news section, found the article about the AirFrance crash at the bottom of first page) This is what I want…I'll read both English and Germany version, usually I read the Germany one first [04:20]*
*I'll use Google to search more…Usually when I search on "AirFrance", Google will give me the official website for the company, but this is not what I want [05:46] [RES]*
*(clicked on the news result section from Google Web search) Ok, basically this is what I want [06:08]*

<u>Participant 14, Travel</u>
Participant wants to go to beach and relax. She needs to find the beaches that are nearby Brisbane city. She carefully read through the description/details of several

beaches, such as Redcliffe or Sunshine Coast. However the images provided on the website were very limited so the participant decided to switch to Google Image.

*Beaches close to Brisbane…Oh Redcliffe, yes! I think Redcliffe is close [21:48]*
*Any other picture about Redcliffe? Only this one? [23:32][RES]*
*(In Google Image) Redcliffe Brisbane, they have so many pictures here [25:21]*

<u>Participant 10, News</u>

After using 'wreckage' with several other combinations to reformulate the image queries, such as 'jet' and '447', participant used Yahoo to search for the wreckage images of the airplane since Yahoo had a large image collection of this crash news. However he failed to retrieve any images from Yahoo, and Google Image did not have any better results either. Finally the participant lost his patience and gave up the search. He concluded that the Yahoo news image collection was the best results he could find for this search task.

*Considering that biggest 282 image collection is found from Yahoo, I have reasons to believe Yahoo may have better results than Google Image, so let's have a look at Yahoo [15:57] [RES]*
*Too bad, not any result, that adds one more reason not to like Yahoo [16:48]*
*But "storm" doesn't help as well, I think I'll have to give up, I guess I have lost my patience about this [17:39]*
*I not satisfied with the result, but I'm partially satisfied with the biggest image collection found from Yahoo [17:59]*

<u>Participant 16, News</u>

After finding that it was an AirFrance airplane which had crashed instead of the Air Canada that he initially thought, participant compared results from Google Image and Bing for AirFrance crash news, and explored related keywords such as 'wreckage', 'inside', and 'after crash'.

*Just the airplane itself…it's not what I want, I'm looking for the after crash news*

*images [11:20]*
*So you want to see the wreckage? Yes, so maybe I add 'wreckage'…[11:27]*
*Looks like there's nothing more [12:44]…let's try another search engine [12:54]*
*[RES]*

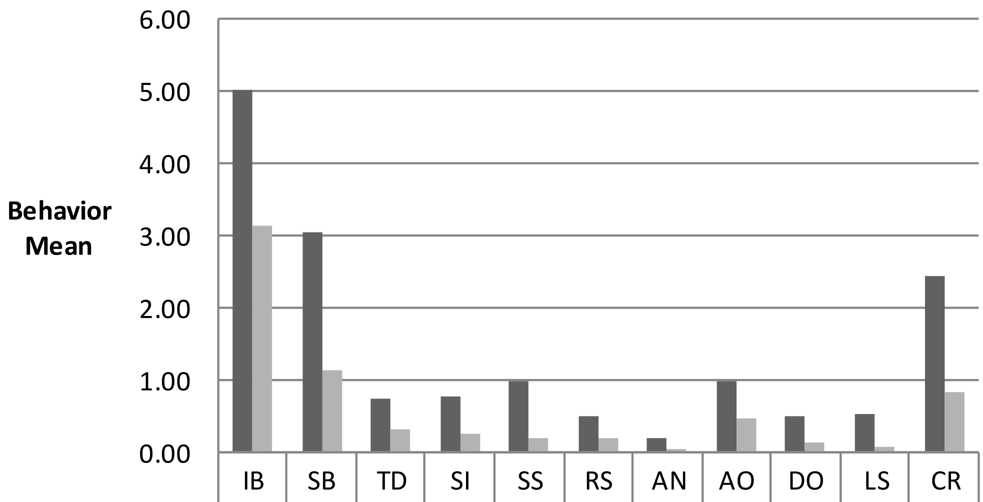
In cases where the search task involved some regional information, participants may tend to trust some localized resources more, especial for news related topics.

Participant 13, Product

Participant started with Google Web initially because he needed the descriptions about the jeans as well. The English search query did not return any results that particularly interested him, so he switched to Google Web Taiwan to search in Chinese and replaced 'outlet' with the Chinese term '養褲' (Yang-ku) which means the process of gradually making new jeans look like used ones. He used this term because he was only interested in jeans that are suitable for this kind of purpose. He then found a link to some Taiwanese jeans lovers' blog, from which he learned a new brand of 'Hysteric Glamour' jeans. He also reviewed the history of this jeans brand and some product images which convinced him that this was the style he wanted.

*I plan to start from Web searches because I cannot know the descriptions from image [35:22] [KEI]*
*(no results seemed to interest participant, thus switched to Google TW) [RES]*
*"Jeans Talk - The must buy jeans blog"…I'll have a look to see why everyone needs to buy this one and how to "Yang-ku" [38:09]*
*Although I want to find the jeans, but this series of images (on the blog) helped me understand the style so I can decide whether to keep searching on this [40:52]*

*Figure 4.12* showed that pattern 2 participants significantly more switching search engines (SS) and more switching to image searches (SI), performed more browsing (both IB and SB) and several types of query reformulations such as replacing with synonyms, adding original term and deleting original term (RS, AO, and DO). Most importantly, the localized search (LS) and comparing results (CR) were significantly higher as well. Compared to pattern 1, the significantly more use of SS, AO, and DO characterized pattern 2 searches. While more SS and CR clearly manifested the comparison among different search engines, the significant higher AO and DO indicated the need to submit the same set of queries in order to compare the results from multiple search engines (i.e. deleting the original term when switching to a new search engine and subsequently adding the original term back). Overall, both pattern 1 and pattern 2 have significant more CR than the rest of population, thereby confirming the need for result comparison in these two search patterns.




| | IB | SB | TD | SI | SS | RS | AN | AO | DO | LS | CR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Pattern 2 | 5.03 | 3.05 | 0.73 | 0.76 | 0.97 | 0.49 | 0.19 | 0.97 | 0.51 | 0.54 | 2.43 |
| Non-Pattern 2 | 3.14 | 1.13 | 0.30 | 0.25 | 0.20 | 0.18 | 0.04 | 0.47 | 0.13 | 0.06 | 0.83 |

*Figure 4.12* Significant behavior differences from pattern 2 (RES)

## 4.7.4 Pattern 3 – Result expansion for accuracy improvement [REA]

*The use of domain-specific collections or websites for experience users to improve result accuracy*

When search task clearly involves some domain specific collection or knowledge, participants may utilize websites that are specialized in providing the domain-specific information if participants have prior experience or knowledge about the target domain. This was especially important when participants failed to improve result accuracy from general Web search engines. Particularly, searching on blog articles (and the accompanying images) had been claimed by our participants as a very useful approach for travel search tasks. The main reason was that participants were more prone to trust information or opinions provided by other users rather than from some profit-oriented organization such as travel agencies.

*Examples:*

<u>Participant 14, News</u>

Participant found many stamp images of the Queen's birthday, but she wanted to focus on the celebration event itself or the images that can report the particular event. Thus the participant went to BBC UK to search for news on the Queen's birthday event. She chose this website because she knew that BBC is one of the major news media of British news, which suits the purpose of current search task.

*It's all stamps here, see? [05:11]*
*But I want to find the images of the event, the news agency report of the event on the day, not the stamp or other pictures [05:30] [REA]*
*I would like to go to BBC…when I want to browse news around the world, I use BBC news, they have a search function [06:46] [DS]*

<u>Participant 13, Product</u>

After finding the particular jeans of interest from someone's blog, the participant used online stores to search for the images and prices of this particular jeans.

*I want to find the jeans they don't sell in Taiwan… (back to the "Hysteric Glamour jeans" in blog) so in the end, this is still the one [50:18]*
*I don't know whether this is a Japanese brand or America brand …*
*(copied "Thee Hysteric XXX") [50:58] [TD]*
*I still can't find anything I want even using Chinese [52:42] [REA]*

*This is the outlet website…oh, since this outlet has the brand, it would be easy then…I can see the price straightaway [54:30] [DS]*
*Hmm…this is what I want [55:23]…so I can find out where the outlet is and with the brand name…then I can send to my friend [55:54]*

Participant 15, News

Participant used DW-World.de to find the news of AirFance crash because participant knew it to be a Europe-oriented news website.

*I was interested in this particular news because I'm very cautious about airline safety [02:05]*
*I'm 100% sure I can find the news on this website…it's a Germany website…it provides news in about 20 different languages [02:48] [DS]*
*(In world news section, found the article about the AirFrance crash at the bottom of first page)*
*This is what I want…I'll read both English and Germany version, usually I read the Germany one first [04:20] [REA]*

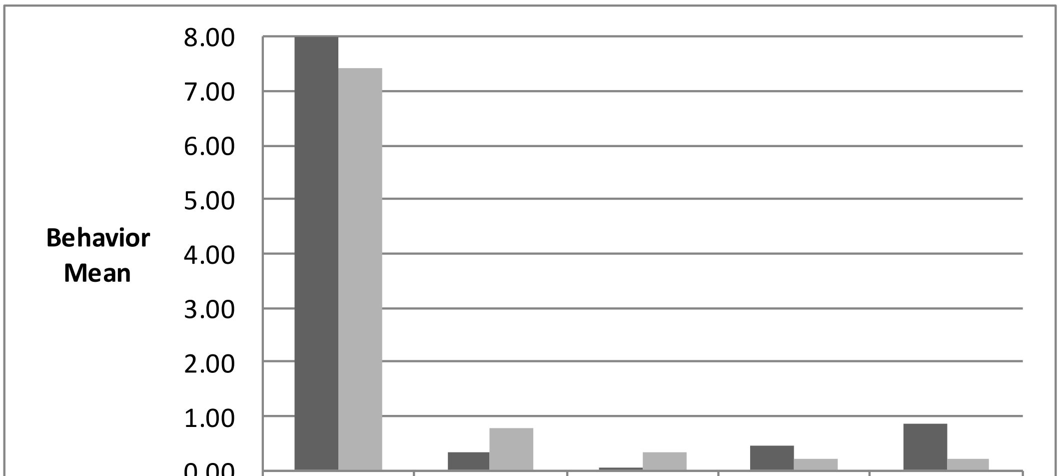
Participant 28, News

Participant went directly to Yahoo Finance and HSBC HK websites for currency exchange diagram, and later on compared results from Google Web to show that the domain specific search provided much better results.

*Usually, I'll go straight to Yahoo Finance, which is the first result from Google [00:36]*
*(in Finance News) Usually, you can see some exchange rate news here [01:10] [DS]*
*There's the graph…I usually need this exchange graph for the recent 5 days or 3 months data to see the trend [02:05] [REA]*
*Because this website…basically it updates every minute…so the information is the most up to date [02:58]*
*(in HSBC website) It's all text…don't they have the graph?...I'll search on Google [05:41] [REA]*

*(Google Image result) but these are not up to date, they are mainly the historical data [10:14]…so it's better to use Yahoo Finance [10:21]*

As predicted, *Figure 4.13* showed significantly higher search experience (EXP) and more domain-specific searches (DS) from this search pattern. Interestingly, the higher frequency of replacing with new terms (RN) may indicate the gaining of new knowledge or terms while searching on the domain-specific websites. The fewer replacing with related terms (RR) and replacing with synonyms (RS) also suggested the exploratory style of query reformulation under this pattern.




| | EXP* | RR* | RS* | RN | DS |
|---|---|---|---|---|---|
| Pattern 3 | 8.67 | 0.33 | 0.05 | 0.48 | 0.86 |
| Non-Pattern 3 | 7.43 | 0.78 | 0.32 | 0.21 | 0.21 |

*Figure 4.13* Significant behavior differences from pattern 3 (REA)

### 4.7.5 Pattern 4 – Results biased by search engine preferred keywords

*The masking effect from search engine preferred keywords in the search results*

When the query contains some search engine preferred keywords (e.g., the keywords that have been indexed from many resources and searched by many users), these keywords appeared to be masking the effect of other keywords. As a consequence, the results are heavily biased to these search engine preferred keywords, with hardly any matches from other keywords. Image users sometimes suffer from this problem because images can be indexed by many different aspects but search engines are generally not sensitive enough to detect the particular aspect from users' queries. A relevance feedback mechanism may be useful for users to actively fine tune the weighting of each keyword. However such an approach seems impractical given the short period of general Web search sessions. In this pattern, participants constantly switched between search modes and used the newly discovered terms to test if the search results could be improved.

*Examples:*

<u>Participant 2, News</u>

When the participant used 'storm' as the search term, many results retrieved were lightning images, despite the images of 'flood' were actually closer to participant's concept of the storm.

*There are even some pictures about sports! Actually I want to see images about the flooded water, not lightning or thunder storms… [01:04]*

<u>Participant 10, News</u>

The term 'airline crash' was the popular keyword that masked the effect of 'Brazil' in the same query.

*I now put "brazil" to the query where the airplane crashed just few days ago [02:20]*

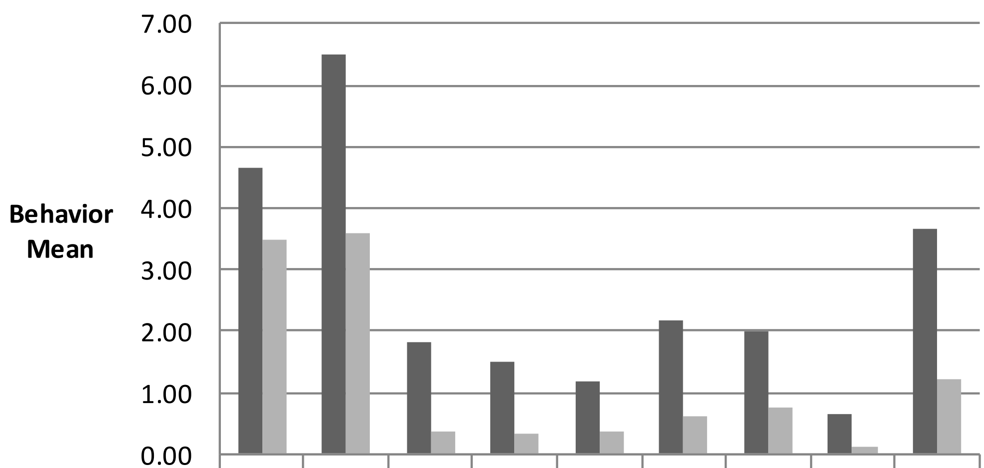
*I think I need to go to Google Web search to find some keywords, some text information to help me reformulate my query [03:13]*

<u>Participant 36, News</u>

The keyword 'Maclaren' masked the keyword 'recall', resulting in images mainly of the strollers and the photos of Maclaren's designer. Participant then switched to Web search and discovered that it was the stroller's hinge that caused this problem and was able to used 'hinge' to continue the search.

*It shows a lot of car images…did I spell it (Maclaren) wrongly? [01:13]*
*(switched to Google Web)*
*I'm looking at the recall notice from Maclaren's official website [02:03]…so it is the stroller hinge mechanism, I'll copy it [02:21]*

Although the occurrence of this search pattern seemed to be more random than other patterns, and thus is difficult to predict, some behaviors still significantly differed from the rest of our population. As shown in *Figure 4.14*, the much higher switching between Web and image (SW and SI), together with more intensive browsing (IB) and term discovery (TD), indicated the frequent switching of search modes in order to compare results and discover potentially useful terms for query reformulation. The more use of replacing with related or original terms (RR and RO), as well as the deletion of new terms (DN), suggested trials of different term combinations, including the originally nominated and newly discovered terms. Overall, participants in this pattern had higher task specificity (SPE), which may result in higher motivation for continuously trying to find the best results.




| | SPE | IB | TD | SW | SI | RR | RO | DN | CR |
|---|---|---|---|---|---|---|---|---|---|
| Pattern 4 | 4.67 | 6.50 | 1.83 | 1.50 | 1.17 | 2.17 | 2.00 | 0.67 | 3.67 |
| Non-Pattern 4 | 3.50 | 3.58 | 0.36 | 0.33 | 0.37 | 0.62 | 0.75 | 0.11 | 1.20 |

*Figure 4.14* Significant behavior differences from pattern 4 (masking effect of search engine preferred keywords)

## 4.7.6 Effects of task domain on overall searching behavior

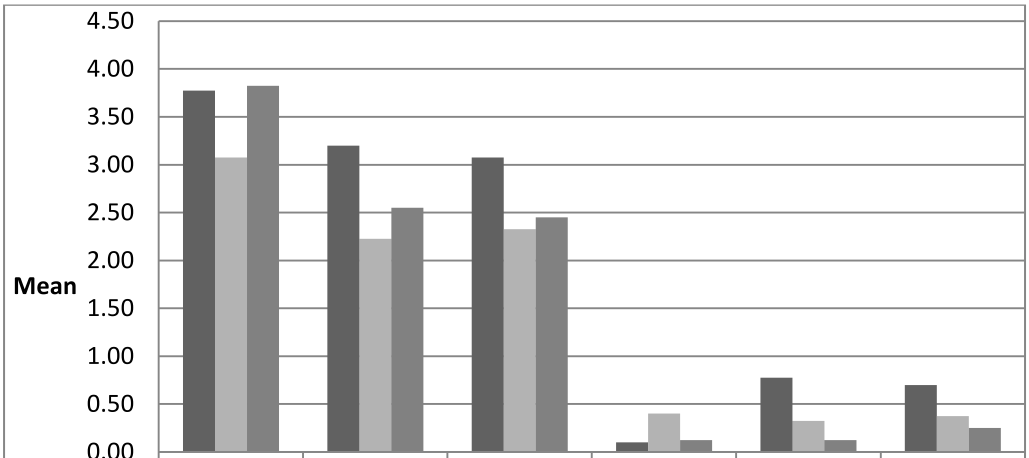
*Table 4.27* shows that our participants possessed similar levels of knowledge (KNO) across the three search domains. They nominated slightly more concepts (CON) in news searches than in travel and product searches. They also formulated more queries in travel searches, followed by news and product searches, as shown in the total queries per session (TQS). Finally, participants performed more intensive browsing (IB) and serendipity browsing (SB) in news. The completion level (COM) was similar across all search domains. However, the statistical testing shows no significant difference among these factors.

*Figure 4.15* depicts factors that were significantly different among the search domains. Task specificity was higher in news and product searches and lowest in travel (chi-square=8.40, df=2, $p$=0.015). Participants utilized the most terms to formulate initial queries (INI) in news searches, and the least terms in travel searches (chi-square=12.92, df=2, $p$=0.002). News searches were significantly more difficult (DIF) than the other two (chi-square=7.60, df=2, $p$=0.022), which resulted in more switching from Web to image search (SI, chi-square=22.14, df=2, $p$<0.001), and switching between search engines (SS, chi-square=7.239, df=2, $p$=0.027). The highest intensive browsing (ID) in travel searches suggested the more exploratory tasks in the domain, as participants intensively browsed for new or interesting information.

Overall, our result shows that participants were most specific in product searches with the highest task specificity and personal knowledge. On the contrary, travel searches showed more openness as they had the lowest task specificity and the least terms in initial queries. News searches can thus be perceived as the most complex task, as shown by the most nominated concepts and initial query terms, as well as the most browsing activities. These results are in line with general expectations and thus representative of the characteristics of public Web image searches.

| | | KNO | CON | COM | TQS | IB | SB |
|---|---|---|---|---|---|---|---|
| News | Mean | 2.70 | 3.63 | 4.18 | 4.88 | 4.03 | 2.18 |
| | SD | 1.30 | 0.95 | 1.06 | 3.69 | 2.20 | 2.66 |
| Travel | Mean | 2.70 | 3.60 | 4.23 | 5.43 | 3.88 | 1.38 |
| | SD | 1.18 | 1.01 | 0.89 | 5.66 | 2.55 | 1.66 |
| Product | Mean | 2.98 | 3.38 | 4.40 | 4.20 | 3.28 | 1.63 |
| | SD | 1.23 | 1.05 | 1.03 | 3.44 | 1.84 | 2.37 |
| Total | Mean | 2.79 | 3.53 | 4.27 | 4.83 | 3.73 | 1.73 |
| | SD | 1.24 | 1.00 | 0.99 | 4.37 | 2.22 | 2.28 |

*Table 4.27* Statistics of non-significant image searching factors among search domains




| | SPE | INI | DIF | ID | SI | SS |
|---|---|---|---|---|---|---|
| News | 3.78 | 3.20 | 3.08 | 0.10 | 0.78 | 0.70 |
| Travel | 3.08 | 2.23 | 2.33 | 0.40 | 0.33 | 0.38 |
| Product | 3.83 | 2.55 | 2.45 | 0.13 | 0.13 | 0.25 |

*Figure 4.15* Factors with significant differences among search domains

### 4.7.7 Effects of retrieval intent on query reformulation [QRR]

Some common query reformulation patterns were discovered from the qualitative analysis of searches with retrieval intent. In particular, we found that when search tasks involved some specific items or scenes that were difficult to describe, participants tended to reformulate the queries by interchanging several semantically similar terms. They adopted this approach to find the query that best described the particular target in mind, or the query that retrieved the most relevant results. Such search pattern was characterized by having a set of constant terms as the core concept across all query reformulations, while substituting other terms with similar meanings.

*Examples:*

Participant 10, Product (used 'Google phone' as the core concept and interchanged 'parts', 'disassemble', 'disassembly' and 'separate' to find images of the disassembled Google phone)

| Search Engine | Query | Change Type | Page Viewed | Duration | Start | End |
|---|---|---|---|---|---|---|
| Google Image | google phone | I | 5 | 0:01:11 | 0:29:07 | 0:30:18 |
| Google Image | google phone parts | A | 5 | 0:02:48 | 0:30:18 | 0:33:06 |
| Google Image | google phone parts disassemble | A | 1 | 0:00:22 | 0:33:06 | 0:33:28 |
| Google Image | "google phone" parts disassemble | R | 2 | 0:01:56 | 0:33:28 | 0:35:24 |
| Google Image | "google phone" parts disassemble separate | A | 5 | 0:01:20 | 0:35:24 | 0:36:44 |
| Google Image | "google phone" disassemble separate | D | 1 | 0:01:21 | 0:36:44 | 0:38:05 |
| Google Web | "google phone" disassemble separate | C | 1 | 0:02:29 | 0:38:05 | 0:40:34 |
| Google Web | "google phone" disassembly separate | R | 1 | 0:00:24 | 0:40:34 | 0:40:58 |
| Google Web | how to "google phone" disassemble | R | 1 | 0:04:39 | 0:40:58 | 0:45:37 |
| Google Web | how to G1 "google phone" disassemble | A | 2 | 0:02:05 | 0:45:37 | 0:47:42 |

Participant 25, Product (interchanged with 'cardbox', 'paper', 'brown paper', 'brown card', 'card box', 'paper card box', and 'paper box' to describe the target camera which was made from cardboard)

| Search Engine | Query | Change Type | Results Viewed | Page Viewed | Duration | Start | End |
|---|---|---|---|---|---|---|---|
| Bing Image | lomo cardbox camera | I | 0 | 1 | 0:00:14 | 0:26:46 | 0:27:00 |
| Bing Image | lomo cardbox | D | 0 | 1 | 0:00:22 | 0:27:00 | 0:27:22 |
| Bing Image | lomography camera paper | I | 4 | 1 | 0:06:33 | 0:27:22 | 0:33:55 |
| Bing Image | lomography camera brown paper | A | 0 | 1 | 0:00:45 | 0:33:55 | 0:34:40 |
| Bing Image | lomography camera brown card | R | 0 | 1 | 0:00:50 | 0:34:40 | 0:35:30 |
| Google Image | lomography camera paper | RC | 0 | 8 | 0:00:58 | 0:35:30 | 0:36:28 |
| Google Image | lomography camera cardbox | R | 0 | 10 | 0:01:07 | 0:36:28 | 0:37:35 |
| Google Image | lomography camera card box | R | 0 | 10 | 0:02:10 | 0:37:35 | 0:39:45 |
| Bing Image | lomography camera paper card box | AC | 0 | 1 | 0:00:25 | 0:39:45 | 0:40:10 |
| Bing Image | lomography camera paper box | D | 0 | 1 | 0:00:52 | 0:40:10 | 0:41:02 |
| lomography.com | (browsing for product categories) | | | | 0:03:20 | 0:41:02 | 0:44:22 |
| Google Web | lomography japan website | RC | 1 | 1 | 0:00:09 | 0:44:22 | 0:44:31 |
| lomography.jp | (browsing for product categories) | | | | 0:05:11 | 0:44:31 | 0:49:42 |

Participant 36, News (Maclaren stroller's recalled 'hinge mechanism' was gradually replaced by 'hinge cover' and 'hinge dangerous' to find the exact image of the faulty hinge part)

| Search Engine | Query | Change Type | Results Viewed | Page Viewed | Duration | Start | End |
|---|---|---|---|---|---|---|---|
| Google Image | maclaren recall parts | I | 0 | 1 | 0:00:42 | 0:00:43 | 0:01:25 |
| Google Web | maclaren recall parts | C | 1 | 1 | 0:01:23 | 0:01:25 | 0:02:48 |
| Google Web | maclaren recall stroller's hinge mechanism | R | 2 | 1 | 0:00:36 | 0:02:48 | 0:03:24 |
| Google Image | maclaren recall stroller's hinge mechanism | C | 0 | 3 | 0:01:24 | 0:03:24 | 0:04:48 |
| Google Web | maclaren recall stroller hinge cover | RC | 1 | 1 | 0:01:38 | 0:04:48 | 0:06:26 |
| Google Web | news maclaren stroller recall | R | 2 | 2 | 0:04:18 | 0:06:26 | 0:10:44 |
| Google Image | maclaren stroller hinge dangerous | RC | 0 | 1 | 0:00:39 | 0:10:44 | 0:11:23 |
| Google Web | maclaren stroller hinge dangerous | C | 3 | 3 | 0:01:32 | 0:11:23 | 0:12:55 |

Participant 38, Product ('DSLR' was used as the core concept and gradually refined with 'review', 'light', 'small', and 'compact' to find the small size DSLR camera for women)

| Search Engine | Query | Change Type | Results Viewed | Page Viewed | Duration | Start | End |
|---|---|---|---|---|---|---|---|
| Google Web | DSLR | I | 1 | 1 | 0:00:56 | 0:39:18 | 0:40:14 |
| Naver Web | DSLR | C | 0 | 1 | 0:00:26 | 0:40:14 | 0:40:40 |
| Naver Image | DSLR | C | 0 | 1 | 0:01:04 | 0:40:40 | 0:41:44 |
| Naver Image | DSLR review | A | 2 | 1 | 0:01:36 | 0:41:44 | 0:43:20 |
| Naver Image | DSLR review light | A | 0 | 1 | 0:00:07 | 0:43:20 | 0:43:27 |
| Naver Image | DSLR review small | R | 0 | 1 | 0:00:18 | 0:43:27 | 0:43:45 |
| Naver Image | DSLR review compact | R | 1 | 1 | 0:01:03 | 0:43:45 | 0:44:48 |
| Naver Web | DSLR review compact | C | 1 | 1 | 0:01:05 | 0:44:48 | 0:45:53 |
| Naver Web | DSLR review compact light | A | 1 | 1 | 0:01:18 | 0:45:53 | 0:47:11 |

Participant 39, Product (gradually used 'inside', 'broken apart', and 'taken apart' to find images of the components inside an iPad)

| Search Engine | Query | Change Type | Results Viewed | Page Viewed | Duration | Start | End |
|---|---|---|---|---|---|---|---|
| Google Image | inside an ipad | I | 1 | 1 | 0:00:33 | 0:12:44 | 0:13:17 |
| Google Image | broken apart ipad | R | 0 | 1 | 0:00:17 | 0:13:17 | 0:13:34 |
| Google Image | taken apart ipad | R | 3 | 1 | 0:04:19 | 0:13:34 | 0:17:53 |

*Figure 4.16* shows significantly more serendipity browsing (SB), replace with synonyms (RS), and add related terms (AR) in retrieval query reformulation (QRR) searches, indicating a rather focused query reformulation pattern in which

participants were clear about their targets and were simply trying the find the ’correct’ search terms.

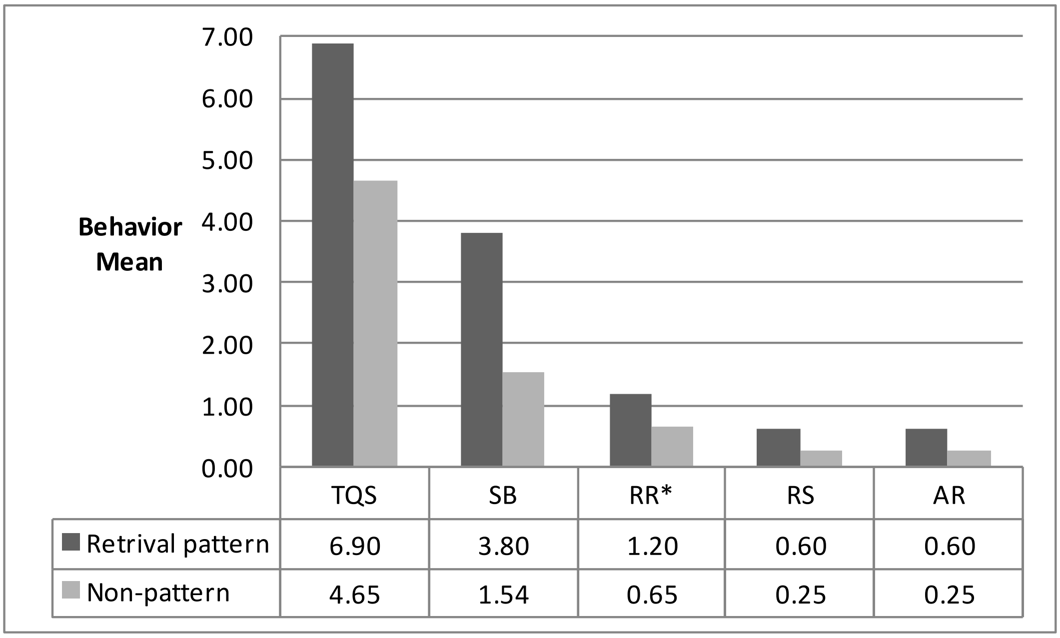



*Figure 4.16* Significant behavior differences from retrieval query reformulation (QRR) pattern searches

## 4.7.8 Effects of exploratory intent on query reformulation [QRE]

In searches with exploratory intent, where participants may have only a broad idea about their targets, they usually started with some generic terms as the core concept and interacted with the results to consolidate their search direction. The interchanging with different but semantically related terms characterized this search pattern. These related terms usually came from carefully reviewing the results (IB), which in turn often resulted in idea discovery (ID). It may also be that participants already had an ‘exploration plan’ in mind (as evident by the nominated concepts in the pre-search questionnaire) and subsequently used the listed concept terms to explore different aspects around the core concept.

*Examples:*

Participant 13, News (motivated by North Korea's missile testing news, the participant subsequently explored 'journalists', 'missile', 'Japan', 'nuclear', and finally the image of the current "North Korea president")

| Search Engine | Query | Change Type | Results Viewed | Page Viewed | Duration | Start | End |
|---|---|---|---|---|---|---|---|
| Google Image | north korea journalists | I | 1 | 2 | 0:01:54 | 0:01:50 | 0:03:44 |
| Google Image | north korea missile | R | 3 | 2 | 0:02:11 | 0:03:44 | 0:05:55 |
| Google Image | north korea japan | R | 0 | 1 | 0:00:39 | 0:05:55 | 0:06:34 |
| Google Image | north korea japan missle | A | 2 | 1 | 0:02:36 | 0:06:34 | 0:09:10 |
| Google Image | north korea nuclear | R | 4 | 2 | 0:03:34 | 0:09:10 | 0:12:44 |
| Google Image | north korea nuclear missile | A | 2 | 2 | 0:01:52 | 0:12:44 | 0:14:36 |
| Google Image | north korea president | R | 2 | 3 | 0:00:45 | 0:14:36 | 0:15:21 |
| Google Image | north korea president now | A | 0 | 2 | 0:00:25 | 0:15:21 | 0:15:46 |

Participant 26, Product ('Wedding gift' was the core concept and the general term 'ideas' was gradually refined to 'hallmark', 'hallmark wedding', and 'Disney')

| Search Engine | Query | Change Type | Results Viewed | Page Viewed | Duration | Start | End |
|---|---|---|---|---|---|---|---|
| Google Image | wedding gifts ideas | I | 4 | 4 | 0:03:15 | 0:26:53 | 0:30:08 |
| Google Image | wedding gifts | D | 1 | 3 | 0:01:07 | 0:30:08 | 0:31:15 |
| Google Image | hallmark gift | R | 0 | 1 | 0:00:23 | 0:31:15 | 0:31:38 |
| Google Image | hallmark wedding gift | A | 1 | 3 | 0:01:30 | 0:31:38 | 0:33:08 |
| Google Image | disney wedding gift | R | 1 | 1 | 0:01:49 | 0:33:08 | 0:34:57 |
| Google TW Image | wedding gift | DC | 3 | 5 | 0:04:49 | 0:34:57 | 0:39:46 |

Participant 29, News ('Ekka' was the core concept and aspects of 'photos', 'strawberry ice cream photos', 'show photos', 'showtime', 'car showtime' were gradually explored during the search)

| Search Engine | Query | Change Type | Results Viewed | Page Viewed | Duration | Start | End |
|---|---|---|---|---|---|---|---|
| Google Web | ekka brisbane | I | 5 | 1 | 0:04:44 | 0:00:25 | 0:05:09 |
| Google Web | ekka photos | R | 1 | 1 | 0:00:11 | 0:05:09 | 0:05:20 |
| ourbrisbane.com | (browse ekka archival images) | | 0 | 4 | 0:02:01 | 0:05:20 | 0:07:21 |
| Google Image | ekka photos | C | 2 | 5 | 0:02:48 | 0:07:21 | 0:10:09 |
| Google Image | ekka strawberry ice cream photos | A | 0 | 1 | 0:00:22 | 0:10:09 | 0:10:31 |
| Google Image | ekka show photos | R | 2 | 1 | 0:04:26 | 0:10:31 | 0:14:57 |
| Google Image | ekka Toyota V6 Hilux Heroes and Showtime FMX | R | 0 | 1 | 0:00:20 | 0:14:57 | 0:15:17 |
| Google Image | ekka showtime | D | 0 | 1 | 0:00:15 | 0:15:17 | 0:15:32 |
| Google Image | ekka car showtime | A | 0 | 2 | 0:00:35 | 0:15:32 | 0:16:07 |

Participant 30, Travel (used 'Eiffel Tower' as the core concept and gradually explored the 'fountain' in front of it, and photos taken from the 'bottom view of' the tower)

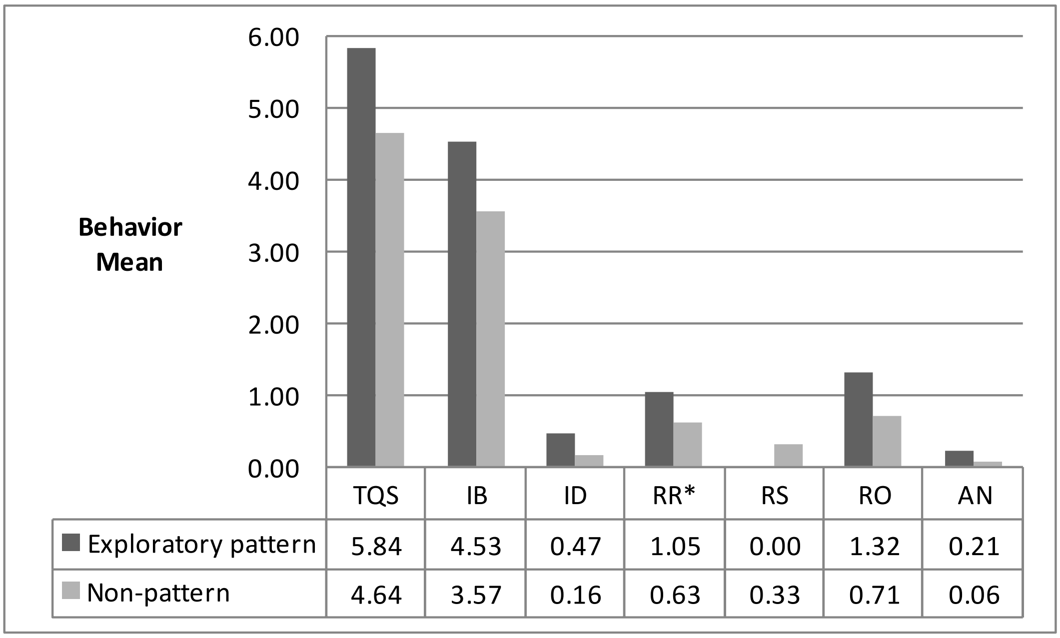
| Search Engine | Query | Change Type | Results Viewed | Page Viewed | Duration | Start | End |
|---|---|---|---|---|---|---|---|
| Google Image | effiel tower in london | I | 0 | 1 | 0:00:11 | 0:09:32 | 0:09:43 |
| Google Image | eiffel tower in london | R | 2 | 1 | 0:01:27 | 0:09:43 | 0:11:10 |
| Google Image | eiffel tower in paris | R | 1 | 1 | 0:00:39 | 0:11:10 | 0:11:49 |
| Google Image | eiffel tower in paris fountain | A | 7 | 2 | 0:03:35 | 0:11:49 | 0:15:24 |
| Google Image | bottom view of the eiffel tower | R | 9 | 1 | 0:06:06 | 0:15:24 | 0:21:30 |

Participant 37, Travel (used 'London' as the core concept and gradually explored 'travel', 'cultural heritage', 'church', 'sightsee and tourism', 'old building', 'shopping', 'shopping mall' and 'local food' in London)

| Search Engine | Query | Change Type | Results Viewed | Page Viewed | Duration | Start | End |
|---|---|---|---|---|---|---|---|
| Google Image | London travel | I | 3 | 1 | 0:01:53 | 0:17:29 | 0:19:22 |
| Google Image | cultural heritage in London | R | 3 | 1 | 0:03:10 | 0:19:22 | 0:22:32 |
| Google Image | church in London | R | 2 | 4 | 0:03:14 | 0:22:32 | 0:25:46 |
| Google Image | sightsee and tourism in London | R | 2 | 5 | 0:01:34 | 0:25:46 | 0:27:20 |
| Google Image | old building in London | R | 5 | 4 | 0:04:08 | 0:27:20 | 0:31:28 |
| Google Image | shopping in London | R | 2 | 4 | 0:00:43 | 0:31:28 | 0:32:11 |
| Google Image | shopping mall in London | A | 2 | 1 | 0:02:47 | 0:32:11 | 0:34:58 |
| Google Image | local food in London | R | 0 | 1 | 0:00:27 | 0:34:58 | 0:35:25 |

*Figure 4.17* shows significantly higher intensive browsing (IB), idea discovery (ID), replace with terms in original construct (RO), add new term (AN) and no replace with synonyms (RS) in exploratory query reformulation (QRE) searches. The statistical test results are consistent with our qualitative findings and thus can be used as the factors for determining participants' query reformulation intent. While replace with related terms (RR) is similarly higher in both the query reformulation with retrieval intent (QRR) and the query reformulation with exploratory intent (QRE) patterns, other behaviors differentiate the two patterns. The QRR pattern exhibited more focused search strategy shown by the higher replace with synonyms (RS) and addition with related terms (AR), as well as the higher serendipity browsing (SB), which indicated the scanning of useful keywords for query reformulation. On the

contrary, the QRE pattern was less focused as participants often reviewed results intensively for inspiration or new ideas (higher IB and ID), and reformulated the queries with newly acquired terms (higher AN and no RS).




| | TQS | IB | ID | RR* | RS | RO | AN |
|---|---|---|---|---|---|---|---|
| Exploratory pattern | 5.84 | 4.53 | 0.47 | 1.05 | 0.00 | 1.32 | 0.21 |
| Non-pattern | 4.64 | 3.57 | 0.16 | 0.63 | 0.33 | 0.71 | 0.06 |

*Figure 4.17* Significant behavior differences from exploratory query reformulation (QRE) pattern searches

# 4.8 Web Image Search Outcome and Problems

## 4.8.1 Search completion and satisfaction

*Table 4.28* shows the average task completeness, satisfaction level, difficulty, and accuracy among search domains. Regarding the search outcomes (i.e. the completeness and satisfaction of the task), task completeness was found to be significantly different only among levels of personal knowledge (Kruskal-Wallis test, Chi-square=10.873, df=4, $p$=.028) and task specificity (Chi-square=12.760, df=4, $p$=.013). However, when we further investigated the difference, participants with moderate personal knowledge (KNO=3) reported the lowest level of task completion while participants with the lowest personal knowledge (KNO=1) claimed the highest completion level. On the contrary, participants with higher task specificity (SPE=4) achieved the highest completion level, whereas participants with lower task specificity (SPE=2) achieved the lowest task completion. These unsystematic results were reflected in the correlation tests as KNO did not correlate with COM significantly and SPE only showed a weak correlation (Spearman's rho=.211, *p*=.021). Other significant but weak correlations include search engine familiarity and personal knowledge (Spearman's rho=.286, *p*=.002), task specificity and personal knowledge (Spearman's rho=.247, *p*=.007), task completion and difficulty (Spearman's rho= -.298, *p*=.001), and task difficulty and satisfaction (Spearman's rho= -.442, *p*<.001). It is difficult to draw any conclusive relationships among these factors due to the weak correlations found. In other words, our data suggests that the success of image search task cannot be predicted by any of the predetermined factors investigated, thus highlighting the crucial role of the interaction during searching activities, especially the query reformulation activities. Despite the unsystematic relationship shown above, task completeness and search satisfaction were found to be distinctively correlated (Spearman's rho=.682, p<.001), indicating that the higher completion level participants feel, the more satisfied they are with their searches.

| Domain | Completeness | Satisfactory | Difficulty | Accuracy |
|---|---|---|---|---|
| News | 4.18 | 3.90 | 3.08 | 3.15 |
| Travel | 4.23 | 4.38 | 2.33 | 3.73 |
| Product | 4.40 | 4.20 | 2.45 | 3.75 |
| Avg | 4.27 | 4.16 | 2.62 | 3.54 |

*Table 4.28* The average ratings of task completeness, satisfactory, difficulty, and result accuracy across search domains

## 4.8.2 Common search problems

| | Problem 1 Unable to Interpret need | | Problem 2 Unable to find correct search term | | Problem 3 misinterpriting | | Problem 4 Too many result | | Problem 5 Too few result | | Problem 6 unable to consolidate | | Problem 7 other | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Task Domain | Frequency | % | Frequency | % | Frequency | % | Frequency | % | Frequency | % | Frequency | % | Frequency | % |
| News | 9 | 47.4% | 14 | 51.9% | 11 | 50.0% | 13 | 31.0% | 9 | 60.0% | 11 | 37.9% | 3 | 21.4% |
| Travel | 5 | 26.3% | 6 | 22.2% | 8 | 36.4% | 16 | 38.1% | 2 | 13.3% | 9 | 31.0% | 3 | 21.4% |
| Product | 5 | 26.3% | 7 | 25.9% | 3 | 13.6% | 13 | 31.0% | 4 | 26.7% | 9 | 31.0% | 8 | 57.1% |
| Total | 19 | | 27 | | 22 | | 42 | | 15 | | 29 | | 14 | |

*Table 4.29* Frequencies of search problems reported in post-search questionnaire

Common problems participants reflected in the post-search questionnaires and their frequencies in each domain are listed in *Table 4.29*. As the table shows, most participants reported having too many results as a problem in their searches. This was consistent with the previous research finding that users were concerned with search precision over recall. The second common problem was the inability to consolidate the search problem, which may be due to the exploratory tasks that participants initiated. The third, fourth, and fifth problems were related to query formulation and reformulation. While more participants found it difficult to find the correct search terms that would give them the results they wanted, a considerable number of participants indicated the problem of misinterpretation by search engines. The masking effect of search engine preferred keywords in pattern 4 searches can be regarded as an example of this misinterpretation problem. The fifth problem was the inability to interpret search needs as query terms, which is common in the query based searching paradigm as users need to articulate their implicit needs into explicit terms and formal queries. Finally, a small number of participants reported having too few results. However, this problem should be relatively insignificant as current search engines (e.g., Google) generally returned many results regardless of how specific the query is.

## 4.9 Chapter Summary

The results of our Dogpile log analysis pre-study and Web image searching user study were presented in this chapter. The log analysis pre-study findings indicated some unique characteristics of Web image searching, particularly the constant search strategy from consecutive replacement search sequences (the *I-R-R* and *I-R-R-R* sequences). The prevalence of constant search strategy in Web image searching implied that image users typically replaced terms with similar meanings (e.g., synonyms) or the same constructs (e.g., iPad and iPhone). Such unique feature led our user study to further investigate different query reformulation patterns according to different search intents.

The user demographic data and statistics of participants' searching behaviors were first reported in this chapter. Differences in session length, coded searching behaviors, the tendencies of tasks types and overall search strategies, as well as the categories of terms utilized in query formulation were discovered among the three search domains. For the qualitative analysis, we focused on the common problems and corresponding search patterns in general users' Web image searching. Six distinctive search patterns were qualitatively identified and the significant behaviors under each pattern were statistically tested to support the qualitative findings. Participants who had higher task specificity but limited ideas about the search target tended to consult Web searches for knowledge expansion or idea inspiration. When the initial search results were limited, participants would utilize multiple search engines to expand and compare the results, and consequently used the newly acquired terms to reformulate queries. Experienced participants were more likely to perform searches on domain-specific websites if the results from general search engines were not accurate enough, particularly when searching for products. Participants also tended to be more explorative when searching on domain-specific websites. Finally, participants would endeavor to find better search terms by switching between textual and image contents, especially when the results appeared to be biased to some search engine preferred keywords.

We also investigated the effects of search domains and the types of interactive intent on participants' Web image searching behavior and query formulation strategies. While there is a tendency for higher task specificity in product searches and least specific in travel searches, the news topic was found to be the most difficult one, in which participants often struggled to find the correct terms. Exploratory intents were found to lead to significantly more intensive browsing and idea discovery during the search. The use of original concept terms and newly acquired terms was also important in exploratory query reformulation. Retrieval intents mainly resulted in more serendipity browsing and used more synonyms for query reformulation.

One thing to note here is that although most of significant behaviors identified in each pattern are generally in line with our assumptions, behavior scores across different patterns are not comparable because the search sessions are not exclusive to one pattern. In other words, one search session may exhibit multiple search patterns, as shown in *Table 4.22* to *Table 4.24*. Hence it is not valid to compare the mean values of the behavior scores from each pattern, as the patterns may contain overlapping search sessions. Future work should include a more confined experimental design (e.g., closed search tasks) with designated groups of participants to further investigate the influence of particular factors on search patterns. More sophisticated measurements of participants' knowledge and task specificity may also help identify the relationship between participants' predetermined factors (e.g., knowledge, search experience) and the search outcomes more accurately.

# CHAPTER 5: DISCUSSION

## 5.1 Strategies for Knowledge Expansion

The first common problem in Web image searching is the lack of knowledge or concepts to formulate effective search queries. From the statistics of pattern 1 (KEK/KEI) searches (*Figure 4.11* in *Section 4.7.2*), participants with more specific tasks are more likely to consult with Web search results at some point to expand their domain knowledge. This somewhat contradicts our hypothesis, as we assumed that participant with more exploratory search goal should consult Web searches more. However, with a closer look at participants' search, it appears that these participants generally start with Web searches first, either as a habit or to ensure enough breadth in their searches. In fact, as evidenced by significantly more switching to image search (SI), nine out of fifteen participants in this search pattern commenced their search task in Web searches. These characteristics in pattern 1 somewhat matched most of the characteristics of news searches, as news searches were reported to be the most difficult, being more specific, with more switching to image search mode (*Figure 4.15 in Section 4.7.6*), and being more prone to adopt top-down strategies (*Table 4.18* in *Section 4.5.2*). In fact, 60% of pattern 1 searches were news searches, as shown in *Table 4.25* in *Section 4.7.1*.

Participants' needs for knowledge expansion can be further divided into the need for more information (KEI), or the need to find potentially useful keywords (KEK). A number of participants indicated the problem of being unable to consolidate their search tasks. This problem is associated with the need for more information (KEI) as exploratory participants need to see what is out there first to refine their search direction. For example, *Participant 14* began the search on *ourbrisbane.com* to explore the beaches near Brisbane, not only because she knew the website, but also because she expected the localized resource should give her more relevant results. After she found the 'Redcliff' beach particularly suited her criteria, she went to Google Image and searched for the beach. Similarly, *Participant 12* initially used Google Web to find the official website for the Barbie doll, from which she found the 50th anniversary Barbie doll interesting. She then searched on the different Barbies in every decade in Google Image. These searches demonstrated the important process of using Web textual information to consolidate the search ideas in this pattern.

Beyond the problem of consolidating search ideas, more participants reported problems in finding correct search terms or in interpreting their needs as query terms. Unlike the participants with KEI intent, these participants wished to use Web search results to find useful terms that could help them progress the search. They generally believe that they have enough information on the search topic and have a clear search goal. What they want is some terms that are more representative of their search needs or that could help them retrieve better results. Hence their interactive intent concentrates on finding more terms or keywords (KEK). For example, when *Participant 10* found the results from his initial query did not match his knowledge about the AirFrance crash news, he switched to Google Web to look for more keywords to reformulate his query, and consequently found the correct airline name.

However, as participants can clearly indicate whether they are looking for more information or keywords, there is no absolute connection of knowledge expansion for information (KEI) to idea discovery (ID) or knowledge expansion for keyword (KEK) to term discovery (TD). Apparently, participants may pick up more information or ideas while looking for keywords, and vice versa. Hence the analysis did not further differentiate KEK and KEI in pattern 1, as they do not necessarily result in TD or ID respectively. In addition, given the limited search samples in each pattern, partitioning data based on additional factors will void statistical validity since the samples in each category will be too few. Nevertheless, the significant behaviors found in this pattern provide valuable insights into participants' searching activities for knowledge expansion. The significantly higher task specificity indicates the motivation or requirement for more information or knowledge to search, which is also prone to news searches. In order to filter useful information or keywords, participants need to browse more, resulting in the increased intensive and serendipity browsing activities. Term discovery is significantly higher as expected, because no matter what information or keywords are found, it is the newly acquired terms that help advance the search. The original terms are replaced by the new terms for query reformulation, leading to the higher replace with related terms and the more deletion of original terms.

## 5.2 Strategies for Result Expansion

### *Result expansion for sufficiency (RES)*

Pattern 2 (RES) and pattern 3 (REA) searches signify the strategies in regard to the common problems of insufficient and inaccurate results respectively. In pattern 2, switching between search engines (SS) is particularly important. While the increased browsing activities may be the result of comparing, more adding and deleting of original concept terms (AO and DO) manifests the trials of same set of queries in different search engines. Similar to pattern 1 searches, participants may also discover new search terms during result reviewing, and may consequently utilize the new terms to reformulate queries. However, pattern 1 participants focused on using related terms to find particular images, whereas pattern 2 participants utilized new terms that may not be closely related in order to expand the range of their search results. In other words, participants were more specific and focused in pattern 1 searches; pattern 2 participants allowed some degree of shift in their searches since they mainly wanted to increase the number of results. Another important characteristic in pattern 2 searches is the use of localized information resources. Participants usually adopt general search engines such as Google or Yahoo as their first choice for search. However, in situations when no sufficient results can be retrieved from these general search engines, participants tend to perform localized searches by adding the country domain to the search engine URL (e.g., add '.tw' to search for Taiwan, and add '.au' to search for Australia resources), or by switching to the localized search engines (e.g., Naver for Korean searches).

### *Result expansion for accuracy (REA)*

Pattern 3 participants were mainly concerned about the precision of their search results. In fact, the problem of having too many results is the most frequent search problem reported by the study participants (*Table 4.29*). When participants cannot find relevant results from general search engines, they tend to search on domain-specific websites (e.g., BBC, ABC for news, travel agencies for travel, and online shopping sites for products), especially if they have more search experience. They tend to explore on the domain-specific website and then try out some new search terms possibly acquired from the website. The more replacing with new terms and less replacing with related terms and synonyms suggest an exploratory style of query reformulation. This is consistent with Thatcher's (2008) findings that experienced Web searchers tend to perform different search approaches concurrently or utilize specific websites by directly entering the URL. In addition, there seems to be a tendency of particular search domains to the use of domain-specific websites. From our qualitative analysis, twelve out of twenty-one (57%) pattern 3 searches were *product* searches.

## 5.3 The Masking Effect of Search Engine Preferred Keywords

Pattern 4 searches can be treated as a special type of knowledge expansion pattern that needs to be discussed separately. A number of participants have indicated the problem of search engines misinterpreting the query. This problem can be partially associated with pattern 4 searches, as the results were biased to certain terms while participants intended to focus more on other terms in the query. The more frequent switching between Web and image searches, as well as the much higher result comparing score (CR), signified participants' effort to find alternative search terms from different search modes (*Figure 4.14*). More deletion of new terms suggests the difficulty of finding suitable terms, which results in much higher intensive browsing and comparing of results. Compared with pattern 1, this search pattern highlights the strategy that when participants have problems in finding potential useful terms, they need to browse through the results more carefully, in order to apprehend and filter the information encountered. Unlike this strategy, both intensive and serendipity browsing increased in pattern 1 searches where participants looked for ideas or specific terms.

Participants who have encountered such masking effects have suggested some sort of relevance feedback functions to overcome the problem. For example, *Participant 10* indicated that relevance feedback and term suggestion tool as possible improvements for future systems. Likewise, *Participant 17* wished a function to "show numbers of hits per search term and somehow prioritize the search terms based on user's search priority". *Participant 24* also reflected that the use of more accurate keywords helped his search, and there "should be a function to filter results to specific domains or areas". This research has attempted to overcome this problem by utilizing the context of users' query reformulations, which is presented in *Section 5.8 – Contextual query recommendation tool*.

## 5.4 Effects of Task Domain and Query Reformulation Intent on Searching Behavior

### *Search domains*

While there is a tendency of higher task specificity in product searches and least specificity in travel searches, news searches were found to be the most difficult ones, in which participants often struggled to find the correct terms or sufficient results. In addition, news searches also had the most problems in search engine misinterpretation (*Table 4.29*), which is associated with the masking effect of search engine preferred keywords (*Table 4.25*, 83.3% of pattern 4 searches came from news searches). As a result, news searches showed more terms per session (*Table 4.21*) and required more browsing activities than the other two search domains

On the contrary, travel searches tended to be the most open and exploratory, evidenced by the most total query per session (*Table 4.11*) and the highest proportion of exploratory tasks (*Table 4.12*). The openness in travel searches resulted in the least initial query terms formulated (INI) and the lowest difficulty ratings, as well as the highest idea discovery (*Figure 4.15*). In addition, 47% of exploratory query reformulation patterns (QRE) were from travel searches (*Table 4.25*). Thus it is fair to say that travel tasks are less difficult and easier to satisfy than news and product search tasks.

Despite being the most specific searches, product tasks required least switching between search modes. While specific terms were effective for retrieving good results in product searches, participants often needed to adopt result expansion strategies to get more accurate results (i.e. REA pattern in *Table 4.25*), such as using domain-specific websites to find the intended products (e.g., the DS behavior in *Table 4.11*). Most (80%) retrieval query reformation patterns (QRR) were also in product searches (*Table 4.25*).

### *Query reformulation intents*

Both exploratory (QRE) and retrieval query reformulations (QRR) have significantly more queries per session (TQS). In terms of browsing activities, the QRE pattern was found to exhibit significantly more intensive browsing, which led to the idea discovery (ID) during the search. QRR patterns had more serendipity browsing, which was assumed to lead to term discovery (TD), however it was not significant in the statistical test. Nevertheless, the replace with synonyms (RS) was higher in QRR but lower in QRE, which clearly differentiated the two reformulation patterns. In addition, the QRE pattern utilized more original concept terms and newly acquired terms to reformulate, whereas the QRR pattern mainly utilized the related terms.

Although it makes sense to link the retrieval tasks to QRR pattern and the exploratory tasks to the QRE pattern, such linkage may not always be the case. As users can undergo multiple stages in a search session, it is possible for a retrieval task to evoke exploratory intent at some point during the search. In other words, users may have a retrieval task as the leading search goal, but the interactive intent becomes exploratory along the search path. In fact, 6 out 10 (60%) QRR searches were from exploratory tasks and 3 out 19 (16%) QRE searches were from retrieval tasks. Hence this study deliberately makes QRE and QRR patterns as types of interactive intents, rather than search tasks.

## 5.5 Summary of Search Intent and Strategy

# Findings

In this section, we summarize the previous discussions on the search strategies found in this study, differentiate the key behaviors that characterized each strategy, and compare our findings with similar studies in recent years. The current research findings highlighted two aspects that were not considered in previous research:

- Using measurable searching behaviors to infer the current strategy
- Associating search strategies with different stages of searching

All search strategies found in this study are associated with a set of significant searching behaviors that can be easily detected from system perspective. Prior studies (e.g., Thatcher(2006; 2008)) typically relied on participants' self-reports to discover the cognitive aspect of search strategies without specifying the distinctive behaviors underneath, thus making it difficult to be applied to current systems. In order to facilitate the comparisons among search strategies, *Table 5.1* lists the distinctive behaviors of each strategy with green color codes.

| Intent / Pattern | Context Factor | Reviewing | | | | | Query Reformulation | | | | | | Info. Source |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Browsing | | Discovery | Switching | | Replace | | | Add | | Delete | |
| KEK/KEI | SPE | IB | SB | TD | SI | | RR | | | | | DO | |
| RES | | IB | SB | TD | SI | SS | | RS | | AN | AO | DO | LS |
| REA | EXP | | | | | | RR- | RS- | RN | | | | DS |
| Overcasting | SPE | IB | | TD | SI | SW | RR | | RO | | | DN | |
| QRR | TQS | | SB | | | | RR | RS | | | AR | | |
| QRE | TQS | IB | | ID | | | RR | RS- | RO | AN | | | |

*Table 5.1* Comparison of significant behaviors among search intents and corresponding search patterns.

First, as shown in *Table 5.1*, strategies in knowledge expansion (i.e. KEK and KEI) share a lot of common behaviors with result expansion strategies, especially the result expansion for sufficiency (RES). A good way to differentiate strategies in knowledge expansion or result expansion is the level of uncertainty expressed by participants. In knowledge expansion strategies, participants are not very clear about their target images, and thus need more information or keywords to help them refine their search goals or search criteria. In other words, participants are still unsure whether the current results contain the images they want, and would try to gather more information in order to verify the current results. On the other hand, result expansion manifests that participants are certain about the images they want and their search goals are clear. The problem is that they cannot see suitable images in the current result and thus would like to improve on it. Furthermore, RES has significantly more addition with original term (AO) and deletion with original term (DO), which characterize this search strategy. RES is also usually associated with searching on localized information resources (LS), which does not commonly appear in the knowledge expansion strategies.

Comparing the strategies in result expansion, result expansion for accuracy (REA) differs from RES mainly in the types of replaced terms. In REA, more new terms are used to replace the query (RN), while fewer related and synonym terms (RR and RS) are used. On the contrary, RES uses more synonyms to replace the query, with the likelihood of adding new terms. Such difference can be apprehended as in REA, where recall is enough and the focus is on precision, the use of new terms is more likely to include more conditions to 'filter' the results, since the current/known keywords do not work so well. In RES, where precision is out of the concern but recall needs to be improved, the use synonyms may provide 'alternative matchings' to the desired images without altering the original intent, and the trials of same set of queries on different search engines or information resources (manifested by more AO and DO) may also yield more results.

The strategy participants adopt to overcome the masking effect of some keywords should be treated as a special case in Web image searching and discussed separately. When participants feel the results are biased toward certain keywords, they try to replace these keywords with other alternative terms to see if the bias can be reduced. If they cannot come up with any alternative keywords, they tend to consult the results from the same query in different search modes (evidenced by more SI and SW), and adopt the trial-and-error approach to test the usefulness of new keywords discovered from these results (higher TD and DN). Hence, the unique combination of switching between textual and image search modes, as well as the deletion of new terms, indicate the strategy to overcome the masking effect and provide detectable clues for system assistance intervention.

Strategies during the query reformulation stage are closely related to the interactive search intents. Retrieval intents usually evoke term replacement with synonyms (RS) and serendipity browsing (SB), as participants are clear and specific about the target images without the need to seek for relevant information. They mainly scan through the results and pick up the keywords that are associated with the most suitable results. Exploratory intents, however, seldom evoke term replacement with synonyms. Participants engage more intensive browsing (IB) under exploratory intent and, as a result, more new ideas are discovered (ID) during query reformulation. The interchange of original terms (RO) in queries is also prevailing in exploratory query reformulation. Because participants with exploratory intents usually have several different aspects under a central concept to be explored, they tend to sequentially deploy keywords from different aspects as they search. When exploring results from different information resources, such continuing trials of the original keywords become an important search pattern under this strategy.

As participants may have multiple interactive intents during a search session, the switching between exploratory and retrieval query reformulation patterns can also occur. Thus the two query reformulation strategies are not exclusive to each other and can appear in different stages of searching. Knowledge expansion and result expansion strategies, on the other hand, usually take place in the early or the later stage of searching respectively. These unique characteristics of the search strategies discovered in the current research contribute the second highlight of our study findings. As the relationship between search strategies tends to [bind to the search stages], a contextual model would be the best way to depict such correspondence (details in *Section 5.7 – Contextual Visual Search Model*).

## 5.6 Search Problems and System Improvement

The common problems listed in *Table 4.29* are related to the interactive intents identified from the six common search patterns in *Section 4.7*. These search patterns can be regarded as participants' search strategies to overcome common problems, such as using knowledge expansion strategies to find more representative terms or useful information, or using result expansion strategies to improve result accuracy or sufficiency. While participants were able to come up with some strategies for these problems, there were some individual problems that did not have a clear strategy to solve them. The specific problems participants reported in the post-questionnaire can be broadly classified into two aspects: *result related* and *search navigation related* problems, which are presented next.

### *Result related problems*

Participant 1, News: too many (visually) similar results

Participant 7, Travel: image biased towards certain types (e.g., too many food related photos)

Participant 7, Product: search engine did not prioritise 'vs' or 'comparison'

Participant 24, Product: certain keyword too popular and can't find results on other keywords, Web search more useful

Participant 41, Product: unable to get images in the intended view (i.e. product view from each side)

### *Search navigation related problems*

Participant 9, News: the website linked from image search result did not contain the image

Participant 17, Product: unable to easily find website with catalogue of pictures to select

Participant 31, Product: cannot provide latest information on the product/no result comparing for similar products

Participants also suggested a range of possible functions to improve the current search engines, including relevance feedback functions, term suggestion tools, some result grouping based on visual similarity or subject or image format, result comparison interfaces, and date/time constrain functions. *Table 5.2* lists each type of improvements with the number of participants who mentioned the function in the post-search questionnaire.

| Improvement functions | Participants | Number of participants |
|---|---|---|
| Relevance feedback | Participant 7, 10, 17, 31, 33 | 5 |
| Term suggestion tool | Participant 1, 5, 10, 14, 16, 26, 37, 38 | 8 |
| Result grouping based on similarity | Participant 2, 3, 16, 19, 40 | 5 |
| Result grouping based on subject or image format | Participant 24, 28, 31, 39, 40 | 5 |
| Result comparison | Participant 25, 33, 37 | 3 |
| Date/Time constraint | Participant 30, 36 | 2 |

*Table 5.2* Participant suggested system improvements

Hence it is clear that more participants considered a term suggestion tool would be useful to improve the current search engines. In addition, a relevance feedback function is also important as evidenced by the significant pattern 4 searches relating to the masking effect problem. We present our attempt in response to these two major functions for improvement, the *contextual query recommendation tool*, in *Section 5.8*.

# 5.7 Contextual Visual Search Model

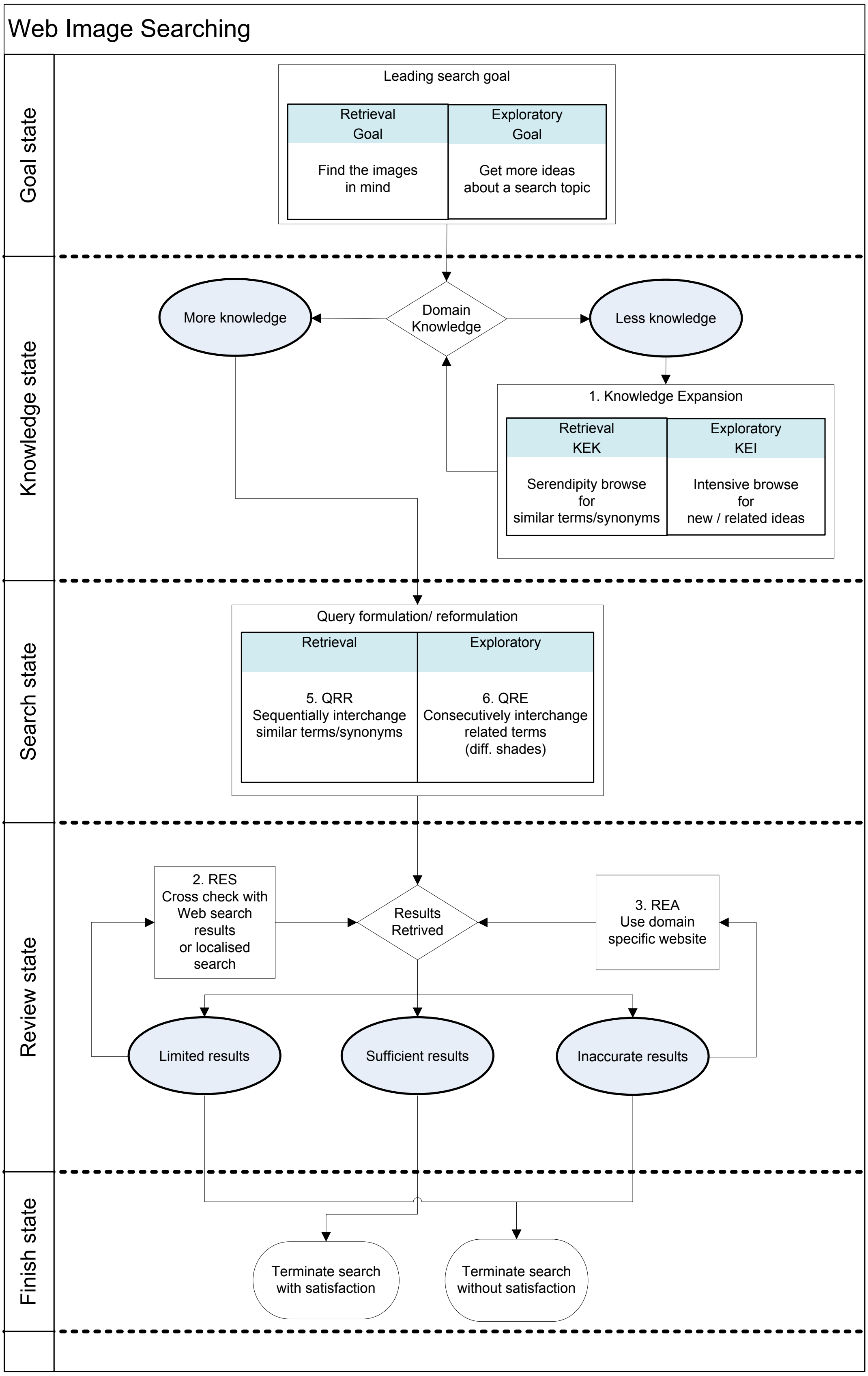



*Figure 5.1* The contextual visual search model

| Kuhlthau's six stage ISP model | | | | |
|---|---|---|---|---|
| Stages in ISP | Feelings Common to Each Stage | Thoughts Common to Each Stage | Actions Common to Each Stage | Appropriate Task According to Kuhlthau Model |
| 1. Initiation | Uncertainty | General/ Vague | Seeking Background Information | Recognize |
| 2. Selection | Optimism | | | Identify |
| 3. Exploration | Confusion/ Doubt Frustration/ | | Seeking Relevant Information | Investigate |
| 4. Formulation | Clarity | Narrowed/ Clearer | | Formulate |
| 5. Collection | Sense of Direction/ Confidence | Increased Interest | Seeking Relevant or Focused Information | Gather |
| 6. Presentation | Relief/ Satisfaction or Disappointment | Clearer or Focused | | Complete |

*Figure 5.2* Kuhlthau's (2005) information seeking process model

As this study revealed, two broad types of interactive intents significantly differentiate participants' Web image query reformulation behavior, namely the *query reformulation for retrieval (QRR)* and the *query reformulation for exploratory (QRE)* searches. Despite this major division in participants' searching, most participants seem to undergo similar stages of searching. This study briefly defines five stages in Web image searching: *Goal state, Knowledge state, Search state, Review state, and Finish state*.

## *Goal state*

In the goal state, participants primarily focus on determining their leading search goals, and thus defining the broad search types of their tasks. This state corresponds to the *initiation and selection stages* in Kuhlthau's (2005) information seeking process model (ISP model, Figure 5.2), where participants usually feel some degree of uncertainty toward their search topics, but also optimistically believe in finding relevant information on the Web. In our study procedure, we asked participants to write down detailed descriptions of their search tasks and list some relevant concepts for the search. This process engaged participants in reviewing their problems at hand, and in articulating the broad search needs into more explicit search tasks.

### *Knowledge state*

In the knowledge state, participants mainly concentrate on gathering domain knowledge in order to have sufficient vocabulary for their query formulation and reformulation. This state reflects the *exploration stage* in Kuhlthau's ISP model, where feelings of increased confusion and uncertainty are common when inconsistent or irrelevant information is encountered (Kuhlthau, 2005). One particular knowledge expansion strategy found in this state was to consult Web search results for more related information (KEI) or terms (KEK) in the search targets. For example, participant 9 began with Google Web for a news search in general to see if there was any information on the crash site of the AirFrance flight. Participant 12 began with generic Web search because she wanted to be explorative first, and consolidating her criteria later on for having both the performer and the audience in the target scenes after reviewing some retrieved images.

The two types of interactive intents divide participants knowledge expansion behaviors: exploratory intent participants tend to perform more intensive browsing (IB) while looking for new ideas or information (KEI) to enrich their search directions (ID), whereas retrieval intent participants mainly scan through Web results (SB) for specific keywords (KEK) to formulate new search terms (TD). For example, participant 10 was looking for direct images of the AirFrance crash, such as the debris of the plane. As he knew little about the news, he skimmed through Web search results to find out the correct airline name 'AirFrance' and subsequently corrected the flight number from '358' to '447' for the target AirFrance crash images. In an exploratory case, participant 14 was looking for Queen's birthday news pictures in UK and Australia. She failed to retrieve any images from the news search and consolidated her search on the celebration event. She then used the BBC UK site and carefully browsed through the results, where she discovered the term ‘official celebration’. This new term helped her retrieve more relevant images later in her search session.

### *Search state*

Querying activities occur in the search state, in which participants further convert their thoughts into explicit queries. This state corresponds to the *formulation stage* in Kuhlthau’s ISP model, in which the search becomes more focused as participants generally have consolidated their target and are more confident in finding what they want. Search strategies in this state can also be differentiated into two distinctive categories according to the interactive intents. Exploratory intent often involves using a set of related terms in query reformulation (QRE), which can be either from participants’ original concepts for search (RO), or the new terms acquired from previous knowledge expansion process (AN). However, the relatedness can be quite loosely connected, compared to those terms used in retrieval query reformulation (QRR). On the other hand, terms used for retrieval intent show much more cohesiveness, with considerable proportion of synonyms. For example, participant 39 wanted to see the inside of the new iPad. He consecutively used ‘inside’, ‘broken apart’, and ‘taken apart’ with ‘iPad’ as the core concept term to formulate his search queries. Such distinction in semantic relatedness provides us with a sound basis for detecting participants’ current search goals and interactive intents, and thus contributes to our contextual visual search model.

### *Review state*

Once the search results are returned, participants need to decide whether the current results are satisfying enough, and then deploy different search strategies in order to improve the retrieved results. We confine such activities to the review state, as the results may alter participants’ interactive intention and sometimes even the current search goal. The review state corresponds to Kuhlthau’s *collection stage*, but only when participants are able to find satisfactory results toward a proper closure of the entire search without the need to further alter their search tasks (Kuhlthau, 2005).

When participants feel that they have enough knowledge for completing the current search task, they may attribute the insufficient/unsatisfactory results to the problem of the search engine and thus adopt some result expansion strategies. In this state, where participants' search targets are lucid and much more specific than in previous states, they may use either other search engines, or domain-specific websites to expand the results according to the interactive intents. If participants' intent is to increase the number of results (i.e. RES), different search engines are likely to be utilized for result expansion. Conducting localized Web searches is also a helpful RES strategy, especially for regional news topics. If participants mainly want to improve the relevance of the results (i.e. REA), searching on domain-specific websites becomes an important result expansion strategy for such intent. This strategy is particularly favored in product searches.

### *Finish state*

Although a 100% completion for each search task was not required in the current study, all participants orally acknowledged their satisfaction and completion levels in order to proceed to the next search task unless they ran out of time. This ensures some form of closure for each search task performed in the study, and makes our findings comparable with Kuhlthau's ISP model, which generally requires a formal closure of the information search activity. The final *presentation stage*, in Kuhlthau's ISP model resembles what goes beyond our *finish state* when a satisfactory closure of the current search task has been achieved.

One thing to acknowledge here is that this model depicts only a general classification of the search intents to corresponding knowledge and result expansion strategies. Although the two search intents seem to divide searching behaviors quite distinctively, participants may change the types of their *interactive intent* during searching, even without changing the *leading search goal* (the original search problem). Since users' searches are dynamic and largely unpredictable, it is impossible to classify an entire search session/task into a simple dichotomy. Multiple different search intents can be embedded in one search task that defines the leading search goal. In fact, as Savolainen noted, *"…the process of Web searching is strongly* *dependent on situational factors such as the repertoire of the links available on the screen; thus, any attempts to define 'a general logic' of Web searching with regard to various types of gaps seem to be doomed to failure"* (Savolainen & Kari, 2006). No further specific model (i.e. other than the search states) regarding a generic search context should be constructed, as it would lose predictability value in general users' behaviors. It is actually the interactive intent that closely relates to certain search strategies in certain stages of searching. Thus the current model illustrates only the relationships between searchers' interactive intents and the corresponding search strategies, not the relationship between the higher level leading search goal and the individual search tactics/activities. By discovering such a relationship, retrieval systems can detect users' search intents based on the significant behaviors, thereby providing context-aware assistance. In the next section, we built a query recommendation tool based on this model to demonstrate its usefulness in better understanding users' search contexts and interactive intents.

## 5.8 Contextual Query Recommendation Tool

From the findings of the user study, most Web image search problems can be categorized in two major aspects:

- Insufficient knowledge
- Insufficient or inaccurate results

Insufficient knowledge is more prominent in the early stages of searching, as users often struggle to find the right direction/tool to retrieve the results they want (e.g., having the correct keywords that precisely describe their needs, or choosing the right website that potentially has the information they want). Thus various knowledge expansion strategies are employed during the early stages in searching (e.g., find useful keywords from Web results, go to other knowledge-based websites that have more information on the search target such as Wikipedia).

Insufficient or inaccurate results, on the other hand, are more prominent in the later stages of searching, usually when users have performed several search rounds and feel that they have sufficient knowledge about the problem domain or search target. In these cases users often try other search engines or information sources, such as localized search engines or domain specific websites, the two popular result expansion strategies our participants have demonstrated.

We now address our recommendations for these two major problems in Web image searching. The recommendations are based on the current public search engines (e.g., Google or Bing) and thus are not specific to particular domains or technologies, which ensures the feasibility for future works.

Since the main outcome of knowledge expansions in an image search is to the finding of useful keywords for search, a query term recommendation tool is developed to suggest potentially novel terms related to users' search contexts. The tool makes use of Google Web search results as the thesaurus, in which the top 50 results from each query submitted are returned to the tool for further processing. Each text snippet of the results is parsed to the bag of words as the pool of potentially useful keywords. We accumulate the occurrence for each parsed keyword in each query. To rank these keywords, we adopt a novel but efficient formula drawn from the Standard Deviation (SD) calculation in statistics:

Let

$N$ be the total number of queries submitted

$x_i$ be the word's occurrence from query $q_i$

$\bar{x}$ be the word's average occurrence in all queries submitted

Word SD score $S_N = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i - \overline{x})^2}.$

Hence each word has a SD value based on the queries submitted and is ranked in descending order (i.e. words with higher SD value are ranked higher). The highest ranked word has the highest SD value, meaning the highest standard deviation in its occurrences among all the queries submitted. The top twenty words are output as the keyword suggestion list.

Common words tend to appear in every snippet, resulting in high occurrence counts but providing little usefulness to users, as they can think of these words as well. On the other hand, for rare words which appear only a few times from one or two queries, the occurrence counts tend to be very small, which inherently suppresses them from ranking high in the keyword suggestion list. Ideally, words that are potentially useful should be highly related to a subset of users' queries but not all the queries, otherwise they would be too common to suggest anything 'new' to the user. These words appear to have high to highest SD values and only occur from a few queries, but with high occurrence in those queries. Because each query potentially represents a slightly different aspect of users' current search goal, words that are partially related to the queries should be representative of the corresponding aspect based on its popularity, yet retain their novelty because they differ from common terms. *Table 5.3* shows the conceptual classification of word SD scores.

| | Inter Query Occurrence - Scattered | Inter Query Occurrence – Uniform |
|---|---|---|
| Total Occurrence – High | [SD = high to highest] Potential useful words | [SD = high to avg.] Common words |
| Total Occurrence - Low | [SD = low] Rare words | [SD = lowest] |

*Table 5.3* The conceptual classification of word SD scores

Unless users submitted multiple queries which retrieved the identical set of top results, in which even the originally useful terms would now occur uniformly across queries as common terms, the use of SD ranking is handy in discriminating useful terms from high occurrence common terms.

The SD ranking is also different from measuring query-wise term co-occurrence, which appeared to be adopted by Google for search term suggestions. In the SD ranking, the more ‘variation’ among single user’s queries contributes to the higher SD score, whereas the overall co-occurrence concerns the high frequency terms from the global user pool. In short, while the co-occurrence approach is only useful for suggesting popular terms which may inevitably be biased by terms that are common to many users, our SD ranking approach is able to suggest popular yet novel terms based on user’s individual interest reflected in the queries.

As users’ image queries usually take a particular structure of having a core concept unchanged throughout the whole session and gradually replacing the related or synonym terms (e.g., the QRR and QRE patterns), it can be conceptualized that the high SD terms are retrieved by these replaced terms. Interestingly, it is these replaced terms that provide more ‘contextual’ information about users’ current search goals and interactive intents. Such characteristics can thus act as a relevance feedback function which reduces the masking problem from the search engine preferred or popular keywords. For example, one participant who searched for pictures of different components in an iPad gradually used the terms ‘inside’, ‘broken’, ‘taken apart’ to reformulate his query and thus provided us with a clear clue of where the search was heading. Without considering the series of replaced terms (i.e., inside, broken, taken apart in this example), it is impossible for the system to know what aspect of the iPad the participant was looking for.

The ranking would thus retrieve useful/important terms from these replaced terms. When the replaced terms are semantically related to each other, as the current example shows, the suggested terms would also converge, as each query retrieved similar or overlapped set of popular terms. Despite no semantic based calculation being performed in our recommendation tool, the ranking can still suggest semantically related terms if such terms were used to reformulate the queries.

*Examples:*

Participant 39, Product (gradually used “inside”, “broken apart”, and “taken apart” to find images of the components inside an iPad)

| Search Engine | Query | Change Type | Results Viewed | Page Viewed | Duration | Start | End |
|---|---|---|---|---|---|---|---|
| Google Image | inside an ipad | I | 1 | 1 | 0:00:33 | 0:12:44 | 0:13:17 |
| Google Image | broken apart ipad | R | 0 | 1 | 0:00:17 | 0:13:17 | 0:13:34 |
| Google Image | taken apart ipad | R | 3 | 1 | 0:04:19 | 0:13:34 | 0:17:53 |

| Top 2 queries | Top 3 queries |
|---|---|
| 1 - ndash;:12.03 | 1 - ndash;:12.46 |
| 2 - screen:8.53 | 2 - screen:9.26 |
| 3 - apple:7.58 | 3 - video:9.16 |
| 4 - ipod:4.09 | 4 - apple:7.57 |
| 5 - iphone:4.05 | 5 - iphone:4.10 |
| 6 - touch:3.61 | 6 - authorslast:4.03 |
| 7 - authorslast:3.34 | 7 - ipod:3.84 |
| 8 - whats:2.96 | 8 - teardown:3.78 |
| 9 - repair:2.96 | 9 - ifixit:3.78 |
| 10 - processor:2.13 | 10 - repair:3.44 |
| 11 - analysts:1.75 | 11 - whats:2.79 |
| 12 - move:1.75 | 12 - move:2.20 |
| 13 - torn:1.75 | 13 - torn:2.20 |
| 14 - increase:1.75 | 14 - increase:2.20 |
| 15 - translate:1.75 | 15 - touch:2.20 |
| 16 - teardown:1.56 | 16 - translate:2.20 |
| 17 - tablet:1.53 | 17 - minutes:2.20 |
| 18 - chip:1.20 | 18 - processor:1.99 |
| 19 - fix:1.20 | 19 - tablet:1.77 |
| 20 - directions:1.20 | 20 - step:1.65 |

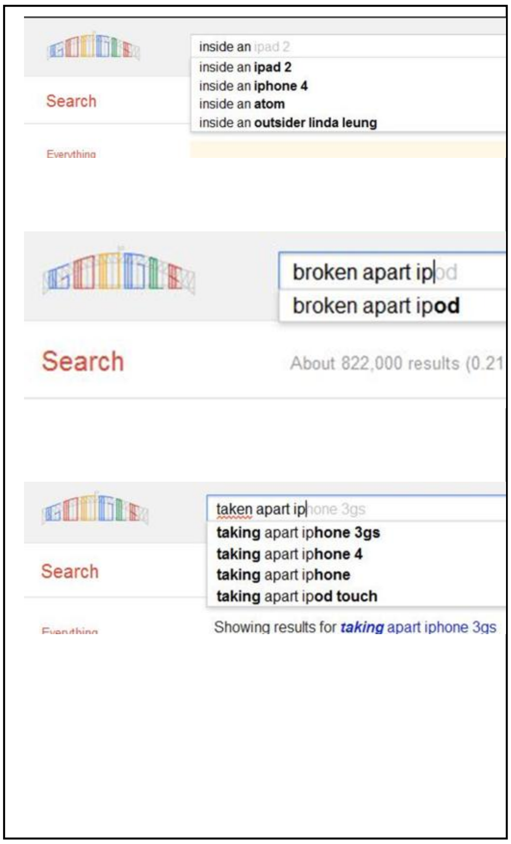



*Table 5.4* Top 20 term suggestion from Participant 39 search queries (synonym terms highlighted, and with Google term suggestion screenshots on the right)

In another case of an exploratory search (the Ekka search in participant 29's news search), the suggestions would come from the popular terms corresponding to different aspects of the Ekka event explored in the session, thus providing a good coverage of related aspects under the core concept of 'Ekka'.

<u>Participant 29, News</u> ('Ekka' was the core concept and aspects of 'photos', 'strawberry ice cream photos', 'show photos', 'showtime', 'car showtime' were gradually explored during the search)

| Search Engine | Query | Change Type | Results Viewed | Page Viewed | Duration | Start | End |
|---|---|---|---|---|---|---|---|
| Google Web | ekka brisbane | I | 5 | 1 | 0:04:44 | 0:00:25 | 0:05:09 |
| Google Web | ekka photos | R | 1 | 1 | 0:00:11 | 0:05:09 | 0:05:20 |
| ourbrisbane.com | (browse ekka archival images) | | 0 | 4 | 0:02:01 | 0:05:20 | 0:07:21 |
| Google Image | ekka photos | C | 2 | 5 | 0:02:48 | 0:07:21 | 0:10:09 |
| Google Image | ekka strawberry ice cream photos | A | 0 | 1 | 0:00:22 | 0:10:09 | 0:10:31 |
| Google Image | ekka show photos | R | 2 | 1 | 0:04:26 | 0:10:31 | 0:14:57 |
| Google Image | ekka Toyota V6 Hilux Heroes and Showtime FMX | R | 0 | 1 | 0:00:20 | 0:14:57 | 0:15:17 |
| Google Image | ekka showtime | D | 0 | 1 | 0:00:15 | 0:15:17 | 0:15:32 |
| Google Image | ekka car showtime | A | 0 | 2 | 0:00:35 | 0:15:32 | 0:16:07 |

| Top 2 queries | Top 3 queries |
|---|---|
| 1 - cattle:13.01 | 1 - judging:12.27 |
| 2 - judging:13.01 | 2 - cattle:12.27 |
| 3 - queensland:11.09 | 3 - queensland:10.43 |
| 4 - gallery:7.64 | 4 - icecream:8.68 |
| 5 - royal:6.48 | 5 - ndash;:8.21 |
| 6 - fun:4.82 | 6 - gallery:7.38 |
| 7 - august:3.61 | 7 - royal:6.02 |
| 8 - annual:3.34 | 8 - fun:5.71 |
| 9 - rna:3.24 | 9 - august:5.06 |
| 10 - showgrounds:3.24 | 10 - picture:3.63 |
| 11 - race:3.07 | 11 - rna:3.54 |
| 12 - exhibition:3.00 | 12 - showgrounds:3.54 |
| 13 - event:2.34 | 13 - exhibition:3.40 |
| 14 - share:2.33 | 14 - annual:3.22 |
| 15 - facebook:2.33 | 15 - race:2.87 |
| 16 - brisbanes:2.33 | 16 - day:2.66 |
| 17 - photo:2.33 | 17 - photo:2.49 |
| 18 - largest:1.56 | 18 - event:2.33 |
| 19 - ndash;:1.45 | 19 - brisbanes:2.22 |
| 20 - day:1.31 | 20 - share:2.20 |


*Table 5.5* Top 20 term suggestion from Participant 29 search queries (related terms highlighted, and with Google term suggestion screenshots on the right)

In summary, the recommendation tool demonstrates:

- Session-wise contextual sensitivity of suggested keywords
- High efficiency of calculation
- Portability to different platforms
- Scalability of the results (thesaurus) utilized
- Unobtrusive relevance feedback using query contexts

As this is an early attempt to utilize the user model for system improvement, there is still much development for the recommendation tool yet to be done. For example, current word filtering is based on only a list of stopwords, more sophisticated filtering techniques can be applied in the future (e.g., natural language processing, NLP, or semantic based filtering). In addition, the patterns of behaviors found in this study are yet to be integrated with the tool to help identify users' interactive intent and to suggest terms accordingly. Nevertheless, the recommendation tool demonstrates the usefulness of the user model in the real-world scenario, and provides a vital example of linking theoretical findings to system improvement.

## 5.9 Limitations

### *Automated Web log analysis*

The use of an automated Web log analysis method helped process huge amounts of data in the first phase of the study, with the tradeoff of not knowing users' real intents and the reasons for the identified searching behaviors. Such limitation is common to all state-of-the-art Web log analysis studies, unless user data is collected alongside the search session. However, in this research, the main purpose of using the automated Web log analysis is for preliminary identification of frequent query reformulation patterns and strategies, without necessarily knowing the reason behind, in order to provide key behavioral measurements for the subsequent user study. Besides, the limitations in knowing users' reasons for actions are complemented by the user study data, which is why the current research needs to include these two methods in its research design (details in *Section 3.2.2 - The combined approach of quantitative Web log analysis and qualitative user studies*).

### *The subjectiveness in some factor measurements*

From the user study data, several subjective measurements were used to assess and quantify the magnitude of user's feelings toward the search, such as the difficulty, completeness, and satisfaction. Due to the difficulties in formulating clear definitions of these measurements, especially for open task studies, the results collected are inevitably subjective. For example, it would be impossible to construct a unified scale on task completeness, since participants with retrieval goals would consider finding all images in mind as full completion of the task, whereas participants with exploratory goals may have infinite images to 'explore', but still regard the task to be completed as long as they are satisfied with the results. Such subjective effects may raise issues such as reliability when comparing the results, but can be reduced by having a reasonably sufficient sample size, such as 40 participants responding to all these measurements in the current study. Furthermore, since the main findings concentrated on the behavioral differences among the identified search patterns, such a drawback should have only limited impacts.

### *Open search tasks*

In this study, only open tasks were used to analyze participants' searching behaviors. As mentioned in *Section 3.1 - Task type vs. search strategy and outcome*, open tasks were deliberately chosen for the current study in order to maximize the behaviors that could be observed. The main drawback is the reliability of the relationship between the contextual factors and the behaviors identified from the data analysis. Hence, statistical analyses were performed based on the identified search patterns to assess their significance, and thus to enhance the reliability of the study findings. If the study had used closed tasks in the first place, search strategies that were not included in the study assumptions would not be measured. Similar search paths discovered from closed tasks may be useful in solving certain tasks, but they also limit the range of search strategies that can be studied.

### *Other searching behaviors*

In this study, only a handful of searching behaviors was measured and analyzed. This is to ensure the findings are of higher significance, as well as the feasibility from system perspective. Other behaviors, such as multi-tasking, and information organizing and use, were not further investigated, despite their appearance in the recorded user data. This is not to say that these behaviors are trivial; rather, they represent other important aspects in Web image searching, such as an interface to facilitate interactive result comparison, a personal information storage mechanism to help organize retrieved information, or a graphical concept map to stimulate search problem articulation/refinement. Nevertheless, due to the research interest in query reformulation behaviors, those behaviors are beyond the current research scope and cannot be included in the research design, but should be considered in future research.

## 5.10 Chapter Summary

The findings in this study shed light for user studies on Web image searching and query reformulation. Systems can also utilize our findings to provide better query formulation assistance, based on users' search topic domains or search intents. Our study complements the understanding of Web image search strategies, particularly the search strategies in knowledge expansion and result expansion. The effects of search domains and interactive intents on query reformulations were also discussed. More importantly, our approach shows the feasibility of using measureable behaviors to infer user's search intent (i.e., exploratory vs. retrieval) and the corresponding search strategies (e.g., knowledge expansion or result expansion). The significant behaviors identified under each search pattern can be utilized to expand user models in Web image searching, as well as to determine users' search contexts in real time and providing assistance when needed.

# CHAPTER 6: CONCLUSION

This chapter summarizes the current research findings and the significant theoretical implications for the research community. The significance and main contributions of the study are also presented. Future research directions are discussed at the end of this chapter, based on the research findings and current methodological limitations.

## 6.1 Overview

This research consisted of two major phases, namely the *Web log analysis pre-study* and the *Web image searching user study*.

### *Web log analysis pre-study*

In the Web log analysis pre-study, Dogpile search engine logs were used as the large-scale dataset to test the new proposed contextual log analysis method, as well as to discover frequent search patterns to be investigated in the later user study. A total of 1,228,310 log records, consisting of 347,175 sessions and 116,466 users, were analyzed and compared across all three multimedia searching modalities (i.e. image, video, and audio). A program was coded to automatically perform the Web log analyses, such as query reformulation classification, reformulation sequence aggregation, and search pattern identification. The results showed that image searches appeared to have the most consecutive replacement query reformulation sequences, followed by video and the least in audio searches. Among these consecutive replacement sequences, image searches exhibited the most constant search strategies (i.e. the number of query terms was held at constant through a series of in-session reformulations). The prevailing consecutive replacement and constant search strategy contributed to the unique character of Web image searching: *user often needs to explore and compare the results from queries with similar or related meanings, while keeping some important terms through the entire reformulation process*.

### *Web image searching user study*

In our Web image searching user study, 40 participants performed image searching on *News*, *Travel* and *Product* domains. A total of 120 search sessions with intensive screen video and participants' think aloud recordings were qualitatively analyzed for significant search behaviors and strategies. These included 580 queries, or 1609 query terms, and 1950 coded behaviors which were also extracted from the user study data and quantitatively tested to triangulate and strengthen the findings. As a result, six search strategies corresponding to three search states were identified. These search strategies and search states were then mapped with each other to show the relationship in the *contextual visual search model* (*Figure 5.1* in *Section 5.7 – Contextual visual search model*).

The model shows the relationships between the three states in Web image searching and their corresponding search strategies. In the *Knowledge state*, users primarily engaged in gathering more information or useful keywords about the search target, depending on the nature of the search tasks. When searching for less tangible or specific images (i.e. exploratory search tasks), users tend to carefully review Web search results to get more information or ideas. When searching for specific or known images (i.e. retrieval tasks), users are prone to quickly scan through the initial results for useful keywords, as they have more knowledge and clearer search goals toward the search target, but simply cannot retrieve satisfactory results.

In the *Search state*, interactive intent plays a crucial role in the choice of search strategies. For retrieval intents, users tend to reformulate queries with synonyms and use serendipity browsing to review the results. For exploratory intents, users tend to interchange the original concept terms on different information resources, as well as adding some new terms encountered during the search. Contrary to retrieval intent reformulations, the use of synonyms is largely reduced in the exploratory reformulations. Apparently, users can freely switch between the retrieval and exploratory types of interactive intents during a search, depending on the information encountered and the ever-changing search needs.

In the *Review state*, the quality of the retrieved results determines users' next search strategies. When users feel the results are not accurate enough, they tend to use new terms to expand the search range from the current results. More importantly, users with more searching experience prefer to use a *domain specific search* to improve result accuracy (e.g., navigate straight to a news website for a news search, use a travel agency website for a travel related topic, and browse on a manufacturer's website for a particular product). When the results are not sufficient, users would use synonyms to reformulate queries, as well as deploy the same set of queries on different search engines because they perceive that each search engine has different coverage of the search topic. It is also interesting to note that due to insufficient results, performing *localized searches* is a prevailing result expansion strategy, such as using local news agencies' websites for local news, or using the specific language of the news origin.

Based on the Web log analysis pre-study and the Web image searching user study, some important implications can thus be drawn from three main aspects: *Contextual log analysis*, *Web image searching user study*, and the *Contextual visual search model*. These aspects are discussed in the following sections.

## 6.2 Implications from Contextual Log Analysis

The contextual log analysis method presented in the current study demonstrated the possibility of using consecutive queries to elicit users' search context information. Users' search context is regarded as both a crucial factor and a major obstacle in predicting the online Web searching behavior, especially when utilizing automatic methods such as the log analysis to gather such information, Our results showed that it is useful to investigate a series of related queries to overcome the limitations in conventional log analysis methods. From the changes in query terms, much more contextual information can be extracted, especially the interactive search intents and the corresponding search strategies. The log analysis approach is beneficial to the current search engines as it does not require extra input from users (e.g., relevance feedback procedures), nor does it involve any human effort in extracting user information. Hence this method can be easily implemented on current search engines.

In short, the contextual log analysis approach inherently shares the strength of the conventional log analysis, which can be used to process large amounts of data with ease. It also improves the limited information that can be elicited from conventional log analysis approach, especially for obtaining users' context information. Finally, regarding the fractional interaction period of typical online users, the automated log analysis approach provides the most viable solution for current search engines seeking to promote user-centered search experience.

## 6.3 Implications from Web Image Searching User Study

The Web image searching user study revealed several interesting characteristics of general online users. First, users are not always so ready to start a search. They may not have abundant information or knowledge to complete their search tasks. Neither they have a clear mind of what they are going to find at the beginning of a search. Users would usually consolidate or refine their search goals only after seeing 'what is around' first. In this sense, search engines should not and cannot provide specific help during the early stage of searching. Instead, search engines should keep users 'informed' of a range of relevant information, particularly highly related keywords that would facilitate the following query reformulation processes.

Second, users' search goals are fluid and frequently changing. It is unlikely to see one user would only use a unidirectional approach (e.g., bottom-up or top-down) or a single search strategy through the entire search session, especially for complex search topics or needs. Hence, it is important for search engines to embrace the dynamics in users' searches, and not to oversimplify the types of a search (e.g., either exploratory or retrieval). Search engines should also be able to constantly monitoring users' current interactive intent, and adapt the results accordingly without putting more burdens on users, such as the explicit relevance feedback or training runs.

Finally, the ability to compare results from different information sources is essential in the result reviewing stage of a search. Some users often need to see different ranges/varieties of images to determine the most suitable ones. The comparing process is inevitable for these users as they do not know the exact requirements for the target images. They can decide the better ones only when they have seen enough results. Hence, it would be very useful if a single search engine could provide results from several different resources (e.g., meta-search engines) and facilitate comparisons among them.

## 6.4 Implications from Contextual Visual Search Model

The contextual visual search model summarized the most significant findings from the current research. Unlike previous studies, such as Kuhlthau's Information Seeking Process model (Kuhlthau, 2005) and the Activity Theory based Interactive Information Retrieval Behavior model (Y. Xu, 2007), this model does not approach searching as a linear process (i.e. straight from beginning stage to end without reversion); rather, the model implies a multi-phased view of searching in which different states of searching may interweave depending on users' various contextual factors. Clearly, users may engage in knowledge expansion or result expansion at any stage of a search, as long as they feel the need to do so. Users may also change exploratory or retrieval patterns of query reformulation, depending on their interactive search intents.

On the other hand, the contextual search model still accommodates the procedural nature of Web image searching. Some models such as Saracevic's (1997) stratified model depict only the important factors or agents in the interaction between user and system, leaving the progressive changes in users' cognitive states and behaviors unaccounted for. Although users do not necessarily proceed linearly from knowledge state to search state, then from review state to finish state, the process view manifests the overall importance of knowledge gathering at the beginning of a search, query reformulation strategies during the actual search, and result expansion for search result improvements. This tendency provides a blueprint for search engines to implement searching assistance, as well as a framework for studying Web image searching behaviors in greater details. The needs for future information retrieval systems to provide stage aware assistance according to users' current cognitive states has also been addressed in the IR research community recently (Allan, et al., 2012). Such kind of assistance can be particularly helpful for searchers with poor information or media literacy, which are typical Web image users.

The specific behaviors that were discovered to distinguish each search state make it practical to apply the current model on any search engines. Despite the theoretical aspects this model illustrates, underlying behaviors are specific and measurable to systems. For example, serendipity and intensive browsing were simply categorized by the temporal length of users' browsing behaviors, and the relationships between modified terms can be detected by our contextual log analysis methods or other semantic measures. In addition, such specificity and transparency also make comparisons with future studies feasible and simple. Hence, the contextual visual search model will not only help systems provide user-centered and context-aware search assistance, it will also contribute to future research in Web image searching as one comprehensive theoretical framework to be based on.

### *Difference from a personalized search*

The contextual visual search model differs from a personalized search in two major aspects:

*The requirement of constructing user profile*

A personalized search typically uses user's search history to construct a user profile, and to infer user's long term search interests (Zhengyu, Jingqiu, Xiang, Yunyan, & Lipei, 2007). However, it is not always clear how much the current search intent relates to the long term search interest (Daoud, Tamine-Lechani, & Boughanem, 2008; Teevan, Dumais, & Liebling, 2008). As a result, personalized search techniques were not explored in the current research since Web image searching is highly dynamic and the search intents may differ significantly even for the same leading search goal (i.e. same search session). Hence, the proposed user model only considers/confines search contexts within a session (i.e. related or same search topics). Based on our model, the needs for collecting and computing on historical search data are obviated and thus enable the recommendation tool to provide assistance in real time.

*The alteration of search results versus merely suggestions*

On user's perspective, the major difference between personalized searches and our contextual search model comes from the sense of control and the ability to drive a search. Personalized searches, designed to use implicit measures to automatically infer searcher's interest (Daoud, et al., 2008; Teevan, et al., 2008), are inevitably a black box to users, in which users are not aware of how the system re-ranks/prioritizes results, and thus have no control over the directions of how the results are 'personalized'. The contextual search model, on the other hand, makes inferences only from the queries submitted in the same session. The advantage is that inferences are made from explicit searching information best related to the current search goal. Since the updated/refined search intents are typically reflected in the reformulated queries, the inferred information should be more representative and responsive to the changes in search intents. Users can drive the search direction via the reformulation of new queries, and do not have to wonder how the results are altered by the system. Given the aforementioned limitations in personalized searches, recent study also explored personalization searches on session bases, which operated on a similar philosophy as the current research (Daoud, et al., 2008).

## 6.5 Significance of the Study

No other research has utilized the combination of Web log analysis (quantitative) and user study (qualitative) measures to investigate general Web user's image searching and query reformulation behaviors. The sole focus on query reformulation behaviors was found to be an effective means of studying online users' behaviors and search contexts.

More importantly, the innovative contextual Web log analysis method in the current research was proven to be a cost-effective and practical way of eliciting user's search context information on a large scale. While this log analysis provides the breadth of the searching behaviors, the complementing Web image user study provides the depth of users' search contexts, particularly the search intents and the corresponding strategies. Only a few studies have investigated Web users' searching strategies, but the current study further expands our understanding by explicitly showing the relationships between users' current search state, search intents, and corresponding strategies.

The resulting contextual visual search model, as well as the contextual query recommendation tool, showed how Web image searching can be improved from the current study findings in both system and user perspectives, even without sophisticated image processing techniques or complex theoretical assessments. Previous studies that focused on either system or user-oriented solutions did not cross their boundaries to provide holistic views on Web image searching problems. Hence, the current research signifies the first attempt to balance the two perspectives and demonstrates their potentials from an integrated research approach. This approach also resonates with the future IR research directions discussed in the recent SIGIR forum (Allan, et al., 2012). As indicated in the report, The IR community has long been focusing on the system side of IR problems while ignoring users, and their goals and interactions with the systems. Thus inadequacies still exist in understanding the new types of interactions people engage, and the new types of system supports for future, particularly in the IR system design and evaluation community. Two types of research approaches were proposed: *controlled observation of people engaged in interactions with information*, and *large-scale logging of search session interactions*. The controlled observation seeks to construct a standard protocol with specific tasks for participants to perform, and investigate important factors such as participant's prior experience, knowledge, their expectations of task difficulty and likely success. The large-scale logging provides server-side interaction records of many people's actions, and is valuable for studying distribution of user queries and result clicks, as well as the overall use cases based on the patterns identified. In this sense, the current research can be regarded as a pioneering study that envisions one of the most important future topics in IR research, improving current IR systems by understanding people and systematic investigation of their interaction with information.

In summary, the mixing of qualitative and quantitative methods helped this research understand general users' Web image searching behaviors beyond the suggestions of previous studies. Specifically, significant query reformulation behaviors were identified to distinguish different search strategies. The relationships between various search intents and strategies were discovered using the Grounded Theory approach, and have also been verified by statistical analyses to ensure their significance and reliability. Future research can benefit from the contextual visual search model, as it provides measurable key factors to study Web image searching process, as well as a theoretical framework to extend the knowledge of users' behaviors under particular search states or interactive intents.

## 6.6 Future Research

Given the limitations in the current study (detailed discussions in *Section 5.9 - Limitations*), some more in-depth studies utilizing rigorous experimental designs should be considered for future research. Two main aspects enlighten future research directions from the existing study findings: the *Query reformulation analysis method* and *in-depth searching behaviors in different search states*.

### *Query reformulation analysis method*

In this study, a new Web log analysis method based on consecutive queries were proposed and tested for its feasibility and usefulness. In addition, our user study successfully utilized the semantic relations in query terms to infer users' search intents and strategies. However these semantic relations were manually identified, which did not demonstrate its usefulness on large data sets. If the detection of term relations can be done automatically, more detailed information can be extracted from Web logs, thus enhancing the transferability and applicability of the new analysis method to comparable studies. For example, replace with related (RR) and new terms (RN), as well as addition with related (AR) and new terms (AN), appeared to be significant reformulation behaviors from our user study. Such significance has yet to be further confirmed using large-scale data such as Web search logs to further strengthen the findings.

### *In-depth strategies and behaviors with different search states*

As mentioned in the limitations section, there were some searching behaviors that were not further investigated from the user study analysis. It would thus be worthwhile to see if these uninvestigated behaviors relate to any of the strategies identified in this study. Behaviors such as multi-tasking and result comparing/organizing were present in our user study, but their occurrence has never been associated with any contextual factors.

In addition, several significant behaviors can be further differentiated to test their relationship with particular search strategies, such as the knowledge expansion for Information (KEI) and intensive browsing (IB), as well as knowledge expansion for keywords (KEK) and serendipity browsing (SB). Such analysis was not feasible due to the limited study samples and the open tasks used in the current research, as too few samples could support the analysis.

It would also be interesting to see if particular strategies are preferable in some pre-defined search tasks. The current study only utilized open tasks to investigate the search strategies, thus the relationship between specific search tasks and search strategies cannot be confirmed, despite some search patterns frequently appearing in particular search domains. The use of pre-defined search tasks in future research should not only help exploring specific task-strategy relations, but can also support determining suitable strategies for different types of search tasks.

## 6.7 Chapter Summary

This chapter provides the summary of current research findings, especially from the Web log analysis pre-study and Web image searching user study. Important implications for research are discussed from three aspects: *Contextual log analysis*, *Web image searching user study*, and *Contextual visual search model*. The significance of this study and its contribution to future research are also discussed.

# APPENDICES

## Transcript for participant 1

<u>Question 1</u>
Participant wants to find the image of a minister of Obama government. Because he heard that there was one Chinese descendant appointed as a minister in the new Obama government. He is only interested in who he/she is and how does he/she look like.

(Google Image) ministor Obama china government -> minister Obama china government -> minister Obama china member -> minister Obama china -> minister Obama government -> minister USA government -> minister china USA government -> (Google Web) minister china Obama government -> minister Obama -> minister Obama Chinese -> government member Obama -> 中國 部長 Obama -> (Google Image) 朱棣文 Steven Chu

The initial query retrieved many images of Obama. The participant reviewed some of them in the hope of finding the related news content or images from the articles. He then changed "government" to "member" to focus on the members in Obama's government. Yet no useful images can be found, so the participant dropped "member" to increase the search range. After failing to retrieve any relevant images, the participant decided not to use "China" in the query because the images then became related to Chinese foreign affair, not the Chinese-American minister in his mind. The participant replaced "China" with "government" and reviewed two pages of results. He then felt that the **images were all biased to Obama** while the use of other terms did not evoke significant changes in the result images. The term "Obama" was replaced with "USA" to broaden the search for all USA government ministers, yet nothing seemed to be related to the Chinese concept and thus "China" was subsequently added to the query. The result showed some images of Chinese people but the participant was **unable to confirm whether that was the target person**, so he **switched to Google Web to find more information.** The query was then modified to "minister obama", "minister obama chinese", and "government member Obama" but none of them successfully retrieved any useful information. The participant then **decided to use Chinese to search** as it may more accurately interpret his intention. By using "Chinese minister obama" in Chinese, many Chinese news articles were retrieved and the top most result already contained the information that the participant was searching for. Finally, he found the Chinese and English name of this Chinese-American minister and used both names in image search to confirm the person.

- Browsing through result pages relatively fast, easy to review images?
- 3 pages viewing for initial search
- Gradually dropping keywords, suggests **a "bottom-up" search strategy**
- Such strategy is thought to be useful when searching for unfamiliar items, the concern is to boost precision first so the results would be under a manageable

size

- when facing with familiar items, fewer and more specific search keywords may be used
- Confounding search work “China”, interpreted as to China policy or affairs with China
- “Obama” a strong keyword, shadows the result from other search keys
- Cross checking with Web content to validate image -> **very useful strategy**
- Change to Chinese web content, useful for finding images from Chinese news
- Using multiple tabs to search as in usual search style

Question 2

Participant wants to find the images of a famous ancient Chinese monument, Jiao Jia Tai. It is said that Lao Zi was once teaching at this place. The participant has heard of this place and knows that it is in the Guilin Mountains, Shaanxi Province.

(Google Image) Jiao jia tai -> 教稼台 ->教稼台 laozi ->教稼台 老子 > 老子 樓觀台

The initial query returned with all irrelevant images, thus the participant decided to use Chinese to modify the query as he knew this could be much more effective for Chinese originated information, just like the case in previous search task. Once the Chinese words were input, the results became much better and some images of the monument had been retrieved. In order to further confirm the place, the participant subsequently the English and Chinese word of Lao Zi, with the original place. However nothing seemed to be relevant so he replaced the place with another one which was the famous teaching place of Lao Zi. The final query retrieved many images of Lao Zi and the place he taught classes. Nevertheless, it was impossible to confirm the relationship between the place Jiao Jia Tai and Lao Zi by using Google Image search.

*Because this is a place in China, I use the Chinese name to begin the search [20:58]*
*I’ll try input the pinyin name in English first [21:10]*
*The images appeared to be very irrelevant, let see next page…also very irrelevant [21:24]*
*Now I use Chinese to search…oh, I can see almost every image is right to my target (laugh…) [22:03]*
*Now I would like to make sure if Lao Zi really did teach in here, I’ll first use the pinyin query of “Laozi” to search…(add “Laozi” to query) [23:00]*
*The query did not return any result, so I use Chinese “老子” for search [23:12]*
*The images did not appeared to be what I want, it seems that Laozi didn’t teach there (laugh…) [23:29]*
*I’ll change to “老子 樓觀台” because this is the famous place where Laozi did his teaching [24:33]*
*The results appeared to be pretty accurate; however I still cannot determine if Laozi had taught at Jiao Jia Tai. [24:28]*

Question 3

Participant wants to find a Nokia mobile phone that supports GPS localization. He has seen a TV ad of the phone but not sure about the product name and its exact appearance.

(Google Image) Nokia map -> Nokia N95 -> Nokia map mobile ->

The initial query retrieved many maps for Nokia mobiles, which was not what the participant intended to find. From one image of the mobile screen which contained a map application, the participant acquired a model name "N95" and used it to modify the query. The query returned with many images of Nokia N95 mobile but the participant was not sure whether it was the right model and needed to review the text content to confirm it. Despite the GPS navigation function was stated in the mobile's description, the participant felt some doubt about this model because it appeared differently from the one he saw before. Thus the participant broadened his query to "Nokia map mobile" and one image captioned with "A navigation-enabled mobile phone" drawn his attention. The participant confirmed it was the one he was looking for as the appearance now matched the one in his memory.

- Usually need web content to verify what the image is about, and if it's the one after

*The first result showed many images of Nokia map software…oh, I found an image of navigation mobile, this may be the one, let's open it… [25:55]*
*The result page showing Flickr page with the model "N95" in the description, I'll use this keyword for search [26:24]*
*I now see many images of Nokia N95 mobile, but I cannot be sure if it has the navigation function…I'll open an image link to see if it has the description of the navigation function [26:50]*
*Ok, it said "browsing the internet or viewing maps is easy…", but this seems not exactly as what I remembered, let's try another search [27:58]*
*I see one image depicting the navigation mobile in the street, let's click on this one…no this is still the N95… (clicked on next page) [28:43]*
*I see several related images with one same mobile, let's click on this… [29:29]*
*OK, from the title I can see "Navigation-Enabled Mobile Phone – Nokia 6110" so this is the phone I was after…it also said "navigator" in its description, I'm sure this is the one I saw before [29:50]*

# Transcript for participant 2

Question 1

Participant wants to find the images about a storm happened in November, 2008. She heard that the storm was the worst storm in Brisbane during the five years. She is looking for the storm images with flood water.

(Google Image) Storm Brisbane 2008 -> Storm Brisbane November 2008 -> "Storm" AND Brisbane AND "November 2008" -> "Storm" AND Brisbane AND flood -> storm hits Brisbane -> Storm Brisbane 2008 -> flood Brisbane 2008 -> (Google News) Storm Brisbane 2008 -> (Google Image) flooding in Brisbane 2008 -> (Google Web) flooding in Brisbane 2008 -> (*Ourbrisbane.com*) storm

The first query retrieved many results of lightning images, which was in not participant's original intent. The participant subsequently specified the time constraint to her query (i.e. by adding "November" to the query) and tried to use "AND" to connect the search terms. However the results appeared to be the same with or without the AND operator. The participant then decided "November 2008" not useful and replaced it with "flood". Only few images retrieved were about the flood while lightning images still appeared in the result set, so the participant changed the query to a complete sentence which was close to a news headline. Some images of people standing in the storm drawn participant's attention. However, after reviewing the published date in the text content, these images did not suit participant's time constraint for the storms that happened in 2008. Participant regularly checked the "More from this site…" link at the bottom of images that interested her link to retrieve more images that may be potentially relevant; however such strategy did not seem to work well in this case.

*There are even some pictures about sports! Actually I want to see images about the flooded water, not lightning or thunder storms… [01:04]*
*Some pictures have "September" in the title, I want to check about the images in November [02:06]*
*The results seem to include all storm images… (hesitation) but I think it's hard to use "AND" here (using "" to make "November 2008" one keyword and "AND" between keywords ) [02:54]*
*I want to use "AND" (operator) to find all images, not the "and" (in retrieved text), so I delete "November 2008" and use "flood" [03:40]*
*There are no flood pictures…oh there is…I also want to find what happened there…maybe Brisbane city, these results are not good enough [04:19]*
*Changed query to "storm hits Brisbane" because saw the title in one of the images (??) [05:04]*
*Oh, this is good…I need more information (clicked on "more from www.smh.com.au" link in new tab from one of the result images) [05:06]*
*Oh, this leads to more images from the site (back to result page and clicked on the image itself)…so I need to check the time, I need to find if it happened in November [05:52]*
*Maybe this site will have more useful news pictures (clicked on "more from www.livenes.com.au" in new tab)…but this is not the image I want [07:14]*

The participant then change back to her initial query because she wanted to continue reviewing more results from that query. Again the results were heavily noisy with many lightning and sports player's images. Participant then switched to Google News with same query and specified 2008 archive in the date filter. She found a news headline of "Brisbane storm brings worst flooding in decades" and an image gallery which satisfied her criteria for the storm in November, 2008. After reviewing the galley she went back to Google Image using the **newly acquired keyword "flooding"** in her previous query. This time the images became much closer to what the participant had anticipated, but when compared the results from Web search using the same query, the participant concluded that **it was much easier to find the news first** (via Web or News search) and retrieve the images accompanied, other than using Image search alone in this type of task. The participant did point out one problem with using Web search instead of Image search, is many results appeared to be images while they were actually videos. This frustrated the reviewing process/pace as you only know it was a video until you have followed that link.

*(a bit frustrated from not able to find any useful images) The first time I used "storm Brisbane 2008", I want to use it again to find more related pictures [09:32]*
*Why is so many pictures happened in September… (continued scanning through page 4)…did I remembered the wrong month? [09:42]*
*Maybe I check news…storm news (switch to Google News) [12:39]*
*(select "2008" archive from side menu) [13:05]*
*(clicked on one news titled "Brisbane storm brings worst flooding in decades") [13:15]*
*There's just a video…no pictures…oh there are some related news like "Flooding in Venice" [13:30]*
*(participant checked the date of the news video and confirmed that the news happened in November 2008, and on the same page she finally found one news image archive containing pictures she wanted) [14:27]*
*I've found the keyword "worst flooding"…(using "flooding" in previous news search query and switched to image search)…now I will find picture in this [18:04]*
*So I want to find the news, then related pictures…(checking Web results)…yes, this is what I want…check the date? November 19, 2008…that's right, so find the news first, then find the related picture is a good idea, I think. [19:35]*
*(constantly opens many news results without pictures or only with videos) Why is so many videos…(open another one) still videos…too many videos about that [23:48]*
*(seeing one result from ourbrisbane.com and opened it in new tab) I think I should check some Brisbane news websites…(looking for photos in ourbrisbane.com, input "storm" in photo gallery search) [26:00]*

Finally the participant used *Ourbrisbane.com* to search for the storm photo collection because she knew the website usually has enormous information about everything in Brisbane. She successfully found some relevant images from the result photos despite the fact that most photos were still of lightning scenes.

*There's always lightning…oh, this looks like raining [27:37]*
*It's pretty hard to find the images, maybe nobody's interested in the photos I want to find, they like the lightning pictures [28:23]*

<u>Key points</u>

Open images in new tabs
Search for relevant keywords in related title, description of the images
**Frustrated with current search results, go back to initial query to have another start** (not any other subsequent query in between)
Some troubles with related news article/picture, no content based similarity
**Content based similarity search will become useful once interesting candidates are found, but not for initial search query**
"Flood" as important turning point for search session, as water is in original intent
Change from image collection to news as an effective strategy
Confounding keyword "storm" with lightening pictures

<u>Question 2</u>
Participant wants to find the desert pictures of Uluru, Australia

(Google Image) Uluru dessert ->

The initial query successful retrieved many satisfactory results immediately, as most of the images showing the famous rock in Uluru. This should be contributed to the specificity of "Uluru". Participant claimed that her intention was to see the rock in different colors or time of the day and the initial results were already satisfying enough so she did not need to further modify her query.

*I want to use Google Image first, I think Uluru is a park…I want to find the desert [29:23]*
*Yeah, there are so many, because it's a general idea. I have no idea about this place, never been there, so I think so many pictures related [29:35]*
*I like the color of the rock, red…I like these pictures [29:56]*

<u>Question 3</u>
Participant wants to find the images of an intelligent robot with woman's appearance. It is a beautiful robot and can understand some simple human commands. The participant has seen the images of this robot before but does not know its name.

(Google Image) woman robot -> Aiko robot

The initial query retrieved many robot images, however not all of them were in female appearance. The participant quickly identified the possible ones as she still remembered how the robot should look like. She reviewed the text descriptions of the images and found the name "AIKO" and subsequently used it to modify the query. As soon as the keyword "Aiko" was used in the query, all images appeared to be consistent and participant was thus sure that it was the one in her mind.

*I have seen the robot but I don't know the name, or which country produced it [31:12]*
*These are robots, but not the one I seen, they are ugly, I think [31:45]*
*(scrolled down on the first page and soon spotted on one image of woman wiping the glass) oh this, this is the correct one I want to find [31:58]*
*(carefully read the image's description and found the robot's name "Aiko") creating Aiko, who he describes as "in her 20s"…Oh, I just need to check Aiko [33:01]*

*(replaced "women" with " Aiko" and kept "robot" in the query) maybe someone name Aiko as well…Oh beautiful, yeah, that's the correct picture I seen in TV or somewhere [33:28]*

## Transcript for participant 3

<u>Question 1</u>
Participant wants to find the maps of the affected areas from the recent bushfire in Australia.

(Google Image) map Australia bushfire -> map Australia bushfire 2009 -> map Australia bushfire

The first query retrieved one Google map image which shows many tagged locations in the map. However the participant was not sure what the map was about, so he added "2009" as search term in hope of finding more accurate results and to exclude the images from previous bushfires. To participant's surprise, the new query retrieved fewer maps than the previous one, which was much more inaccurate in participant's opinion. Participant consistently looked for images with the map of entire Australia, presumably that he was very focused on the "map" concept. After failing to see any relevant images, he went back to his first query (i.e. by dropping the 2009) and scanned through more result pages. When no more results seemed to be relevant, the participant decided to go back to the very first result. After a more careful scrutiny, the participant concluded that the first result was actually very useful and precise to what he needed.

*First one looks like a map (clicked on the first image) [01:00]*
*Alright, it's google map, I don't know what these symbols mean…probably nothing useful [01:30]*
*Some of the results are not showing maps at all…I'm not sure what's wrong [02:57]*
*Ok, I change the query to include the year, which is 2009, because I don't what to see pictures from previous years [03:40]*
*Still there are some results that are not maps…actually, I think this is less useful than previous one… [03:55]*
*(constantly checking the year, but find many images are not from 2009) I'll go back to my first query [05:37]*
*I might go back to that first result (back to the first result which he clicked before, changed to satellite map) …(saw the explanation of the color symbols) Ok, so this is what I was looking for [07:15]*
*So it's actually the first query first result…just when I first time saw it I didn't understand the picture [08:36]*

Not many "map" type image can be found
Jump back to initial query results
Use multiple tabs (as many as 7 tabs)

<u>Question 2</u>
Participant wants to find some images about the interesting places to visit in Japan.

(Google Image) Japan “tourist attractions”-> Japan “tourist attractions” map ->

Participant opened several images in different tabs from the initial results but some of the images were not even in Japan. Participant then quickly reviewed the images mainly by its appearance to judge its relevance. The word “map” was added to the query to focus on the map type images about Japan. The results came pretty diverse as many images were not maps and even if they were, many of them were not Japan maps. It appeared that the participant was hoping to see a map that depict the overall tourism interest areas in Japan, perhaps with some iconic scenery images. Finally some tourism photo collections were found and the participant was satisfied with the particular result.

*(seeing one google map result) Oh, I really like this one…but it’s not in Japan!! [10:51]*
*Maybe I should try look for the maps (add map to query) [12:10]*
*(clicked on one railway transportation map) This one is really good…because it’s a map, the map is really clear…it shows what I can see at where…[14:28]*

Explorative search intent has lower criteria?
Iteratively go through pictures when many interesting results were shown
Change to add “map” as search term, refine search intent and changed focus

<u>Question 3</u>
Participant wants to find out the latest lightweight/mini laptops.

(Google Image) laptop (lightweight OR mini OR small)

Participant was not sure about the term that were used to describe the recent netbook mini laptops. Thus he included all the possible terms in the query by using “OR” conjunctions. The participant was doing an explorative search since he did not have any particular model or brand in mind. One problem emerged after reviewing the product image alone was not able to see how small the laptop is. However, the results were accurate enough so the participant did not feel the need to further reformulate his query.

*I’m sure of the exact term I should be looking at…it’s probably small laptop, mini laptop, or lightweight laptop, so I’ll use all of those [16:15]*
*I hope I can use the “or” operator…seems like it’s working [16:43]*
*Eee pc…MSI…(keep searching for model names or manufactures)…I’m not exactly looking anything here…so just looking around [17:26]*
*Hmm…I want to know how big it is [18:10]*
*Ok, the problem with these pictures are that I’m not seeing how small they are [18:51]*
*I like this one coz it’s comparing with a size of a pencil [19:09]*

Overall, the search strategies indicates a **“top-down“** strategy, especially for explorative search intent or something general

Will use “bottom-up” if knowing which specific image to look for
Only interested in (mini) or small sized laptop, not a general search purpose

## Transcript for participant 4

Question 1

Participant wants to find the images of latest car reviews. He is personally interested in cars and constantly searches new cars on Web as a habit. He focuses on the new car calendar which reveals the actual appearance of the latest cars. He also hopes to find some new cars that are affordable to him.

| | |
|---|---|
| Google Web | latest car reviews on new or used cars |
| carsguide.com.au | (browse the news & reviews section) |
| drive.com.au | (browse the new car reviews section) |
| Google Image | latest car reviews on new or used cars |

Participant first used Google Web to search for known car review websites and consequently **navigated to carsguide.com.au**. Because he knew this website has plenty of car information and reviews, he decided to use **browsing as his search strategy at this stage.** He **went straight to the News & Reviews section** and spent quite some time reading the articles. He was interested in the new cars that are affordable and with modification potentials. The practicality of the car such as space and fuel economy was also of his concerns. He browsed three pages in the news section looking for sports cars that suit his need, predetermined by the look and the brand of the car. The participant then went back to Google Web result and switched to drive.com.au, another website that he knew for plenty of information on new cars. Participant also found the interface of drive.com.au website more user-friendly because the list of review articles also provides a thumbnail image for the car reviewed. Finally the participant also tried using Google Image search, but commented that it was not very useful for his search as he was interested in the specifications and reviews of the car, thus he would **start with some more trustable/reputable sources such as carsguide.com.au or carsales.com.au.**

*I know this website, they have many car reviews, so I usually go to this site or carsales.com.au [01:02]*
*I also remember drive.com [05:56]*

Question 2

Participant is planning a trip to Japan. He wants to find travel information based on the number of days that can be spent for the tour. Information about the city tour and sight-seeing would also be relevant to his search.

| | |
|---|---|
| Google Web | seasonal festivities in japan |
| jnto.go.jp | (browse for attractions in Japan) |
| Google Image | seasonal festivities in japan |

Participant first used Google Web to perform a general search on the tourism of Japan. The link "seasonal attractions" drawn participant's attention. Participant commented that the website very **useful to his search as it provides well organized information** and each of the seasonal attractions **comes with a thumbnail image and short description**. Participant then switched to Google Image but many results were irrelevant to his query.

*Seasonal attractions…[19:48]*
*I'm interested in the cherry blossom and hot springs in Japan [20:10]*
*I feel this website provide much useful information, so I'll keep browsing on this website [25:11]*

<u>Question 3</u>
Participant wants to find some performance kits for his car, either from the factory or aftermarket. Search criterion is mainly based on the unique style of the kit, which can be either the luxurious VIP style or racing style.

| | |
|---|---|
| Google Web | BMW body kits |
| myhotbmw.com | (browse for various body kits) |
| bmwperformance.com.au | (browse for factory body kits) |

Participant used Google Web to navigate to a known BMW modification parts website (myhotbmw.com) and browsed through various body kits. The images that showed how the body kits look like on cars helped participant judge if the kit was the right one for him. The participant then switched to the official website of BMW performance body kits, where the participant would normally browse.

*I know this site (bmwperformance.com.au) because I have brochure mailed to me [33:33]*

## Transcript for participant 5

<u>Question 1</u>
Participant wants to search for images about North Korea's recent unclear missile launch. He is particularly interested in the satellite photos of the military facility after launch.

(Google Image) North Korea nuclear -> North Korea nuclear test -> (Google News) (no results) -> (Google News TW) North Korea nuclear test -> North Korea nuclear missile -> (Google Image TW) North Korea nuclear missile

From the first two queries many satellite photos were retrieved, however many of them were not related to the latest nuclear missile test. Thus **the participant used Google News to search for more results**. **The Google News did not return any results, possibly due to the query was in Chinese, so the participant switched to Google News TW**. This time Google returned many matching news with corresponding thumbnail images, however none of them was considered relevant.

The participant then tried in image search and browsed two pages of results. Still no images were found to be particularly relevant or close to what the participant expected, so he gave up the search because of losing interest in the topic.

*I want to see images about North Korea's nuclear tests, whether before or after the test…or even only after the test, it doesn't really matter, just to see how it looks like [00:35]*
*It looks like the nuclear testing picture…oh hang on… it's actually North Korea launching rockets, so I change "nuclear" to "nuclear test" [03:10]*
*I clicked on one image saying nuclear test" in the description and it looks like a satellite image…but still not the one I want, I want the satellite images of military base after the test [04:14]*
*When I couldn't find the images I want, I'll use news search, but this is Google AU, I'll change to Google TW because I know it's reported in Taiwan news [05:11]*
*Because I know in news search, Google also give you some news images in the results, this is my other way of finding images [06:45]*
*Because I've seen similar images, I think I can find them in Google News search. However based on my previous search experience, sometimes they don't put images in the result; it's a bit of luck whether you can find the images you want this way [07:11]*
*I can't find the images I want, so I now change to related keyword "nuclear missile" [07:28]*
*I still can't find any relevant images, I'll change back to Google Image [08:20]*
*Because I don't really need to find these images, just want to have a look, I'm now tired of this topic after 5-6 minutes of search and would like to move on to next topic [09:02]*

- Use news search to find news images
- Generally one page viewing

<u>Question 2</u>
Participant wants to find a list/table of free English classes in Brisbane.

(Google Image TW) Brisbane free English class -> (Google Web TW) Brisbane free English class

Participant first used image search and found a table of the open dates of English classes in Brisbane, but he claimed this was not the one he saw before. The table in his mind contained information about the types of the English class, the location, school, and prices. Then the participant tried the Google Web search and successfully found the table although it was in Web page format but not an image of class table.

*I've heard of some free English class after I came to Brisbane, so I'll use "Brisbane free English class" as my keywords [09:10]*
*I found this image looks like a table, I think it's the one [09:56]*
*No…this is not the one I want because I've done the search before…it clearly lists the timetable, class types, and institutions around Brisbane city area [10:33]*
*It's a table like graph…but it may not be an image [10:54]*
*After 2 to 3 pages of browsing without correct results, I now change to Web search (clicked on the first result and found the correct information he wanted, but a Web*

*page table, not in image format) [11:19]*

Question 3
Participant wants to find some illustrations/diagrams about the new Blu-ray discs. The diagrams should depict the structure of the Blu-ray disc and how it works. He needs these images in his school assignment.

(Google Image TW) BD CD DVD principal -> CD principal diagram -> DVD principal diagram -> DVD structure diagram

The first query retrieved many images of the optical drive devices and some posters for technology exhibition. However most of them are not suitable for participant's need as he was writing an assignment to explain the structure and operation principals of the blu-ray disc. He found one diagram of the density comparison between the three types of discs, which is good for his purpose. Participant then decided to focus on the mechanism of the optical reader head. He refined the query by leaving "CD" in the query and added "diagram" because he thought it would be easier to retrieve more image results only using "CD" in the query. The results were not as relevant as expected, so the participant changed "CD" to "DVD". **One of the results had the word "structure" in its description and inspired the participant. Thus he replaced "principal" with "structure".** This time the results were very consistent with many images showing the structure of DVD discs. Finally the participant found an image of the structure of the DVD reader head and completed the search.

*I would like to compare the difference between Bluray. DVD, and CD discs, so I use all of them in my query [12:39]*
*I want to find the diagrams of optical reader head mechanisms, I think it's easier to find from CD and DVD, so I'll remove "BD" from my query [16:24]*
*I see many diagrams of LCDs and mouse, which are not what I want [18:32]…*
*I found this diagram says the principal and structure of a CD player, I'll change my query to "DVD structure diagram" [19:36]*

# Transcript for participant 6

Question 1
Participant wants to find images of Korea's ex-president suicide. The retrieved images may include topics like the black money, the nation's crying, as well as the big funeral.

(Daum Web) Korea president suicide -> (looking for information about "black money") -> Roh Moo-hyun (president's name) -> (Daum Image) Roh Moo-hyun -> (eight pages of viewing) -> (give up on black money concept)

Participant started with "Korea president suicide" to search for some general information about the ex-president's suicide. He read one news article about the

suicide and its effects on the Korea's society and economy. After browsing through the results he decided that the query was too general and broad, so he changed query to the name of the ex-president and switched to image search. He wanted to find images about the black money because some reports said the suicide was related to the black money the ex-president had received. Many images were shown about the various topics of the suicide and the president, such as **the portrait of the president**, **photos from earlier ages**, **the funera**l, as well **as his family and the place he committed suicide**. However, none of the images gave the idea about this black money scandal, and the participant gave up one this particular concept after reviewing eight result pages.
*I use Korean search engine, Daum, because I think it's easier than other search engine [01:15]*
*Most pictures are related to this president's life, his achievement in Korea0..but I want to find black money [08:15]*
*I can see black money in the article, but I can't see in images [09:27]*

<u>Question 2</u>
Participant wants to go to Los Angeles. He likes the MLB baseball and NBA basketball team there. He also would like to visit Las Vegas if the trip allows.

(Daum Image) Los Angeles -> (looking for MLB、NBA) -> Hollywood -> Las Vegas -> (browsing) -> (looking for how to get there) -> LA to Las Vegas transport -> Los Angeles map -> (no satisfying results found)

Many of the images retrieved from first query were about Disney land and Mickey Mouse. Participant then decided to look for more iconic images about Los Angeles. He subsequently used "Hollywood" and "Las Vegas" as search queries to discover different images in Los Angeles. The query "Hollywood" retrieved many celebrity photos and almost every image related to "Las Vegas" was the night views in Las Vegas. Participant quickly browsed through these thumbnails without following any links. Then the participant decided to search for the transportation between Los Angeles and Las Vegas, ideally some maps would be good. The query did not return any results so the participant changed to "Los Angeles map". Only three images were retrieved and the closet result was a floor plan of Los Angeles international airport. Participant was not very satisfied with the results but had to terminate the search.

*I see many images about Los Angeles, especially Mickey mouse and Disney land [10:17]*
*I can see many actor and actress in LA, Hollywood [11:49]*

<u>Question 3</u>
Participant is interested in the Sansumg cellular phones. He wants to find some phones that have simple design and various multimedia functionalities such as MP3/Video playback and still image/video recording. The ideal phone should also have wide screen and comes with good customer service.

(Daum Image) Samsung cellular phone -> Samsung cellular phone after service -> Samsung cellular phone break down -> Samsung cellular phone design -> (Samsung.co.kr) -> cellular phone out of order

The initial query retrieved many Samsung cellular phones and it was easy to see some of them meet the participant's criteria. Then the participant **focused on the after service or the breakdown of Samsung cellular phones**. However such concept was difficult to express in visual content and as expected, none of the images were retrieved from these two queries. Participant then **refocused on the new design of the Samsung cellular phones** and easily found the latest Samsung Google phone. He also tried to search the phone breakdown in Samsung's official website but only text information can be found.

## Transcript for participant 7

<u>Question 1</u>
Participant wants to find pictures about Michael Jackson's funeral. The pictures should include the scene and any celebrities attending the funeral.

(Google Web) michael jackson funeral -> (Google Image) michael jackson funeral -> michael jackson funeral celebrities -> celebrities "michael jackson funeral" -> (Bing Image) michael jackson funeral -> michael jackson funeral celebrities

Participant input the initial query in **Google Web as he claimed this is his habit to start a search** as Google would also include image results in Web search. If the results are not sufficient or satisfying enough, he will then try Google Image. The image results were showing a lot of photos of Michael Jackson himself, but the participant only wanted images of people attending the funeral.

*I usually start my search from Web, because Google also includes some images in Web search results [00:30]*
*If I cannot see what I want, I'll then switch to Image search [00:53]*
*I don't want the pictures of Michael Jackson himself, I want images about the funeral, like people moaning in front of his coffin or the 送葬隊伍 [01:24]*
*I'll follow the first one I think it's relevant, and browsing on the page for a while [02:40]*
*Usually, I'll keep following the search result for one or two pages, if no satisfactory images are found, I'll change my query [03:08]*

After viewing three pages and only seeing the Jackson's family attending the funeral, he **decided to focus on the celebrities who attended the funeral**. By adding "celebrities" to the query, however, many results appeared to be Michael Jackson himself or with other celebrities, not many funeral images. He then refined the query by combing "Michael Jackson funeral" into one search term in the hope of eliminating the images of Michael Jackson himself. Nevertheless the results appeared to be pretty much the same with previous query. Hence the **participant tried using the initial query at Bing Image** but the result did not seem better. After seeing some fifty images without satisfactory results, the participant concluded it was difficult to find the images he had in mind. Finally he tried adding "celebrity" to the query but no better results can be found.

*When my keywords are not working, I'll try using the "" to include several of my*

*keywords as one search term [05:33]*
*The results didn't seem to change much, it seems Google did not handle the quotation term well [5:59], can I try another search engine? I'll try Bing with the same strategy [06:18]*
*I don't use tabs in image search, because I usually have strong ideas about I'm looking for; I can visualize what I want to find already, there's no need for using tabs for comparison [07:15]*
*I now have a feeling that I may not be able to find what I want after seeing so many results…even if I can find some, it would probably be his families which I don't recognize anyway [09:48]*
*Originally, I intended to find images that would tell me more about the funeral, especially the people there…but obviously it was not successful [11:28]*

<u>Question 2</u>
Participant is looking for images of Taiwan, particularly the southern part. He is interested in the night market and scenery there and would like to see what places are worth going.

(Google Web) ("South Taiwan" or Tainan) night market -> (Google Image) ("South Taiwan" or Tainan) night market -> (Google Image Advance with **large image**) ("South Taiwan" or Tainan) night market -> (Google Image Advance with **medium image**) ("South Taiwan" or Tainan) night market -> (Google Image) ("South Taiwan" or Tainan) scenery -> Tainan night market -> (Flickr.com) (browsing one's album) -> (Google Image) Tainan night market -> Tainan

As usual, participant started with Google Web search to quickly scan any interesting results. Then he switched to image results and commented that the results were much better than previous search by showing many images of the true night market. He was particularly interested in the scene of night markets. Participant then tried to change the size filter in order to get better quality results but was unable to improve the search.

*So, as usual, I start with Web search [13:34]*
*Normally, I hope the Image search would direct me to a gallery or something like Flickr in a search like this…I don't want people's blogs [14:33]*
*I will also use the image size as a reference for whether it is useful, I normally will just ignore small images [15:12]*
*Because I want to find the scenery images …when I see people's face in the image, I would just ignore it [15:19]*
*For this topic, I want to see photos of the market itself, not food [17:13]*

He **re-typed the query in Chinese** and suddenly the results became very close to what he anticipated with many photos taken in the night market. He followed one result to one's flickr album and browsed some images there. Finally the participant **broaden his search by using only "Tainan"** as the keyword to find some potential interesting images such as the famous tourism points or maps about the city. He admitted **this was an explorative trial** as he has found enough images of his night market search need. He also found some blog pages useful for his exploration on Tainan city.

*After changing to Chinese search, the results seem to improve dramatically [19:56]*
*I clicked on the result because it's from Flickr, because I think flickr would have better collections of images and usually uploaded by local users [20:17]*
*I've seen enough food photos, I'll click on next page, if the images are still the same, I may change my query [24:33]*
*Because "night market" always gives me food images, I'll try backward a bit (broaden) my search to see if there's anything different [25:13]*
*I don't really worried about broadening the query would include many irrelevant results because I've found what I want to see, I just want to explore what else I can find [25:52]*
*When I just want to explore more information about this (travel) topic, I think blog is useful for finding more about Tainan, which is no harm to me [28:09]*

<u>Question 3</u>
Participant would like to know how the new Nikon D3000 camera look like, and possible some comparisons with other similar products.

(Google Web) D3000 -> (Google Image) D3000 -> D3000 D5000 -> D3000 D5000 comparison -> D3000 vs D5000

Participant started with the particular model name as initial query. The first image search accurately returned many camera images despite some mobile phone images which also called "D3000". Participant was particularly interested in how the camera looks like. He reviewed some official images of the camera with standard kit lenses and found some images of side-by-side comparison with other cameras interesting. Thus he decided to focus on how the D3000 compared to other cameras.

*The initial result looks quite right [29:11]*
*I only want to see how the camera looks like [30:53]…then I want to see how it compares with my own camera [31:02]*
*Because I have my own camera, I don't want to see the result images appeared to be something totally different [31:59]*
*I would not click on this because I found it was from the official press release…I don't like the official photos, I'm more interested in the non-official ones [32:56]*

Because the participant personally has a D5000 camera, "D5000" was added to the query to see some comparisons of the two cameras. However, the results were showing many cameras that are neither D3000 nor D5000. **The term "comparison" and "vs" were added to the query for more accurate results** but no observable improvement can be achieved by using these two terms.

*I can't see more new photos…I'll add the model name of my camera [33:58]*
*This one is from Flickr, I'll check this one…I've using Flickr for a while, I know the images from Flickr are generally good [34:46]*
*In addition, I was hoping to find a set of images I want [34:54]*
*I want the images comparing the two cameras [37:02]*
*The result seems even worse [37:28]*
*Now it's the fourth page, I'm going to stop right here, if it still not showing what I want…I'll…(changed the query) [39:07]*
*It's even worse; I think [39:21]*

*In this case, I'll go back to the particular website which provides reviews for all digital cameras [39:46]*

## Transcript for participant 8

Question 1

Participant wants to find if there is any Chinese girl who will auction her virginity. He is interested in this topic because he saw a news that some Western girl is auction her virginity and the bid has now reached to multiple million dollars. He is particularly interested in the look of the girl and what the current bid is.

(Google Web) virginity auction "Chinese girl" -> (Google Image) virginity auction "Chinese girl" -> (Google Web) virginity auction "Chinese girl" -> (six page reviewing) -> virginity auction -> (Google Image) virginity auction

Participant began with Google Web search because he thought it would be easier to find any names from the Web search results. He also temporarily switched to Google Image to see whether any Chinese girls' image would appear. After carefully reviewing six pages of Web search results, the participant decided to drop "Chinese girl" from the query to see the original news he heard previously because he could not find any Chinese girl in similar news. Finally he found the news he saw with the current auction price. He then confirmed the face of the girl by using Google Image and concluded that no Chinese girl doing the same thing on Web.

*Participant went straight to Google Web Advance because he needs to include "Chinese" and "girl" as one phrase for search [01:09]*
*Very hard to find, no Chinese girls are selling their virginity…very hard, that's why I think it's better to use Web results [02:48]*
*(looking at some forum posts for Web result) 3.4million for a girl's virginity?!...Impossible [09:23]*
*I'm looking for the face of the girl…no image…you know, and then you know how much it's worth for, money and the image…if you want to buy something, you must see the thing [11:45]*
*I think we should give up on "Chinese girl", too difficult [15:37]*
*I've seen the photo of the girl, just in Carrier Mail [17:11]*
*I've seen it before, but I just want to know if there's and Chinese girl did the similar thing [17:30]*
*(In final Google Image results) Ok, no Chinese girls, you see, it proved my hypothesis, no Chinese girl doing such silly thing…[24:46]*

Question 2

Participant wants to find a holiday resort surrounded by water near Brisbane.

(Google Image) resort Brisbane -> resort Brisbane Australia surrounding by sea ->

The participant seemed to possess some prior knowledge about some resorts around Brisbane prior to the search because he said that he knew Tangalooma would appear in the top results. In addition, he wanted to some alternative places to go. From the results he found Curon Cove Island also suits his needs with the resort village built on the water. Participant then added “Australia” and “surrounding by sea” to the query and reviewed some more images of the resorts, including maps which is essential for him to decide the location of the resort. In the end, participant found out not many island resorts to go around Brisbane area, possibly the Tangalooma which he had been there before, the Cove Island, and perhaps the Sanctuary Cove that suit his criteria.

*I know one first, it will come (up) here, the one is Tangalooma [25:07]*
*Yes, I've been there, I want to know if there's any alternative…[25:29]*
“Surround by sea” an example of using visually descriptive keywords

<u>Question 3</u>
Participant wants to find a secondhand car in good condition and has a good engine.

(Google Image) second hand car Toyota "good engine" "trading post" -> second hand car "good engine" "trading post" -> second hand car “engine reconditioned" "trading post”

The first query returned many second hand cars for sale, although the images were not all Toyota cars. The participant then followed some of the results and ended up browsing the website for selling secondhand car (*discountusedcars.com.au*). He carefully scanned through the key figures of the car (eg., price, kilometers, years, etc.), and checked the pictures to assess the conditions of the car.
Later on, “Toyota” was dropped from the query because the participant wanted to broaden his search. One problem the participant raised during his search was that despite he has specified “good engine” in the query, what he would like to see is the images of the engine itself with some detail descriptions such as the year and service record, not some images of cars with “good engine” in the descriptions. Thus he replaced the term “good engine” with “engine reconditioned” in order to find more second hand car that has its engine reconditioned/renewed. The results did not turned out quite as expected but some of the engine reconditioned cars were found.

*Yeah…heaps of that, is it? [33:40]*
*That's the company for selling secondhand parts, not the one I want…[34:36]*
*Queensland seems a little bit expansive, you see, 1993, same year, sliver colour…[36:40]*
*How do you define it's a very good engine… yeah, we don't know it, how can you say this? If you say something you should justify it…[39:10]…but for external appearance it is really good…[39:24]*
*Do you buy something for just looking the images?...yeah, just seeing the images is not enough [39:50]*
*Odometers is also one of the criteria [42:43]*
*But what happened…I specify the “engine”…how can you see how good is the engine [43:11]*
*(Participant seems a bit frustrated with the current results, particularly images)*
*What I want is a car, even a secondhand car, if after some minor modification or*

*repairing; they have a new engine [43:28]*
*Ok, "engine refurbished", I'll try that* ***(ID)*** *[43:50]…"engine reconditioned", whether I can get it, OK? [44:02]*
*No, still can't get it…[44:33]*

## Transcript for participant 9

<u>Question 1</u>
Participant wants to find the images about Air France crash in Brazil. He would like to know where the plane crashed exactly.

(Google Web) plane crash -> (Google Image) plane crash -> plane crash airfrance -> plane crash airfrance -> plane crash airfrance place -> (10 pages browsing) -> (Yahoo Image) place air crash France -> (Google Web) plane crash airfrance place -> airfrance crash -> airfrance crash place -> air france plane crash -> (BBC.com) (follow news headline article)

Participant began with Google Web search because this is what he usually does when searching for news.

*Because Google offers some term recommendations, usually I would pick from the top suggestions to start my search, it also suits my need here [00:51]*

He concentrated on something like a map that depicted the location of the incidence, thus other visual information such as videos from Youtube is irrelevant to his search and he would avoid them.

*Usually I would select/follow the first couple of results [01:11]*
*I need some images like maps that clearly depicts where the plane has crashed, I would also avoid links like YouTube because videos do not suit my need here [01:36]*

The participant then switched to Google Image but the results were showing many irrelevant airplane crashes, thus he subsequently added "airfrance" to his query. The results contained a lot of plane crash photos but no maps. Hence the word "place" was added to the query but still no relevant images (i.e. maps) were shown after ten pages of browsing.

*I've already input all my keywords in Google, I'll keeping browsing the next few pages [03:38]*
*I won't be looking till the end of result pages, usually around 10 pages [05:21]*

The participant then switched to Yahoo Image with re-ordered query but still no useful images can be found.

*I can't find what I need, I'll change to another second-choice search engine, personally I incline to use Yahoo Image [05:50]*
*I'll change the sequence of my keywords this time [06:10]*

*Form Yahoo search, I still can't find the images depicting where exactly the airplane crashed [07:07]*

Participant went back to Google Web and reviewed four news results.

*Can I use Web search because some information I need was not able to be found in image search [07:30]*

Then he changed the query to "airfrance crash" and added "place" to see if different news results can give him more idea. After several trials and reviewing the news results, participant decided **to go directly to a news website**, such as the BBC.com. He thought they should have more detail information than general search engines.

*It seems I still can't find anything I need for this topic up to now [12:59]*
*Usually in this condition, I would go to other website…like BBC, they may have some news images [12:24]*

Form the home page the participant was able to see this particular incident in news headline and found the map he wanted in the article. The participant concluded that perhaps the search engine failed because the news was just received and yet to be indexed by the search engines.

*Now I found what I need, of course it's not directly from search engines like Google or Yahoo, because the news is fairly new, it may not yet be indexed by search engines… but now this is what I need [14:55]*

Hence going directly to the news website may be more efficient in this particular case.

<u>Question 2</u>
Participant is planning a trip to Tibet for his holiday. He wants some image information regarding the landscape in Tibet.

(Google Image) Tibet -> Tibet temple -> Tibet interesting place -> Tibet interesting place overview ->

As soon as the participant saw the results from the initial query, he decided to focus on the temples because he knew there are many historical temples in Tibet.

Ok, I see many images of Tibet, I know Tibet is famous for the temples there [15:27]

He showed particular interest in magnificent temples not the ordinary or small ones because, as he commented, they are more worth going.

*I plan to select the famous temples as my destination for the tour [16:36]*
*For example, I would not go this one because it does not look magnificent [16:50]*

The images were satisfying enough so he moved on to search for the "interesting place" in Tibet.

*Also I would like to see other famous places in Tibet, because it's a big county, I would not be able to go every place there [18:07]*

The participant intended to find some maps that depict the interesting places in Tibet and subsequently added "overview" to describe the use of a map image. From the query he finally found a map that illustrated a list of famous places in Tibet, a highly suitable result for the participant.

*The previous results where all showing some particular place, like a mountain or temple, but what I expect is some overview maps depicting the famous places…but it seems that there are no such images [21:03]*
*Ok, this is the map of places of interest in Tibet [21:40]…Ok, this website, or I should say this particular map is what I needed [21:56]*

<u>Question 3</u>
Participant wants to buy a new printer. He needs to see the printers online before making a decision.

(Google Image) printer ->

The participant began with a very broad query "printer" in Google Image with some doubt about the accuracy in perspective. To his surprise, the images returned were all pictures of various kinds of printers so he browsed through the pages to find the printer he liked.

*I'm not sure if it has the information I need…(surprised) Ok, there are quite a few, [22:53]*

Because the participant is used to online shopping, his intention was to see the printer first before making the decision. His main concern was the size of the printers without any preference for the brands in mind.

*Because I was used to online shopping, the biggest problem with online shopping is you can't see the actual thing…so I'll focus on the size of the printers [23:14]*
*I don't want the big ones…and I don't have any preference for the brands, I'm more interested in its look [23:41]*

He also stated that the only criterion is it has to be an inkjet printer, not a laser one. There was one image with the printer and its ink cartage set which perfectly addressed participant's need for this search.

*I also prefer inkjet printer, of course you can't always see whether it's an inkjet or laser printer from the images, I'll look into the descriptions [24:22]*
*Ok, this image clear shows it's an inkjet printer because it has the cartages on the side, and the size looks quite right to me, I may choose this one [24:49]*

# Transcript for participant 10

Question 1

Participant wants to find images of the recent French airline crash. His focus is on the exact, detailed and direct images about the incident or the crashed plane. Related images such as rescue actions or press conferences are not considered as relevant to his need.

(Google Image) French airline crash -> French airline crash Brazil -> (Google Web) French airline crash -> air France crash -> (Google Image) air France crash Flight 358 -> (Google Web) air France crash Brazil -> (Google Image) air France crash Flight 447 -> (Google Web) air France crash Brazil black box -> (Google Image) French airline crash Brazil wreckage -> French airline jet Brazil wreckage -> French airline jet Brazil wreckage 447 -> (Yahoo Image) French airline jet Brazil wreckage 447 -> (Google Image) French airline jet Brazil wreckage 447 crash storm -> French airline jet Brazil wreckage 447 storm -> French airline jet Brazil wreckage 447

The first query retrieved many plane crash images, however most of them were related to the Air France crash few years ago, not the recent incidence the participant was interested in.

*Most of the images seems to be related to the one happened few years ago…what's that called? The Continental? [01:30]…whatever, it's not the one I'm looking for, I'm looking for the one that only happened few days ago [01:39]*

The participant then added "brazil" to his query in the hope of finding more specific images. However the results still contained a lot of irrelevant images, so he **switched to Google Web to search for more keywords from the news**.

*I now put "brazil" to the query where the airplane crashed just few days ago [02:20]*
*I think I need to go to Google Web search to find some keywords, some text information to help me reformulate my query [03:13]*

Immediately after inputting the query, the participant **realized that it should be "Air France" instead of "French airline"** from the titles of top results. Thus he made a change to his query by replacing "French airline" with "Air France".

*I'll start with my initial query…so that's the problem, it's not French airline, that means my initial query was not correct, it's "AirFrance"… [03:43]*

The participant then followed the image result section from this Web search result, yet the images looked pretty similar to the initial query. Thus he added to flight number from the previous Web search result to the image search query but soon he discovered that it was an incorrect flight number because the images were in 2005.

*Oh beautiful, even though I typed in Google Web search, it also shows Image results from the query… [04:18]*

*Oh, too bad, it's the one we got before [04:35]*
*So we can have the Flight 358 there, and see whether we can use this flight number to specify the query [05:10]*
*Good, this seems much better [05:20]…oh no, that's not the one…[05:50]*

Participant then went back to his previous Web search and added "Brazil" as a keyword. **From the news results, the participant discovered that it was Flight 447** and reformulated his image query again. Despite the query was very specific and precise this time, the images still did not look like what the participant had anticipated, with some irrelevant images such as a plane flying in the sky or press conference images.

*"Brazil confirms AirFrance jet crashed in ocean…" that's the correct news [06:20]…Ok, it's flight 447 [06:28]*
*Now we got some…not direct results to what we need [06:49]*
*I'm just trying to find some keywords in the news…those keywords specify the event and differentiates from others because it seems AirFrance had many crashes [07:45]*

Subsequently, the participant went back to previous Web search results and found **a Yahoo News result with the gallery (282 images) of the recent Air France crash news**, which looked satisfying to participant's need. After browsing around 70 images in the gallery, the participant concluded that most images did not directly depict the crash, so he decided to do a bit more search **to see whether the crash images really exist.** The participant first added "black box" to his Web search query and was inspired by the word "wreckage" from one news result.

*In Yahoo news, we found a database of biggest numbers of related images we found so far [09:28]*
*We have scanned about 50 to 70 of these 282 images there, some of them actually duplicate and I didn't visualize any images particularly describing the crashed aircraft itself, so this leaves me to question whether those images existed [11:50]*
*To confirm this, I think I need to extend my search to has any part of the aircraft being found? [12:21]…I need to go back to Google Web search to check that [12:45]*
*A news updated few hours ago says "wreckages" found in a three mile path …confirming the missing "jet"…let's reformulate the search query in image search [14:10]*

He then **used "wreckage" with several other combinations to reformulate his image queries, such as "jet" and "447".** However, none of the queries retrieved satisfactory image results. Since Yahoo had a large image collection of this particular news, the participant then used Yahoo to search for the images of the plane wreckages. After **failing to retrieve any images from Yahoo, the frustrated participant tried several queries in Google Image** but still no better results.

*Considering that biggest 282 image collection is found from Yahoo, I have reasons to believe Yahoo may have better results than Google Image, so let's have a look at Yahoo [15:57]*
*Too bad, not any result, that adds one more reason not to like Yahoo [16:48]*
*I remove "crash" from the query because according to the news, "crash" is not confirmed [17:32]*

Finally the participant **lost his patience and gave up the search**. He concluded that the Yahoo news image collection was the best results he can find for this search task.

*But "storm" doesn't help as well, I think I'll have to give up, I guess I have lost my patience about this [17:39]*
*I not satisfied with the result, but I'm partially satisfied with the biggest image collection found from Yahoo [17:59]…but my essential expectation is to find the direct, descriptive images about the crashed jet itself, so this search is failed even though we've find some related information [18:40]*

<u>Question 2</u>
Participant wants to travel to Milan. He wants to know the landmarks in Milan, such as the most popular, typical, and expensive attractions whichever suits for tourism purposes.

(Google Image) Milan landmark -> (Google Web) Milan home -> Milan -> (browsing the 2nd page of previous image search result) -> (Google Image) Milan historical building

The initial query retrieved many landmarks in Milan. Particularly, eight out of twenty image results appeared to be of the same building, so the **participant thought the building must be an important landmark in Milan**.

*I expect to find some beautiful and very specific, and popular landmarks in Milan [19:22]*
*Eight out of twenty images are about one particular building, I guess it's the most popular landmark in Milan…so let's confirm if this is the most popular one in Milan [20:32]*

Participant then **went to Google Web to search for some official/representative websites** that have information on the landmarks in Milan, presumably from some government tourism websites.

*Why not we go to the official websites in Milan, for example provided by Milan government and see what they say [21:08]*

He then broadened his query to "Milan" because the keyword "home" did not return anything relevant. From the results, the participant **found a Wikitravel page of Milan and acquired a list of historical churches in Milan**. The participant then refined his search topic to the historical buildings in Milan. Except for the Duomo church which was retrieved in the initial query, the participant also reviewed images of other historical buildings such as Andreola Central Hotel and **confirmed that is was also listed in the Wikitravel page**.

*Duomo is the one we're looking for…main cathedral…[23:03]*
*At least four of the images on the second page are still the same building [24:07]*
*Because my interest is actually more about the historical buildings other than, say mountains…I'm 80% sure that Duomo is one of the famous churches…but I'll use more keywords or concepts to see if I can see any surprise or not [24:53]*

*By using "historical buildings "…this is the as the same frequency as we got for Duomo church…but according to Wikipedia, it seems Duomo is more important than this one…I think I can conclude that Duomo church is the one I'm looking for, if I go there, this is the place I would definitely go…so the task is successful [28:35]*

<u>Question 3</u>
Participant wants to find images of the latest Google phone because he have heard it from friends but has not been able to see how it looks like. The images should focus on the phone itself, some disassembled parts would be interesting.

(Google Image) Google phone -> Google phone parts -> Google phone parts disassemble -> "Google phone" parts disassemble -> "Google phone" parts disassemble separate -> "Google phone" disassemble separate -> (Google Web) "Google phone" disassemble separate -> " Google phone" disassembly separate -> how to "Google phone" disassemble -> how to G1 "Google phone" disassemble

The participant was looking for the disassembled parts for the Google phone. He **expected the images of this particular need would not appear in the top results**, so he browsed up to page five and decided to reformulate the query. **New keywords such as "parts", "disassemble" and "Google phone" were subsequently used to reformulate the query**, but still no highly relevant images were shown.

*But Google phone itself is not what I'm looking for, I'm looking for some images about its parts [29:28]*
*Such images would definitely not be the first couple of pages of search engines because those searches or those images are usually not popular…especially we give such a general query [30:02]*
*We found something for the parts, but it's not Google phone [32:16]*

Participant then added "separate" to his query because he thought the word "disassemble" may be too formal for general Web users. He also dropped "parts" as it was unnecessary to have it in the query. Participant later on switched to Google Web search because no images found that were likely to be relevant.

*Sometimes people may not use disassemble because this word is to formal [35:17]*
*If I can't find what I want from Image search, I may just go to Web search to see if I can get some links there which leads to some images, sometimes that happens [38:08]…because I believe image search engine has much limited search range comparing to Web search engine [38:20]*

The participant believed that the image search is more limited by its indexed data and searching on Web content should give him better chance in finding what he wanted. After reviewing the results from either "disassemble" or "disassembly", the participant added "how to" to his query and found some discussion threads in some mobile forums. From the forum he found the a cached page that show a tutorial on how to disassemble the phone step by step, which was exactly what the participant wanted to find for this task. He also discovered the particular model "G1" from the Web search and subsequently used the term to find more relevant discussions.

*Let's change the query as "how to disassemble the Google phone" [40:54]*

*We got the forum for Google phone, I think we're closer and closer to the result [41:09]*
*Watch how to disassemble G1…it's a tutorial! I love it [41:54]*
*This is a YouTube video of how to disassemble the phone…oh this guy doesn't disassemble that, just a tutorial showing how to use that…too bad [44:39]*
*So let's put the particular model in (query) [45:44]*
*(Went back to previous Web search result and followed a link which was previously neglected) trace it up…haha…I think that's the one [46:17]…Finally, we got it…so let's confirm this is the G1 [46:22]*
*The lesson I learnt from this is that sometimes Google image didn't provide what I want…the exact result I'm looking for…I may need to go to other search engine to trace or browse the text information…what I found is from some forums…gave me the link to another site and finally found what I want, so only relying on image search engine is not good enough for me [47:30]*

## Transcript for participant 11

Question 1
Participant wants to find the news image about the death of Korea's ex-president's. The ex-president committed suicide and many people were sad and shocked. Many Koreans went to the hospital that he stayed to say sorry to his family. Participant was also shocked by the news and still felt a bit hard to believe.

(Naver Web) Korea ex president -> Roh moo hyun -> Roh moo hyun pusan hospital -> Roh moo hyun family

Some images were shown in a separate section from Naver Web search results. The participant was looking for Korean people mourning their president at the funeral, perhaps with some flowers and people crying.

*I want to check the news about Korea's ex-president [01:13]…in Korea people, many people were invited to the funeral with flowers [01:37]…*
*(clicked on one image and ) It's the current president attending the funeral, I'll have a look …[02:50]*

Participant first reviewed several news images of the funeral, then reviewed the news results from the query. However the news did not return any images, so the participant **changed her query to ex-president's name, Roh moo hyun**. From this query she was able to retrieve more news with many images, especially the full story of his suicide and the funeral.

*I'll change the keyword [04:40]…this is his name [05:18]*
*I change to his name because I want more detail news about him, why he decide to suicide [05:34]*
*These are his pictures when he was president [05:50]*

Finally she subsequently added "pusan hospital" and "family" to her query in the hope of finding more images of people paying their condolences to president's family. However the result did not show any images except some text descriptions so the participant left the search task without full completion.

*After he suicide, many people went there, so I want to see the hospital, where or…[08:09]*
*So you want to see more about his family? [09:57] Yeah, because he decide to suicide just to protect his family, I just want to check about that…[10:09]*
*I'd like to see the crowd and the feeling…[11:07]…many Korea people were shocked about the news because he was just the ex-president [11:31]…and also he wrote download some end notes [12:18]…I can't believe there were not many pictures about this [12:26]*

<u>Question 2</u>
Participant wants to find images of Paris such as the attractions there, the Eiffel Tower, and the fashion brand shops. She is also interested in the beautiful river and bridge in Paris. She wishes that she can have a trip there and really enjoy the view.

(Naver Web) paris -> effle tower -> paris

Participant used "paris" to check everything about Paris. She went to the image results section to review images about Paris, such as the famous scenery points. In particular, the Eiffel Tower has been shown in most of the images and participant reviewed several of them. Then the participant focused on Eiffel tower and found someone's blog provided many interesting pictures of Eiffel Tower at night. Participant thought the blog was particularly useful when searching for travel information.

*I want to check some information on Paris [14:19]…first I want to check everything, just where and location, and…[14:40]*
*I'm looking at images of the tower [15:48]*
*There's description of how to go there in the night [18:34]*

Participant then changed the query back to "paris" again because she wanted to know more information such as the transportation and accommodation in Paris. From the results she found some links to people's blogs who shared their travel information, such as the food there, and the hotels. This kind of information was extremely useful to the participant because the descriptions usually came with some images. It was easy for the participant to make judgments based on the text and visual information provided in these blogs. In fact, the participant commented in the post search interview that blogs is one type of online information she usually utilizes when searching for this kind of tasks.

*This is about the famous food in Paris [22:50]…it also have the details about the restaurant, location, how to go there…[23:17]*
*Also I want to check about the accommodation…[23:50]*
*I used blog search to find these information [25:13]…I know there will be some useful information there [25:38]*

Question 3

Participant wants to find a book which is about economy and money. She heard that this book teaches about the money to children.

(Naver Web) rich dad poor dad -> robert T kiyosaki

Participant searched the book by using the title in her mind. Clearly the query was specific enough for her to correctly retrieve the right book by the initial query. Again she went to review the results from people's blog as her first choice. Then she searched on the book author's name to find more information about him.

*I'm looking for a book, I'll use the title of the book [27:08]*
*I know the title from my friend [27:15]*
*This also a blog [28:12] when I checking on blogs, I get more information in detail…when they write their blogs, some people explain in more detail [28:30]*

# Transcript for participant 12

Question 1

Participant wants to search some images of a show or event theme. The images should show the passion of the audiences. The suitable themes may vary such as music concert or fashion events. She needs to use these images in her presentation to convey the atmosphere of the theme. Only one or two images are needed for such purpose but they have to be highly relevant.

(Google Web) music scene -> (Google Image) music scene -> fashion Milan 2009 ->

Participant first **began with a generic search query because she wanted to be explorative** first and see how the results would turn out. If nothing particularly satisfying can be retrieved, she would search on some specific musical events which she knew prior to the search. After reviewing six results from the initial query, participant thought that her query might be too broad despite she primarily had an explorative intention behind. **She carefully reviewed the images from music concerts or pop star photos, and consolidated her criteria for having both the performer and the audience in the images**.

*I usually start reviewing from the first result in the first page, when I finish results in this page, I'll move on to next one [01:46]*
*(on reviewing one YouTube video) I don't know how to capture the screen, but I think some scenes are quite good [03:16]*
*I want to see images with more people…both on stage and the crowds [04:51]*
*I want to find images that can give some direct feelings when I do presentation [06:15]*

When switched to Google Image search, the participant seemed **to focus on the image content itself rather than the descriptions from Web search results**. She explained that because of her particular need, it is difficult for her to judge whether an image is relevant just based on a glance or the overlook of the image. **She had to look into details and make sure that she can understand the "meaning" of the images**. When the details or the meanings of the image are not clear, the participant would read through the descriptions to confirm the image was from the relevant event. Some posters of the rock music concert also evoked her interest.

*I feel like search broadly first…If I cannot find satisfying images, I'll search on some particular music festivals [07:10]*
*I know there are some famous (bands/concerts), but I incline to search the bottom-up music scene, the not so famous ones first [07:48]*
*I feel the image search is quite useful…not the image itself, also other information… like this one happened in Philippine [08:44]*
*I think viewing images are slower, they have a lot of information…like its composition [09:37]…and I need to understand what it means [09:50]*
*I found more videos than images [12:00]*
*This looks like the one I want, because of its color…the kind of feeling...crazy [14:40]*
*This one looks not bad…what year was it [16:01]*
*It looks like a poster…still useful…I like posters a lot because of their background, not just plain white, they are designed to be attractive [16:41]*

Having seen enough of the music event photos, the participant decided to address on fashion event. She also included "2009" as a search keyword because she wanted to find the most recent images. **Many of the results were images of the fashion models, which were not suitable for participant's search intent**. She was more interested in the overall scene of the event or the crowds rather than the model herself. After reviewing up to eight result pages of images, the participant concluded that there was unlikely to be more relevant images and finished the search.

*I think I had enough for music, I now search on fashion [17:22]*
*I include "2009" because it has fashion show every year, I want to find the recent one [18:03]*
*I found one problem with Google Image search is that it's not intuitive enough…when you clicked on one image and it will have many in the page [18:26]*
*This one looks good…I feel I need to narrow down more, like (focus on) FENDI or Gucci [19:52]*
*It's mainly the models [20:19]…it's hard to find the "scene" from pictures like these [20:30]*
*I feel that audience in fashion catwalk are relatively unique…they are fewer than the crowds in concerts [21:48]*
*(on reviewing images from Adidas show) I want to crowds to be representative of themselves…not like the crowds in fashion shows which were just there and appreciate [22:56]…there need to be more activities [23:05]*
*I feel fashion show may not be suitable [23:20]…it's too elegant [23:28]*

<u>Question 2</u>
Participant is planning a trip to Sydney. She needs to know the places of interest there. Some maps showing the routes of the tours may also be useful.

(Google Image) Sydney -> university of Sydney -> university of Sydney, women collage -> (Google Web) university of Sydney, women college -> (Google Maps) 15 Carillon Ave, Newtown 2042 -> blue mountain, Sydney -> (Google Image) Blue Mountain

Participant began with the broadest query to see the full range of Sydney images. The results showed many iconic Sydney scenes with most attributed to the Opera House and the Sydney Bridge. Then the participant **gradually specified her search to the women college in the University of Sydney** because she recalled a conference was going to be held there. However the results appeared to have many images of some people related to the college while the participant was interested in the location and the environment of the college.

*I think the drop-down suggestion provided by Google is kind of useful [26:07]*
*The results seems mainly showing opera house [26:19]*
*Women college…I remembered the conference is being held there [26:52]*
*I want to know the location of the conference…so maybe I shouldn't be looking in here (image search) [27:49]…I think I should search in Google Web [27:59]*

Hence she **switched to Google Web and found the website of Women's College**. From that website participant retrieved the floor plan of buildings, as well as the address of the college. Then she searched on the location of the college and the distance from there to Opera House using Google Maps. Once the participant has gathered the information she needed for her trip, she also **used Google map to explore the possible sightsee places she could go**, like the Blue Mountains. Finally she searched form some images of Blue Mountains but concluded that she may not be able to visit it because of the travel distance.

*I want to know how many campuses in the University of Sydney [28:12]*
*I'll save this (campus floor plan) in case I get lost [29:53]*
*I'll copy this address and search in Google map [30:43]*
*Now I want to find the direction from Opera House to the college [31:53]*
*I now want to check the direction to airport [35:20]*
*I will now check "blue mountain" [36:40]*

<u>Question 3</u>

Participant wants to see the variety of different Barbie dolls. She likes Barbie and is collecting some dolls as a hobby.

(Google Image) Barbie -> (Google Web) Barbie -> (Google Image) Barbie 50$^{th}$ anniversary doll -> Barbie 1958 -> Barbie 1968 -> Barbie 1978 -> Barbie 1988 -> Barbie 1998

Participant used only one term "Barbie" as the initial query. She also **used Web search to find the official website for Barbie**. The participant spent quite some time browsing the Barbie website, especially the grownups dolls that she was interested. The sluggish flash website seemed to frustrate the participant a bit.

*I want to find the related news first…it should have…like the official site [43:25]*
*(reading out the text on website) Celebrate 50 years of Barbie…step onto the pink carpet…[45:12]*

**From the website she learned that Barbie dolls have been there for fifty years, so she refined her search to focus on the 50th anniversary dolls**. The results appeared to be pretty accurate with all kinds of Barbie dolls. Participant subsequently used "1958" as the search term in the hope of finding the very first Barbie doll. She then **subsequently searched the Barbie dolls in every decade and compared the styles of different eras.** Google Image search seemed to respond very accurately to these simple but effective queries so the participant can easily see the trend from the past fifty years.

*I'll search on the 50 year anniversary Barbie, to see if it has the full history of Barbie…and the later development…[49:17]*
*Is it a video?... this is 1958…it seems irrelevant to image [51:22]*
*I want to search from Barbie 1958, then every decade…I really want to have a collection of the representative pictures of Barbie's 50 years history…[52:24]*
*How come they don't have it on their website [53:41]…maybe somewhere else has this information [54:25]*
*Looks like there's only one kind of 50th anniversary doll [55:49]*
*This may represent the style back in that time [56:29]…I'll look for every decade, it should be better to see the changes [56:41]*

# Transcript for participant 13

<u>Question 1</u>
Participant wants to find visual information about North Korea, including the map of the nuclear military base or launch place, or the pictures of the president.

(Google Image) North Korea journalists (use suggestions by Google) -> North Korea missile -> North Korea Japan -> North Korea Japan missle -> North Korea nuclear -> North Korea nuclear missile -> North Korea president -> North Korea president now

The initial query returned many similar/identical images of the two journalists captured by North Korea government. The participant was **sure that they are the right persons because of the high similarity in the results** that would not appear to be a coincidence. Then participant searched for images about the missile, which he was **only interested in the place of the missile** (eg., the military facility or missile base) or some illustrations of the missile's description (eg., the individual parts of the missile or the comparison diagram of different types of missiles). Images of the missiles appearance is not considered as relevant.

*These look like the photos of the two journalists…it should be pretty much it, because this is classified…North Korea would probably not release more detail pictures [02:40]*
*So now I'll change my search to "missile" [03:40]…like the maps, the missile facilities or descriptions…but not their appearance [04:05]*

Participant then replaced "missile" with "Japan" to see the images that portrays the tension between these two countries. However the results did not appear to be good which only showed the government officials from each of the country. Thus the participant added “missle” to the query to see if the results would become more accurate. He found some satellite pictures of what may be the missile facility base, and the diagrams of the route of the missile launch.

*Originally, I want to see if these missiles can reach America [05:15]*
*I would search on “Japan” because I have no preposition in the relationship between North Korea and Japan [06:01]*
*Oh, and this, the satellite images…this should be the route map of their missile launch [06:40]*
*Because I haven't used “nuclear”, it does not show the nuclear weapon, but I don't know how it would appear either [08:21]*
*Missile and nuclear did not seen to overlap a lot…but originally I thought they are quite similar, because missile usually means nuclear missile [09:50]*
*This doesn't look like a military base [12:11]*

Participant then replaced “Japan missle” with “nuclear” to focus on the nuclear weapon which he thought the results should only give him the nuclear missiles. From the results the participant retrieved many more satellite pictures but hardly any missile images. This was a bit unexpected to the participant **and the term “nuclear” seemed to overcast the effect of “missile”** although participant assumed the two keywords should be highly overlapped. **Thus the participant added “missile” back to his query and the results became much more accurate this time**, as many of the missile images with “nuclear” in descriptions or captions. The participant then replaced “nuclear missile” with “president” to see the images of current North Korea's president. He wanted to see the images of the son of current president, Kim Jong-il so he subsequently added “now” to his query. However, because **participant mistook Kim Jong-il as the former president**, he could not find the images he anticipated (i.e. most images from his query were all showing pictures of Kim Jong-il, which was correct to his query), and had to leave the query incomplete.

*I expect there would be more images of his son, but it seems not [13:52]*
*Still no? there's no images of his son [15:10]*

<u>Question 2</u>
Participant is planning a trip to Cairns. He wants to find landscape images of the tourist attractions there.

(Google Image) Cairns attraction -> (Google Web) Cairns attraction -> Cairns skyrail -> Cairns reef beach -> Cairns the Great Barrier Reef beach

Participant was primarily focus on the famous or main attractions in Cairns. He was not interested in planning the itinerary just yet as he would like to know where in Cairns is worth visiting first and the whole trip would emerge from there. The initial query returned many scenery images of Cairns but the participant **seemed to be more interested in the maps which show him the geographical position of the attractions**. He then **switched to Google Web search to get more information.** He reviewed several links with “Cairns attraction” in title and focused on the various kinds of trips he can join there. He then **found a skyrail trip** interesting and searched on this particular trip. From this search he found a rainforest experience trip to Redpeak and commented that this is the one he intended to find at the beginning of the search because he has heard of it before.

*Map…I want to find the scenery images [16:39]…I don't want to find the travel itinerary…because once I found the scenery attractions, the itinerary will emerge itself [17:03]…I just need to know the important attractions around Cairns, I just don't know where the attractions are [17:17]*
*I found that I can't find what I need from image search, I'll use Web search [18:31]*
*I've heard that there's a mountain in Cairns and it's very beautiful there [21:50]*
*(copied "skyrail" from the web page) I copy this…and search on this [23:44]…I've heard about this…riding in a tram to the mountains…yes, this is the one [24:22]*
*Yeah, this is it, redpeak…and there's a rainforest underneath [24:35]*

The participant then searched on the attractions near the sea /beach, which was also part of his original intention for the search. The results reminded the participant of the famous Great Barrier Reef in Cairns, so he decided to focus on which beach to go if he wants to see the Great Barrier Reef. He discovered a list of islands under the Great Barrier Reef search results and carefully browsed these results. One island (Wilson Island) with images of sea turtles drew his attention because he has always wanted to see the wildlife there. He also reviewed the images of accommodation facilities there. Overall, **the participant was very satisfied with the images** that came with detail descriptions about the island.

*I've found something like a category of all the activities I can do there…like the beach as well…I can just copy the keyword and search on it [25:17]*
*I want to find if there's the most popular beach…if there isn't…I'll input (change query to "Cairns reef beach") [25:37]*
*The great barrier reef [27:31]…so which beach should I go to see the great barrier reef ? [28:24]*
*(browsing the list of islands) So…should I go to this island? [30:27]*
*So this is the island that has sea turtles (Wilson Island with a sea turtle in the image)? ... I saw (a news of) an environmental group going to one island to pick up the eggs of sea turtles before [31:19]*
*I think I'll stop here…I originally searched on beaches…in the end I found so many islands, I'll save them to my favorites [33:40]…so I'll go to the islands, not the beach, because it's more important to see the reef [33:55]…originally, I want to find the most famous beach, but now I know I should go to the islands [34:11]*

<u>Question 3</u>
Participant wants to find a nice pair of jeans from New York outlet shop. He wants to see the shape and the style of the jeans, especially the patterns on it.

(Google Web) jeans New York outlet-> (Google Web TW) jeans New York 養褲 -> jeans New York Hysteric Glamour -> jeans New York Hysteric Glamour original -> jeans New York Hysteric Glamour weights -> jeans New York Hysteric Glamour high weights -> jeans New York high weights -> jeans New York high weights recommend -> jeans high weights New York -> jeans high weights New York classic -> Thee Hysteric XXX New York

**Participant started with Google Web because he wanted to gather some descriptive information about the jeans first**. However the **English search did not return any results that particularly interested him**, so he **switched to Google Web search in Taiwan**. He also replaced “outlet” with the Chinese term “養褲” (Yang-ku) which means the process of gradually making new jeans look like used ones. He used this term because he was only interested in jeans that are suitable for this kind of purpose. He then **found a link to some Taiwanese jeans lovers’ blog, from which he learned a new brand of “Hysteric Glamour” jeans**. He also reviewed the history of this jeans brand and some product images which convinced him that was the style he wanted.

*I plan to start from Web search because I cannot know the descriptions from image [35:22]*
*“Jeans Talk - The must buy jeans blog”…I’ll have a look to see why everyone needs to buy this one and how to “Yang-ku” [38:09]*
*Although I want to find the jeans, but this series of images (on the blog) helped me understand the style so I can decide whether to keep searching on this [40:52]*

As the consequence **he added the brand to his query, and gradually specified the details or the features of the jeans such as “original”, “weights”, and “high weights”.** However the results were all very limited and nothing particularly interested the participant, therefore he dropped the brand name to broaden his search again. The results were still not satisfying so the participant **went back to the previous blog result and copied a particular product name of the Hysteric Glamour jeans**, the Hysteric XXX, into his query. The query returned with a link of an outlet store in New York which sells many products from the Hysteric Glamour. The participant was **very satisfied with this finding** and commented that he would visit this website later to find more products he can buy there.

*These jeans will be cheaper if (buying) in New York [41:12]…(copied “Hysteric Glamour” to Google Web search) [41:35]*
*So are you going to United States? No, just that my friend told me he’s going to bring some stuff from New York several days ago…and asked me if I need anything from there [41:56]…He was visiting New York and said things are cheaper there, like the discounts from outlet stores [42:09]*
*Like this one, I don’t like it because too many patterns on it [43:05]*
*The simple ones are better…I mainly concern its weight [43:13]*
*OK, I just want to search on “high weights”…I’ll copy this one down (Hysteric Glamour jeans) and ask my friend [46:31]*
*I want to find among the high weight jeans, what are the other jeans in New York that people would recommend [46:41]*
*I decide to use all keywords in Chinese [48:51] [LS]*
*I want to find the jeans they don’t sell in Taiwan… (back to the “Hysteric Glamour jeans” in blog) so in the end, this is still the one [50:18]*
*I don’t know whether this is a Japanese brand or America brand (copied “Thee Hysteric XXX”) [50:58] [TD]*
*I still can’t find anything (I want) even using Chinese [52:42] [REA]*
*This is the outlet website…oh, since this outlet has the brand, it would be easy then…I can see the price straightaway [54:30] [DS]]*
*Hmm…this is what I want [55:23]…so I can find out where the outlet is and with the*

*brand name…then I can send to my friend [55:54]*

## Transcript for participant 14

<u>Question 1</u>
Participant is looking for Queen's birthday news pictures in UK and Australia. The images retrieved should include the celebration scene on the day.

(Google Web) queen's birthday 2009 Australia -> queen's birthday 2009 Australia picture -> queen's birthday 2009 UK picture -> (Google Image) queen's birthday 2009 UK picture -> (BBC UK) queen's birthday 2009 Australia picture -> queen's birthday 2009 -> (Google Image) queen's birthday 2009 official celebration -> (BBC UK) queen's birthday 2009 official celebration -> (ABC News) queen's birthday 2009

The first query did not return any image results, so participant added "picture" to the initial query. However the results still not showing any image results, so participant **followed several news results** to see if there were some images in the news articles. Then the participant decided to see if some images can be found **in UK news**. Again, she followed several news links but the images in the articles were pretty irrelevant.

*I'll use the keywords Google provides…2009...maybe? Yes, 2009 [01:01]*
*I need the picture, but Google did not give me any picture [01:26]*
*What's this? This is a news? [01:53]*
*I actually want to find the news…news agencies like ABC or BBC news to report Queens birthday event…I need pictures, how people celebrate in UK and Australia [02:24]*
*Oh that's a UK news, sky news…[03:41]*
*Queen's birthday celebration…good, this is 2009 in British [04:18]*

Then the participant switched to Google Image to directly search on image content. The results were much more satisfying this time as many images of the Queen were shown immediately. Participant **found many stamp images** of Queen's birthday, but she wanted to focus on the celebration event itself or the images that can report the particular event. Thus the participant went to BBC UK to search for news on the Queen's birthday event. She chose this website because she knew that BBC is one of the major news media of British news, which suits the purpose of current search task. However, as BBC does not provide searches on images, the participant had to review the news article and the images accompanied with it.

*It's all stamps here, see? [05:11]*
*But I want to find the images of the event, the news agency report the event on the day, not the stamp or other pictures [05:30]*
*I would like to go to BBC…when I want to browse news around the world, I use BBC news, they have a search function [06:46]*

By reading the articles, **she got the idea of using "official celebration**" as one of the search terms may produce more accurate results from Google Image search.

From the results she found a collection of Queen's birthday celebration images, which was very useful for her search. This was an important turning point for her search task since once the term has been introduced to the query, all results became much more accurate and close to what she had in mind. She carefully reviewed the descriptions of individual images to confirm whether they were taken in 2009. She was pretty satisfied with the results from using "official celebration" as the search term.

*Yeah, I think maybe I found some keywords here, official celebration…maybe I can try that keyword [08:44]*
*Is there's no time limited or I have to finish this in one hour ? [10:50]*
*I don't think this is this year…just to check…oh, yes, this is 2009 [11:46]*
*So, google image is good [12:24]*
*There's no too many (images)…(in BBC UK) maybe I try this one…[13:00]*

The participant then **compared the results from BBC UK** using the same query, but the results were not as good as in Google, especially for the 2009 constrain. Participant further **compared the results from ABC News**, yet the results did not show up anything particularly interesting or useful. She believed that there must be some Australia news reporting the celebration event in Australia, however she was unable to find the articles and have to finish the search without full completion due to the time constrain.

*A lot of information in BBC News [14:00]*
*ABC news is Australian broadcast…I don't remember its website so I'll go Google and search…[14:58]*
*It should be some news report…on the day, to report the celebration event, but I cannot find it…how much time passed? [17:23]*

<u>Question 2</u>
Participant wants to go to beach and relax. She needs to find the beaches that are nearby Brisbane city as Gold Coast is a bit too far for her. Images should mainly be the view of the beach and etc.

(Ourbrisbane.com) beach -> (Google Image) Redcliffe -> (Google Image) Redcliffe queensland -> Redcliffe Brisbane

Participant first searched on *ourbirsbane.com* because she knew that the website provide plenty of useful information about Brisbane. She was only interested in the beaches nearby Brisbane, therefore one particular result showing "beaches close to Brisbane" drawn her attention. She was not interested in the beaches in Gold Coast because too far away for her and too many people have been there, she wanted to discover some "new place" to go. She wanted to find the images about the beach scene, or how the beach looks like so she can decide whether it is worth going.

*I want to go to a beach for relax, I don't want to go too far away, maybe within one hour by car [17:44]*
*So I go to ourbrisbane.com, because ourbrisbane.com is a very comprehensive website for everything in Brisbane [18:00]*

She carefully read through the description/details of several beaches, such as Redcliffe or Sunshine Coast. Her plan was to find the beach that was close enough so she can leave in the morning and have lunch there, thus information about the food or restaurants at the beach was also useful. However the images provided on the website were very limited so the participant decided to switch to Google Image.

*Beaches close to Brisbane…Oh Redcliffe, yes! I think Redcliffe is close [21:48]*
*Any other picture about Redcliffe? Only this one? [23:32]*

From Google Image, the participant successfully retrieved many images of beaches in Brisbane by using "Brisbane" as one of the search terms. The participant was very satisfied with these results from Google Image search.

*Redcliffe Brisbane, they have so many pictures here [25:21]*
*So I may go to Redcliffe, a good choice…because it's new, and it looks nice [27:06]*

<u>Question 3</u>
Participant is interested in energy saving products. She wants to find the images of different kinds of energy saving products currently available on the market, especially those designed for families.

(Google Web) energy saving equipment family -> energy saving equipment family on the market -> (Google Image) energy saving equipment family on the market

Participant has no idea about the energy saving product despite it has been widely advertised in many places. She particularly focuses on energy saving products that families can install or use to reduce the electricity bill. She first used Google Web to search for some general information. One of the results provided a list of manufactures of energy saving equipments which the participant thought it would be useful; however the description of the products did not seem to be suitable for family use.

Because we have been talking about energy-saving products for long time, I don't know whether there are any mature, or commercial products in market that can be used in family life [28:19]

Despite some products appeared to be the energy/power saving convertor or adapter, most the reviewed results did not appeared to be highly relevant to family appliances. Thus the participant add "on the market" to address the availability aspects of the products although she was a bit unsure about the effect of this search term. Some more energy saving products was retrieved from online store websites. Then the participant tested the same query on Google image and found some interesting looking products such as "energy saving coin bank". Participant was happy with these results.

It's not yet for family use, it's more to attract the investors [33:26]

# Transcript for participant 15

Question 1

Participant wants to find the images of the recent Air France crash. She would like to know the severity and if it was really nobody survived.

(DW-World.de) (browsed in World news section) -> (Google Web) Air France Crash in Brazil -> (Google Image) Air France Crash in Brazil

Participant first went straight to a Germany news website to browse the Air France crash news. Because of her German study background, **she usually checks international news on this website**, especially for news in Europe. She also likes the news broadcast recordings from this website so she can "listen" to the news she is interested without the need to focus on the screen. Form the website she found the Air France crash news in international news section, **but only limited number of images were shown in the news article**.

*I was interested in this particular news because I'm very cautious about airline safety [02:05]*
*I'm 100% sure I can find the news on this website…it's a Germany website…it provides news in about 20 different languages [02:48] [DS]*
*(In world news section, found the article about the AirFrance crash at the bottom of first page) This is what I want…I'll read both English and Germany version, usually I read the Germany one first [04:20] [REA]*

The participant then went to Google Web and searched for Air France Crash, where the related news results have been nicely aggregated by Google and were helpful to the participant. She also used Google Image search but it was difficult to tell whether there was any survivor from the image results as no pictures found showing the survivors.

*Usually when I search on "AirFrance", Google will give me the official website for the company, but this is not what I want [05:46]*
*(clicked on the news result section from Google Web search) Ok, basically this is what I want [06:08]*

Question 2

Participant wants to find the images of Neu Schwanstein Castle. She would like to go there and need to search to history about this castle and relevant information.

(Google Image) Neu Schwanstein -> (Google Web) Neu Schwanstein Schloss -> (neuschwanstein.de) (browsed for history and images) -> (Google Web) YHA ->

Participant first used Google Image to find the images of Neu Schwanstein castle. Because the query is specific to the castle's name, all results were retrieved at ease with high accuracy. However the participant wanted to find the images inside Neu Schwanstein castle, so she **used Google Web to find the official website**. Despite the sponsor link and results from travel agencies, the participant found the intended website easily because she knew the county in which the castle is located.

*I'll first use "Neu Schwanstein" to search, which is the name of the castle meaning new swan [07:15]*
*Since I will go in summer, I want to know how it looks like in summer time [07:24]*
*I don't want image (search), I want to see the inside of the castle [08:06]*
*These are all travel agencies websites, I don't want them [08:54]*
*Ok, I found it (the official website) [09:05]…because I know the castle is located in a southern county of Germany; when I see the keyword which is the name of its state, I know this is the correct website [09:23]*

**From the website she browsed for the history and images of the castle**. To complete her travel plan, the participant also searched for accommodation and railway tickets by using Google Web, such as the YHA site in Germany and DB station.

*Because I want to go there by myself, I'll need to know the transportation and accommodation [10:30]*
*I'll stay in YHA, so I use this as a keyword [10:51]*
*I'll take the train…assuming I go from Fuessen [14:50]*
*I know the train station in Germany is called "DB" [15:25]*

<u>Question 3</u>
Participant wants to buy some pants or swim suits for beach and surfing. She likes water sports and would like to buy some gifts for her friends as well.

(Google Web) Roxy -> Billabong -> DFO -> (Yahoo TW) Billabong ->

Participant first used Google Web to search for the big brand beach shorts, Roxy, because she had done some research from retail shops. She **went to the Roxy AU site to find the prices**. She then looked for the Billabong website and checked the prices as well. However both were too expensive for her budget, so **she searched for DFO** which she heard form a friend that she can get discounted brand products there. She also compared the prices of Billabong shorts with Taiwan online shops. The participant seemed to focus more on the price and the availability of the product rather than on the appearance of the product itself.

I want to buy some beach shorts…I've been browsing in stores in city, I know there's Roxy [17:47]
I'll use Google to search for it…I've heard from friend about "DFO" [20:40]

# Transcript for participant 16

<u>Question 1</u>
The participant wants to find photos taken from inside of the air Canada plane that crashed recently

(Google Image) Air Canada plane crash – (Google Web) -> wikinews -> (wikinews) -> air canada -> air Canada crash -> (Google Web) -> air Canada crash -> (to previous Google image) -> (Google Web) -> air Canada crash recent -> (discovered air france news) -> air france crash -> (to previous Google image) -> air france plane recent crash -> air france plane recent crash wreckage -> (back to Google Web) -> (to previous Google image) -> (Bing image) air france crash -> air france recent crash inside -> air france recent after crash inside -> (to previous Google image) air france recent after crash inside

Participant first used "air Canada crash" in Google Image search to retrieve the recent news of an airplane crash, but the images were showing only the crashed airplanes, lacking the indication of recent news event. Then he **changed to *Wikinews* website to find more information about this crash** but nothing particularly helpful. He tried Google Web search with original query "air Canada crash" hoping to find more information about the crash. After viewing the Wikipedia webpage about an air Canada crash backed in 1983, he seems to realize the accident may not happen with air Canada as himself was not sure about the news.

*I'm going to search about the Air Canada plane which just crashed [00:30]*
*Because I'm not sure about the news…I need to find the news first before finding the images [03:44]*
*I sometimes use Wikinews to search news [03:52]*
*I'm still looking for the news, like when it happened, or where…[06:31]*
*I'm looking for the dates only [09:24]…maybe I thought of wrong keywords [09:34]*
*Maybe it's not Air Canada [10:07]*
*Ok, so I made a mistake…should be Air France [10:24]*

He then went **back to Google Web and add "recent" to the query**. After seeing the highlighted dates of the crash, **he decided it was AirFrance that has crashed** because the date corresponded to his memory. Hence he changed the query to "air France plane recent crash" in Google Image, but not many images were of the crash scene. He refined his query by adding "wreckage" but still not many relevant results were shown. So he **tried the Bing search engine and found some interesting images that were close to what he thought**.

*Just the air plane itself…it's not what I want, I'm looking for the after crash news images [11:20]*
*So you want to see the wreckage? Yes, so maybe I add wreckage…[11:27]*
*Looks like there's nothing more [12:44]…let's try another search engine [12:54]*

He again **added "recent" and "inside" to the query** in the hope of finding more detail images, especial images taken inside the plane after the crash, but nothing particularly relevant can be found. Finally **he tried the "air france recent after crash inside" in Google Image but again most images were of people and not many results showing the actual crash**.

*Let's see…if there are more detail photos [16:02]*
*I think there are some survivors [17:13]*
*Ok, I think that's enough…I'm partially happy with the results, at least I got some images [19:24]*

Question 2

The second question is to find images about the view from the top of Mt. Hua.

(Google Image) huashan -> huashan top view -> (Bing Image) huashan top view -> (Google Image) mount hua top view -> mount hua top view spectacular

The initial query "huashan" was able to get quite a few images taken from Mt. Hua, thus participant decided to refine the search by adding "top view" to the query. The result seems a bit different but it was close to what the participant anticipated. However the duplicate images put a burden on the browsing.

*I get plenty of the images…so let's put "top view" [20:28]*
*Yes, the images were close to my need [20:50]*
*I think…seen these images over and over…same images [21:08]*
*(jumped to page 14) I think their search is not good [21:28]*

The participant then **tried the same query in Bing Image to see if the results were different**. The results from Bing Image were not much different from Google for the query. Meanwhile the participant changed his Google image query to "mount hua top view" and **quickly reviewed seven pages**, but then decided that he needed to find more spectacular images. After adding "spectacular" to the query, some images showing the snowy Mt. hua were satisfying for the searcher's need.

*You comparing your results from two search engines? Yes, but I found not much difference for this query [23:13]*
*I want to find something more spectacular views [23:41]*
*Something more like this… [24:36] You want to see the snow? [24:42]*
*If I can, it could be good…but I think there's no snow [24:55]*

Question 3

The third question was to find images about the intelligent system used in Toyota Prius car.

(Google image) Toyota prius -> Toyota prius intelligent ->

The initial query "Toyota prius" was good to retrieve many images about the appearance of the car, but after four page of viewing the participant decided to find images about the special features of this car. "intelligent" was added to the original query and the results started to show some diagrams of the hybrid system, and the participant think results are generally good enough.

*I want to see the image of Toyota Prius [25:37]*
*Are you interested in the interior or engine [26:42]*
*I want some…maybe some specials on the Prius…something like special features [27:00]*
*Something like this…like a diagram for how the system works [27:55]*

# Transcript for participant 17

Question 1
The first question is to look for images that are related to soil science in the news articles. Anything that shows soil or something alike could possibly be useful. The reason is to show students in current affairs to soil science.

(Google Image) Soil science climate change -> (Google Image News) soil climate change 2009 (news OR current OR affairs) -> soil climate change 2009 -> (Google Image) soil climate change 2009 -> soil erosions Victoria fires

Participant originally used four key concepts as the search keywords in Google Image search, after reviewing several images with soils, some diagrams drew participant's attention. However, most diagrams were to do with greenhouse emission or climate change. After viewing three pages without any satisfying results, the participant change to advance search to find images related to news or current affairs in news content images. The participant also tried to limited the time frame by adding "2009" to the original query. However the search engine failed to return any images on this query, the participant then broadened his query to "soil climate change 2009" only.

*I think that's probably the most …we are gonna to get the stuff in the current affairs about soils [00:38]*
*I go straight to images even though sometimes I do look into the web pages [00:48]*
*I'm not looking into people [01:02]*
*Again, there are some people presenting stuff [02:11]*
*This is another diagram here, a pie chart, which is not really a soil thing but it might lead me to something [02:58]*
*Some interesting imagery…but it's all rather generic stuff…and it's not associated with particularly current affairs, although some of them might be doing with climate change [04:14]*
*(in advance search page) …As news content…I can really put a time frame here…if I put 2009 at least, that would give me some recently stuff, I sincerely hope [05:39]*
*Didn't return any documents, so I'm going to take that out [06:00]*

After failing to find any images again, the search was been broadened again to include all contents of images. "**2009" seemed to be a strong keyword as the results are showing more images about the 2009 bush fire in Victoria**. Thus the participant **developed a new strategy** to search for the Victoria bush fire in February. Images of soil landscape or people holding soils were not the participant's intention. One image showing a senator looking agitated in the parliament was of the right direction, but since he did not hold a soil, there is no direct link of that image to the soil science. Some diagrams or posters have also received some attention but were not suitable because they are too generic.

*That is getting closer to something like I can deduce or I'm looking for, we got fire scar areas, and obviously burnt out areas, and therefore some eroded areas as well [07:22] ...from the February fires in Victoria, I haven't thought about that, so there are something I can focus on that [07:31]*

*General image of climate change and drought and something about health soils…but nothing it shows recent stuff [08:14]*
*Coz I'm looking into something that's in news…it's showing the immediacy [08:22]*
*We got a senator fielding looking very agitated, this is about climate change as well, it's nothing to do with soil but he held a bit of soil in his hand in parliament, that would be useful [10:18]*
*There's a picture of soil profiles…that's good, but again it's the eco system preservation society website which is probably fairly generic and nothing to do with news…I don't think they've done anything in the news recently…no, it just the pictures of top soils [11:48]*

Eventually "climate change" was replaced by "**soil erosion Victoria fires" because the participant thought that images of this particular news should have soil images**, particularly of some people investigating the soil. The participant thought he should have also include "Australia" in the query to limit to Australian news first, but then realized that the search engine should list Australia news in the top results given the recency of this news. Finally he found one image of some people investigating the soil after the bush fire. He was happy with this particular image as it is from the recent news and an Australia based news.

*Victoria fires 2009…Because that's the one image…and they don't seem to relate to something in the news… and something needs to be investigated from the soil science point of view and probably have pictures of people investigating it [12:54]*
*I now have some aerial images and satellite images of the fire, I have pictures of forest fires [13:06]*
*It's a land care workshop…that would be good if it actually shows something in the background that would lead to…relating to soil science but it's not unfortunately [14:23]*
*We have an image from US [15:16]…an picture of US forest service's scientist looking at soil test repellency [15:35]…now, that would be good…if that was actually related to the Victoria fires in Australia [15:43]*
*It's not exactly what I'm after but I have to say it's in America, but it's of recent fire…and it's something to do with the news [16:05]*
*This is again the Delburn fire…I don't know where the Delburn was but it's obvious in America [16:20]*
*I'm reading the article, it says…two United States burned area emergency response teams were very busy in Australia…Feb 15…so it is Victory…Delburn is in Victoria Australia [17:01]…if I read the captions of the photographs, which I should have done earlier…so that's it, that's good enough for me, it's Australia, it's recent fires in February, and it's to do with soil science stuff…so I'm happy, that'll do [17:15]*

<u>Question 2</u>
The second question is to find images that portrays bush air travel that is related to eco tourism, incorporating a wildness or strong feelings.

(Google Web) bush flying ecotourism -> (Google Image) bush flying ecotourism -> (*ebushpilot.com*) -> (Google Image) bush aircraft ecotourism -> bush pilots ecotourism -> bush airstrip flying -> (address "bush" as thing not person)

The first query retrieved **no images of airplanes** which were a bit to participant's surprise. Clicking on an image with “forest flying” as caption, the participant found the image about the forest adventure tour but nothing to do with airplane flying. The second page had some airplane images, particularly an image from *ebushpilot.com* drew participant’s attention, however the images from the website were **lacking the mystic feeling that the participant wanted**.

Again we get images of people…we get brochures or posters [18:45]…It haven’t got anything to do with airplane or anything [18:54]
Oh, this is the first page that I have an image with aircraft…and I was looking for aircraft [19:55]
It doesn’t evoke the wildness experience…but it’s actually the website associated with it called “ebushpilot.com”…I think ebushpilot might be quite useful [20:24]
On the website, there’s an image of an airplane flying over the forest landscape…it is Africa apparently…it doesn’t evoke that sort of mystique of bush flying [20:47]
It’s actually got lots of airplanes in places…but not really the adventure of flying or being in the bush or bush plane [21:22]
I’m going to that website…and I’m going to the website’s front page…of ebushpilot in the hope that it might provide a photo gallery [22:06]

Participant then tried to access the home page of that site in the hope of finding a gallery of flight images but failed. After following several links which were considered not useful for the current search topic, the participant decided to go back to Google Image with “flying” replaced by “aircraft”. Some images even have **US ex-president, Bush, confusing for the current concept “aircraft” and “ecotourism”.** Then the “**aircraft” was replaced by “pilots” to be consistent with the concept of “flying”**. The results showed more people but not obviously appeared to be pilots, so the “pilots” and “ecotourism” were replaced by “airstrip” and “flying”. While seeing some images of airplanes in dessert or remote areas, participant thought he could have used “remote” or “wildness” to find more images. However after browsing two pages, the results were satisfying enough, particular the one from *africanbushpilot.com* that fulfilled the current search need well.

*I’m not sure really what it is doing…I’m now just doing website surfing…now it’s giving me list of links of different websites to go [22:54]*
*We got sea planes, float planes…not really showing the bush stuff [24:26]*
*Interesting…because I’m using word “bush”, I’m now ending with ex-president Bush, George Bush [24:44]*
*Perhaps I need to put bush “pilots” in…before I start changing my search items again completely [25:18]*
*Surprisingly…I’m not getting anything about airplanes…I’m getting some pictures of wildness, maybe, and some ecotourism, certainly [24:40]…so I’m not getting really what I’m after…which is aircraft of landing or taking off, or airstrips [25:51]*
*Right…I’m getting some pictures of some remote airstrips…that’s the term I haven’t use and perhaps I can use is remote or wildness [26:30]*
*It’s someone’s personal website about their visit to South Africa [26:58]…but only one picture of the airplane…that type of picture is what more sort of the thing I’m after [27:21]*
*[29:00]*

Question 3

The third question is to find images of different BMX bikes for teenagers, intended for evaluating what to purchase for son's present

Bmx bikes retail (Web search) -> (browsing online store for catalogue) -> (to Google image) -> bmx bikes retail .au -> (getprice.com.au) -> (bmxbicycles.com.au) -> (to Google ads) 99 bikes -> (back to Google Web)

Originally looking for Websites that sale BMX bikes, thus **the "sale" concept was translated into "retail" to focus on the online store**. Participant did not begin with image search because he assumed the **store site should have lots of images of BMX** bikes. The bicyclestore.com.au has a range of BMX bikes with product images, however the participant wanted to find more similar websites. Then the participant tried using Google image and retrieved lots of BMX bike images. Because the search is to find a store within Australia, ".au" was added to the original query to limit results from Australia websites. An image from getprice.com.au was followed because the searcher thought it should have lots of BMX bikes with prices. However the search function did not perform well after inputting "bmx bikes" on getprice.com.au. After trying several commercial websites without useful information, the participant went back to Google image results. At this point **the participant did not think the browsing of images is helping him much and switched back to Web search again**. Yet still no more websites seems useful in showing different ranges of BMX bikes and prices. Finally the participant concluded the first website (the bicyclestore.com.au) was useful enough for his search.

# Transcript for participant 18

Question 1

Participant wants to find images about Barack Obama in his inaugural speech. Presumably preparing for his report writing.

(Google Web) 美國 歐巴馬 就職演說 -> (Google Image) 美國 歐巴馬 就職演說 -> (only one page viewing)

Participant began with Google Web search because he knew for news search, Google will include both textual information and news images as well. Both kind of information was important for his search at initial stage as he also wanted to gather more information about Obama's inaugural speech. After viewing several news articles, he can only find limited images in this event.

*(reading news articles with images in the page) I need more images…I think I'll copy the article and switch to Google Image to search for more pictures [03:44]*

He then switched to Google image because he felt the articles reviewed had provided enough descriptive information about the event. As soon as he saw the thumbnails on the first result page, he was satisfied with the results because he can clear see images of the beginning, middle, and the end of Obama's speech.

*In the image search results, it showed a lot of thumbnail image, which helped me quickly find the images I want…for example, people in the background…or he giving the speech…[04:58]*
*I would choose three kind of images, first his body movement when giving the speech; second, his gestures during the oath of inauguration; third, his interaction with the audience after the speech [05:17]*

Question 2
Participant wants to find images about the famous tourism places in Europe because he is planning a trip for his holiday. The countries he is mostly interested in are Germany, France, and Italy or Netherland.

(Google Image) 法國 歐洲 火車自由行 -> 歐洲 火車 -> (Google Web) -> france railpass

The first query returned some images from people's blogs. Thus the participant decided that **searching on people's blog can be a good strategy**. Because blog articles usually contain plenty textual and image information, including the trip planning process, the itinerary, the accommodation, and transportation information which are all useful for participant's purpose. The **tip for identifying blog images were to look for images with people**, such as family photos with some scenery background.

*I'll start from Google Image search…I mainly want to see where I'm interested in…I don't have any assumptions for where to go [06:57]*
*There are three cities I'm more interested in…first is Germany, second is France, the third one is a bit rough, maybe Italy or Dutch…around that area [07:08]*
*In the results, I can see many images from people's blog…I'll first use blog from people who have been there, how they get there…with image and text (information) [09:19]*
*I think it's from people's blog because I can see people in the photos…I can see their travel route, in how many days, how to use the transportation…there's plenty of information in blogs which makes it easier to understand the details [10:06]*

Another part of the original intention was to find the train schedule in Europe, the participant then broadened his initial query to "Europe train" to search the prices and timetables for trains. However the results only showed the type of train or scenic spots along the railroad line. He then **switched to Web content** to find more information, particularly railway company's official websites. He first tried to find the name of these Europe railway companies, but then **happened to find a website with a list of Europe railway companies and links**. This particular website helped him to find a rail pass for the train service across France and Germany. Participant then used "france railpass" to retrieve the railway company's official website and the ticket booking service.

*Because I'm focusing on traveling by train…I'll search other websites for trains in Europe…like the timetables etc.[10:59]*

*I broadened my search because I want to see the scenery along the railway, timetables, and prices [11:38]*
*I used "France rail pass" to go to the official website for European rails across France and Germany…this is what I want [20:38]*

<u>Question 3</u>
Participant wants to find images about Apple's iPod Touch, particularly focusing on the functions or features of the product.

(Google Image) apple ipod touch -> apple ipod touch wireless -> (to Google Web) -> (to Apple.com) -> (back to Google Web) ipod touch movie format -> ipod touch E-book -> (to Apple.com) (browse support section to find supported ebook formats)

Participant began the search in Google image with "apple ipod touch" as the initial query, however the result images are mostly about the product's appearance. He then added the "wireless" as the feature to specify the search. Again the results showed nothing particular about wireless function so the participant switched to Web content. He went to **the product introduction page on Apple's website**, and consequently found information about the video support features of the product. He also tried to find the movie format and ebook that ipod touch accepts but found not much helpful information. Finally he browsed the apple website but still was unable to find information about the supported ebook formats or files.

*I want to find the descriptions of its functions in images [23:07]*

## Transcript for participant 19

<u>Question 1</u>
To find the images of Japanese actor Hiroshi Tamaki's new gossip girlfriend. Participant is particularly interested in her full name and appearance because she only know the last name and has never seen any picture of her before.

(Yahoo Image) 玉木宏+吉高 -> 吉高由里子 -> (to Yahoo.jp) 吉高由里子+玉木宏 -> (to Google image) 吉高由里子+玉木宏

Participant used Hiroshi Tamaki's name and his girlfriend's last name, Yoshitaka, as initial query. The result instantly showed a newspaper image of their full names and portrait pictures. Having known the full name of Hiroshi's girlfriend, Yuriko Yoshitaka, the participant refined the query to find more images about her. The query successfully retrieved many images of her, especially the portrait pictures which helped the participant know more about how she looks like, and the various press release events.

*Now I see the Japanese newspaper…a photo of Hiroshi Tamaki and his girlfriend [02:12]…but I think it's not enough for just one photo…since I know the name of his*

*girlfriend, I can use it for next search [02:22]*
*I only want to find the photos of Yuriko Yoshitaka now, because the photo I just saw is not clear enough…I want to see how beautiful she is [03:19]*
*Now I found many photos of her…I now know she is the girl who co-acted "Love Shuffle" with Hiroshi Tamaki [03:53]*

In order to find more images about the couple, participant then changed to *Yahoo.jp* because she expected the Japanese media would have more images of this news. However, the result turned out very unsatisfying with **only one image which was irrelevant**. The participant consequently tried Google Image with same query but still lacking images of the couple in the same scene. She thus concluded that the lack of images may due to timing problem as recent news sometimes does not have many pictures released by the media.

*Because I don't expect websites from Taiwan would have lots of images of the couple, I'll search on Yahoo.jp now [04:57]*
*The result is totally irrelevant…what should I do? [06:09]*
*I'll use the same query on Google Image…it seems not many images of the couple in the same scene [06:54]*

<u>Question 2</u>
Participant wants to find some information about Egypt, particularly the attractions or famous points. The intention is to plan a tour in Egypt.

(Yahoo Image) 埃及旅遊 ->

The initial query returned with lot of famous Egypt iconic items, such as ancient painting or the statue of Sphinx. The travel images from some people's blog were particularly helpful for gathering information about the famous scenery and attractions. Some sponsor links which direct user to travel agency websites were also useful for trip planning.

I want to find travel information in Egypt…I want to find images of famous attractions in order to decide where to go [08:15]
This image, which looks like an ancient wall painting in Egypt, leads me to someone's blog…from this, I can see the activities the author has done there…I think I can include this in my travel plan as well [10:43]

<u>Question 3</u>
Participant were interested in one perfume made by Juicy Couture. She has seen the perfume once and remembered the brand and its smell, but cannot recall the product name and how does the perfume look like.

(Bing image) juicy couture+perfume -> (to Juicy Couture official website)

The initial query returned with lots of Juicy Couture's perfumes, which confused the participant a bit. Originally participant was expecting only few kinds of perfumes from Juicy Couture but turned out many more similar images. Thus the participant clicked on one image which was closet to her memory of the perfume bottle; however the detail description of the smell did not match to her memory. She then clicked another one with different package, but was unable to confirm whether it was the one she saw before. The participant then went straight to Juicy Couture's official website to browse the fragrance product. After viewing the description of two perfume products, the participant concluded the first one was the correct one for her search.

*I've seen the perfume before when I was in a duty free shop, but I already forgot how the perfume looks like…I only remembered the brand…I want to find out its look so I can buy it next time when I'm in the store [14:27]*
*Oh, there were so many different kinds (of perfume from Juicy Couture)…I'm a little bit confused [15:14]*
*Because I remembered the smell was closer to flower scent…just by the description, I don't think this is the one [16:10]*
*I found there were so many similar ones…in order to find more information, I'll go to Juicy Couture's official website [17:42]*
*(On juicycouture.com) I found there are only two kinds of perfume…so it should be this one [18:40]*

## Transcript for participant 20

<u>Question 1</u>
Participant wants to find images about swine flu because it is a serious issue world wide. He is interested in the graphs that depict the spreading rate.

(Naver Web) swine-flu rate graph -> (Google Web) swin-flu rate graph ->

The first query did not return any useful result, so participant changed to Google "swine flu" is English term. Then participant found a blog website (wordpress.com) about swine flu, particularly focusing on Australian's infecting rate. Some graphs depicting the overall cumulative cases and daily new cases are very helpful for participant's search intention. The participant then carefully went through all the graphs in the page and compared with global growth rate from the same website, then concluded the search.

*I put "swine-flu rate graph" but I cannot find those information (on Naver)…I think because swine-flu is English (term), maybe I should change search engine…I want to change to Google [02:39]*
*Oh , great, I found this one…and that's for Australia [04:23]*

<u>Question 2</u>
Participant wants to gather some travel information around Australia because he has only been living in Brisbane. Information about the attractions and activities around Australia would be useful. Some transportation information is also considered relevant.

(Google Web) Australia famous places -> Australia activity

Participant first used Google web search to find the famous places in Australia. He

clamed that he had little knowledge about the famous scenes or attractions in Australia, nor he had seen the pictures before. Then he found some images on Bond University's website, but the information is not what he intended to find. He then change the query by replacing "famous places" with "activity", in the hope of finding more interesting activities around Australia. Then he followed a link to a tourism website and browsed for some tour information with images. He was satisfied with this particular website and the information it provides.
*I'm more interested in the activities in Australia, and outbacks…because when I was in Korea, I've never seem people in the outback [09:40]*
*(on activitytours.com.au) There are many kinds of activities on this website…I think this website is very useful…that's enough [03:48]*

<u>Question 3</u>
Participant is currently looking to buy some shoes. He would like to see some online stores or catalogues for the range of different shoes and compare the prices. The shoes that are in his mind are the Nike Dunk range. Other shoes are also considered as long as the designs are simple and white.

(Naver Web) nike dunk -> (browsing several online shops) -> (to Nike Korea website)

Participant first used "nike dunk" as initial query because he was pretty sure about the product he wants. He has also searched about this particular kind of shoes before so he knew the design and the look of the shoes. He is interested in the white/red range of Nike dunk shoes, with the retail prices online. He opened multiple online stores in different tabs to compare the models and the prices. He then changed to Nike Korean website to browse more products. Finally he found a particular one that suits his need and finished the search. The useful thing to conduct similar search on Naver.com is that it separates results from different resources in different columns, such as news, images, sponsor links, or even people's blogs. This helped the participant quickly identify the information he wants if he is sure about his intention.

*I want to buy some shoes, the shoes brand is Nike…because I was interested in Nike shoes [04:23]*

## Transcript for participant 21

<u>Question 1</u>
Participant needs to find the images from the formal announcement of the new Pentax k-7 camera. The reason is that he is writing a camera review for magazine and personally he is a fan of Pentax cameras.

(Google Image) pentax k-7 advertisement -> (Bing Image) pentax k-7 advertisement -> pentax k-7 sprite -> pentax k-7 idea -> pentax k-7 position -> (Google Image) pentax k-7 position -> pentax k-7 improvement

The first query returned many similar if not identical images of the camera. After clicking/opening five results in different browser tabs, participant **switched to *Bing.com* with the same query**. Again, participant browsed through the thumbnails to find the interesting ones. Participant also complained about the computer performance after opening five or more browser tabs concurrently. At this point, participant reviewed the tabs that were previously opened because he thought the pages should have been loaded and wanted to close irrelevant pages to release some resource from computer. Some of the returned images are not considered useful because they are ordinary official release images like the front or the back of the camera. What the participant wanted were the **images that portray/demonstrate the camera's special features** well, such as water proof ability or the in-built image stabilization system. Some sketch images or spy pictures of the camera also drew participant's attention.

*I'll open the images in new tabs [00:38]…for saving my time while it's loading the webpage [00:49]*
*And…after reviewing about three pages and find that most of them were similar images, I'll change search engine [01:20]*
*I found the computer is getting slower and slower…[01:30]*
*After I opened about five tabs, I'll begin to review and compare the results (in these different tabs) [03:11]*
*I found some advertisement images of the camera…this is not I want because maybe it's too ordinary…and I found this image with water dripping around the camera, I think…yeah…I've found one image depicting its water-proofing ability [04:02]*
*I also found a sketch picture of the camera…some spy or leaking photos also interest me as my background is in marketing [04:50]*

Feeling the lack of extraordinary images, the participant then **replaced "advertisement" with "sprite" in his query** (a type error of the word "spirit"). After failing to retrieve any results from the query, the participant subsequently **tried replacing with "idea" and "position"** but still no useful images can be found. He then switched back to Google but the images returned all seemed similar to what he retrieved from the initial query. Thus, he **replaced "position" with "improvement"** and somehow the results became a bit different, but he was not sure about the reason behind. The participant then concluded that not many new images can be found and finished the search without satisfaction.

*Most of the images I found are quite ordinary…they are quite different from what I expect to find…about the camera's spirit…I'll change my query now [05:50]*
*I only have some vague ideas about what I want to find…like the camera with water dripping is a good one for me…as I knew there's water-proofing feature on the camera…I was hope there are more impacting pictures like using a hose washing the camera [06:39]*
*When I can't find any results from one search engine, I won't change to another search engine…I'll keep changing keywords because I think if one keyword fail to retrieve any result from one search engine, it won't be better on another search engine [07:30]*
*After I changed several keywords…but I'm not satisfied with the results from Bing, I'll change to Google [08:18]*
*I found that Google keep giving me similar results (despite using different keywords),*

*although it does show a lot of results [08:40]*
*To this point…I think I'm a little bit tired…not wanting to keep searching…it's bit pity that I didn't really find what I want to find…but I did have found something [11:12]*

<u>Question 2</u>
Participant wants to find the famous landscapes in Taiwan. He is particularly interested in foreign people's view about Taiwan. He also misses Taiwan, his home country, and feels a bit homesick now.

(Google Image) Taiwan -> famous landscape in Taiwan -> (Bing Image) famous landscape in Taiwan -> different landscape in Taiwan -> Taiwan style -> Taiwan feeling -> (Google Image) Taiwan feeling -> (Flickr) famous landscape in Taiwan -> (blogger.com) -> (facebook.com) -> (myspace.com) famous landscape in Taiwan -> (Google Web) landscape -> (Google Image) Taiwan landscape -> Taiwan see-sight -> (Google Web) Taiwan R.O.C. ->

Participant first used "Taiwan" as his initial query, and some images surprised him because they did not even look like any place in Taiwan. So he changed the query by adding "famous landscape in" and the results became more close to what he anticipated. The results showed many typical scenery in Taiwan and are useful for him to show to his foreign friends. He then **switched to Bing.com, but the results appeared to be worse than those from Google image**. He was not particularly satisfied with the results but felt that he could still finish the search at this point because he attributed that search engines are not perfect, **a merely 60% of completeness is enough for him as an explorative task** without any particular motivation or usage behind. Yet he tried to replace "famous" with "different" but the result went worse, some product images were even included in the result set.

*I found some photos of Taiwan which I haven't seen before…are they really in Taiwan? [11:43]*
*Yes, the results are more close to what I expected, for example, this is in 野柳…or some temple and flower images [12:20]*
*On the third page, I've lost my confidence in Google, I would like to switch to Bing [13:28]*
*I found many photos of foreign people…is it possible because I used English for search? [15:10]*
*Anyway, I think that's enough…although I still feel a bit pity but I think I'll stop here…because I always think search engine cannot 100% fulfill my need [15:47]*
*I'll change "famous" to "different"…it even shows product images when I search on landscape…I'm very surprised [17:05]*

He then **switched to Yahoo image using the same query**. Despite only few results returned, images from Yahoo appeared to be more relevant and useful. Having gained more confidence in Yahoo, participant **shifted his intention to see more images about typical Taiwan "style"** and the results were pretty satisfying. He then replaced "style" with "feeling" in the hope to find images from foreigner's perspective but the results became irrelevant with the majority showing people's portrait. Same query was then searched in Google, but no better results were found. Then the participant came up with the idea searching people's album. After viewing three pages in Flickr without discovering any interesting photos, participant refined his searched direction to people's blog. However, both Blogger.com and Facebook.com did not allow search without logging in first, so participant jumped to Myspace.com to try his luck. Yet nothing useful was retrieved. He then changed his strategy to find landscape websites from Google, hoping that he will be able to refine the area to Taiwan later on. The Web search did not return anything useful, so he went back to Google image and added "Taiwan" in the query. Surprisingly, this time the result appeared to be much closer to what he wanted than using the original query "famous landscape in Taiwan". He then followed the link to a landscape website which contains many professional landscape images around the world. The participant was particularly satisfied with this website as it provided many high quality landscape images from Taiwan, both city and country views. Finally he searched and went to the official website of Taiwan Information Office because he thought there will be some images and information that promote the famous scenery in Taiwan to foreigners. The images from Taiwan Image photo archive were very useful in showing the attractions and famous sights in Taiwan.

*To my surprise, Yahoo only gives me three pages of results…but the results are much closer to what I want…the quality is much better [18:28]*
*I quickly found some "Taiwan style" in Yahoo, such as subway and motorcycle…I've changed my search direction [19:30]*
*The results make me feel very familiar…the images depict a lot traditional Taiwan feeling…but I'm not sure whether this is what foreigners feel about Taiwan [20:13]*
*I found the results from Google were not good either, I think I can search on some online album website…I'll start from Flickr [22:10]*
*When I changed my query from "landscape in Taiwan" to "Taiwan landscape", it seems that I've found what I want…for example, images of traffic jams…mountains, and the winding road on east coastline…[30:05]*
*I just realised that I've made a mistake…I should have found Taiwan's government website first, and search from there [34:50]*
*Yeah…this is what I want, Taiwan today…I found (a section of) Taiwan image [36:30]*
*Enchanting Taiwan…this could be interesting…I found plenty of pictures…although these are not the typical Taiwan I anticipant, but these are still in Taiwan [38:40]*

<u>Question 3</u>
Participant wants to find some sample images of the Casio FC-100 camera. Because all his friends think Casio as an awful camera manufacture, but in fact this camera has just been awarded the best pocket camera 2009. As an expert in writing camera reviews, he would like to check the images himself and make his own judgment.

(Google Image) Casio FC-100 sample -> (Casio.com) (browse for FC-100 product info) -> (Google Image) high-speed exilim ex-fc100 -> Casio ex-fc100 high speed still image samples

Participant first searched for **Casio FC-100 camera's sample images** in order to compare the quality of the resulting photos in different conditions. He was particularly interested in the images taken under fast shooting mode and wanted to see if **some extraordinary photos** can be created using this feature. After opening four images from Google in separate tabs, participant decided **to go the Casio's**

**official website for the official image samples**. The participant found the full name of this camera and used it to search more accurate images from Google. He then carefully browsed through the result pages and found many useful images. Having discovered the new term “high speed still image samples”, the participant modified his query in the hope of finding more images taken under high speed mode, however the results did not differ much from the initial query. Nevertheless, the participant appeared to be very pleased with the results he has retrieved.

*I want to see the overall performance of the camera, including color and special features for some extraordinary photos [40:12]*
*Because its special feature of high speed continuous shooting…I don’t want the photos that are simply “good” photos…I need series of photos that depict this feature [40:41]*
*I feel a bit confused for my search targets…I’ll go to Casio’s official website for other keywords I can use [41:03]*
*high-speed exilim ex-fc100…this is the keyword (copied the term from web page) [43:56]*
*Difficult to stop at the top, but it’s so easy…yes, this is the image I can show off to my friends [49:15]*
*This is what I want for continuous movement shots…but I don’t know how to search for “continuous movement”... or how to connect it to Casio [50:05]*
*Hang on…I found a keyword…”Casio high speed still image sample” (copied the keywords) [50:11]*
*So…I’ll use the new keywords to search again…but the results are almost the same with previous one [51:03]*

## Transcript for participant 22

<u>Question 1</u>
Participant wants to find the latest movie photo of Japanese actor Takeshi Kaneshiro. She is a fan of Takeshi and just recently heard about the new movie. However, she did not know the name of the movie, nor has she ever seen any pictures from the movie.

(Google Web) Takeshi Kaneshiro -> Takeshi Kaneshiro movie -> Takeshi Kaneshiro movie list -> Takeshi Kaneshiro official website -> (to takeshikaneshiro.net) (browse for movie clip thumbnail images and back stage photos) -> (Google image) k-20 movie

Participant first used general terms to search for the movies of Takeshi Kaneshiro, but the results were too general and only associated with news articles of Takeshi Kaneshiro. She then formed the strategy to search for the list of Takeshi Kaneshiro’s movies through the years, however the term “list” did not seem to work. Consequently she tried to find the official website of f Takeshi Kaneshiro in the hope of finding the list of his movies in personal profile. This time she discovered a personal website for Takeshi Kaneshiro and went straight to the website by inputting Takeshi Kaneshiro’s name in URL. As soon as the participant went into the “movie” section, she found the list of Takeshi's movie and was able to identify the latest one which is called "k-20". She followed the link to the k-20 movie website and reviewed some back stage photos and the thumbnails of the movie. She then went back to Google image and used "k-20 movie" as the query to find more images of the movie. The results from Google image appeared to be very satisfying and thus concluded the search.

*Because I want to find his latest movie, I need to know the list of movies starred by him…however nothing seems relevant here [01:37]*
*Is there an official website for him? It should have the information there [02:06]*
*Now I go the website which looks like the official website of Takeshi Kaneshiro [03:18]*
*Yes, this is his latest one…the K-20 [03:38]*
*This is the list I want to find from the beginning [04:20]*
*I also found the photos when the movie was being shot [05:13]*

<u>Question 2</u>
Participant is interested in the famous Japanese Himeji castle because her friend has just came back from Japan and showed many pictures of the castle. She is also interested in the transportation from Osaka to Himeji and the accommodations nearby.

(Google Web) Himeji castle -> Himeji castle hotel -> Himeji castle bagpacker -> Himeji castle cheap hotel

Participant first began with Web search of Himeji castle. The first result already contained some images of Himeji castle, so she followed the link by clicking on the images. She also browsed some information on the transportation to go there, and subsequently decided to search on the accommodations near Himeji castle. By adding "hotel" to the original query, participant successfully found some websites for the hotels that are near Himeji castle. However the prices were too expensive so she tried to search for the accommodations for backpackers. The search term "bagpacker" did not retrieve any good results and she replaced the term with "cheap hotel". She then followed **a link to someone's blog** because the article mentioned about one cheap hotel which is famous on the Internet. After reviewing the article about this particular hotel, she decided the previous hotel was more suitable for her and concluded the search task.

*Oh...ok, it (Google Web) already has the images (results) [09:22]*
*I was drawn by this description… "the north side of the rooms can enjoy the view of Himeji castle through window…" [12:01]*

<u>Question 3</u>
Participant wants to buy some compression stockings for herself because her work requires long hour standing. She is particularly interested in the functional aspects and the prices of different brands.

(Google Web) compression stockings -> compression stockings price -> (Google TW Web) compression stockings -> varicose vein prevention stockings -> varicose vein prevention stockings medical product -> varicose vein prevention stockings brand ->

(Google Web, AU pages only) compression stockings price -> (getprice.com.au) compression stockings -> jobst

Participant first started with "compression stockings" as the initial query. She followed the first result saying "medical stockings" but the information was too little and only contains two brands of stockings. So she added "price" to the query to see different prices of different kinds of compression stockings. This time the results showed a website that sell many brands of compression stockings online and looked pretty reliable to the participant. Then she went to **Google TW to cross check the prices** for similar products in Taiwan. She followed a particular cosmetic product forum because she has been searched on that forum before. Participant then developed an idea of refining her search to "medical product" to see if there will be a website that sells compression stockings for medical purposes. However no such websites were found. She then looked for a list of "famous" or "big" brands of compression stockings in Taiwan to cross reference the brands she found earlier. Finally she determined the website she found from the second query sells all the good brands of compression stockings. She then restricted the query to Australian websites only to find the prices here. The query returned with a link to *Getprice.com.au* website from which the participant was able to find a range of prices of different compression stockings. She then search to brand "jobst", which was the brand retrieved from the second query, and compared the prices of this particular brand on getprice.com.au.

*So it got many brands …(opened a new window) [19:43]*
*Because I also want to know the price in Taiwan [20:10]…but this one did not mention about any brands, so I'll change the query to "varicose vein prevention stockings" [21:12]*
*I want to see if there's any websites that sell medical products so I can buy from there [24:04]*
*(on previously found web result) These are the big brands…but because I'm not familiar with them…(back to the Taiwan forum page) oh…so the brands I saw on that website are all big brands [26:18]*
*Since I want to compare the prices between Australia and Taiwan…I remembered there was a website for comparing prices [26:49]*
*(on getprice.com.au) but there are not many images [31:23]*

# Transcript for participant 23

Question 1

Participant wants to know the news about "the best job in the world" because she has heard of it before. She is interested in what are the duty and salary for the job, as well as where is the workplace. She also wants to find the reasons why the job attracted so many people around the world.

(Google AU Web) the best job in the world -> (Google AU Video) the best job in the world -> (Flickr) (browse the photos by Tourism Queensland) -> (Google AU Web) great barrier reef -> (Google AU Web) tourism Queensland

Participant first searched on Google AU Web because she knew the job was released by Queensland government. She then followed a link to **Google Video search** and clicked on one video result titled as “Tourism Queensland | The Best Job in The World”. Then she realized that she was reviewing the result from video search, which probably would not give the information she wanted. She went back to her previous Web search result and followed the top **link to the winner of the best job in the world’s blog, Island Caretaker Blog**. From this blog she was then led to the Flickr album of the Queensland Tourism and reviewed many photos from the island. She also followed the link from the blog to *Queenslandholidays.com.au* and **browsed for several different travel destinations in Queensland**. Participant then decided she wants to know more about the Great Barrier Reef. She also **searched for tourism Queensland to get more information** about the travel destinations in Queensland. However she was unable to find the salary of the job from her search results.

*Normally I’ll use Yahoo, but since Great Barrier Reef is in Australia, I’ll use Google AU to search for the news…it should help me find the news quicker, I think [00:40]*
*I found many results about the best job in the world, and there are some videos from Australia…unlike Yahoo, which will show a lot of Chinese news…I think this should be closer to Queensland Government’s information [01:31]*
*I see this (video) Tourism Queensland…when I saw the newspaper before, I knew this is from Tourism Queensland Government, so I’ll click on this result [01:49]*
*This is a video…I need to find images…so I’ll go back (to previous Web search results) [02:24]*
*Island Caretaker…I think someone has started working there, I’ll have a look on its blog [03:06]*
*Because I knew there was a Taiwanese girl who’s also in the competition, I have also noticed this news [04:05]…Many of my friends encouraged me to apply for this job…they said that I’m very suitable for the job, so I’ve been noticing this news for a while [04:24]*
*(in the blog, go to ‘About the Island| holiday to the islands of the great barrier reef’)[07:35]*
*(on queenslandholidays.com.au) If I want to go there, I’ll…yes, find this, Queensland Holidays [07:45]*
*I would like to know more about the job, what’s the duty, salary, or others…I’ll search what are the interesting things there, or some scenery points [11:30]*
*(back to Google AU Web) I want to find the travel destinations around Queensland [15:11]*
*Because I originally only want find “the best job in the world”, I think the (best) news is the blog I found [16:14]*

<u>Question 2</u>
Participant is currently planning a trip to Tasmania. She wants to search the travel information about Tasmania, such as the famous scenery and weather there.

(Google AU Web) Tasmania government -> (Google Image) Tasmania government -> tourism Tasmania -> (Google AU Web) tourism Tasmania ->

Participant started with Web search to **find Tasmania government’s website** about local travel, however no results particularly interested her. She them jumped to Google image to see if there is anything inspiring. After reviewing several irrelevant results, she decided to go back to Google Web and search for “tourism Tasmania”. Her intention was to find some websites that provide information on the travel in Tasmania, form which she should also be able to **see some images of the interesting sightseeing points**. The results did provide some useful information, especially from *discovertasmania.com*. The participant then browsed many images from the website and was particularly interested in the outdoor activities she can do there. The participant seemed to have **quite specific personal knowledge about Tasmania** and the famous scenery sites, thus she concluded the website was very useful for her needs and situation.

*First, I want to know about Tasmania's geological information, and some travel destinations...to plan my trip [23:46]…for example, if I go there for a week, and it's winter there… [24:06]*
*I've heard that Tasmania is very like a small New Zealand, and I personally like outdoor activities like mountain climbing, landscape, and bush walking, etc…since I've been there, I still think it's very beautiful when I see these (pictures) now [27:16] (in discovertasmani.com) I think the website is very good, because it also have Google map, it shows the locations of many destinations with images…so I don't need to search separately [29:05]*

<u>Question 3</u>
Participant wants to buy a backpack. Any good quality backpack which can be used for travel and hiking would be suitable. Especially it must be designed for girls and around 55kg size. Participant knew some of the brands such as The North Face and Columbia may have the right product for her.

(Yahoo TW auction) backpack -> 登山背包 -> Columbia -> salomon -> (sunbrisbane.com.au)

Participant began the search from Yahoo TW because **she was more familiar with the Chinese description of backpacks**. However using the keyword “backpack” on the Chinese website did not appear to work well, so she changed the query to the Chinese of backpacks. She mentioned about the usefulness of **term suggestion mechanism in search engines**. She browsed through the different ranges of backpacks sold in Taiwan, particular focusing on the design and functionality that suit her purpose of hiking or mountain climbing. She also compared the prices of similar products. After getting more general ideas about what is currently available on the market, she refined her query to search on the backpacks from the brands she knew or heard before, such as the Columbia and Salomon. However the search results were not satisfying as they only had few backpacks and hardly any images were shown. She then decided to go *Sunbrisbane.com.au* to find some second hand backpacks there. She **knew this is the website** that many people in Brisbane sell their used items. However the website still did not provide any useful information on backpacks and thus she was unable to fulfill her search need.

*I'll search on Yahoo bid first because I want to know the general prices [32:53]*
*It's not as what I expected, these are all more for casual (use)…I want the serious backpack for mountain climbing, I need to change my keyword here [34:22]*
*I'll look at the pictures first, and the brands…and price [35:25]*

*I'll look for the new design in these backpacks…for example this one can be carried on back or pulling on the ground [37:35]*

## Transcript for participant 24

<u>Question 1</u>
Participant wants to find the images from the recent violent riot in Xinjiang city, China. He wants to know more about the cause of the incident and the photos from the Chinese force intervention, especially the bloody conflict scenes.

(Google Web) Xinjiang -> (Google image) Xinjiang -> Xinjiang "bloody quell" -> Xinjiang conflict scene -> Xinjiang quell

Participant first **began with one keyword "Xinjiang" in Google Web search**, some image results were already clustered/aggregated in the result page. Participant usually would click on Wikipedia page for more general information about the city. Since the target was to find news images, he switched to Google image with same query. The results showed lots of landscape images about Xinjiang, which was not suitable for participant's intention. He then **added "bloody quell"** to the query in the hope of finding more violent scenes from the incidence. He started looking for images containing both visual and textual (caption) content because he though that would provide more information about the incidence as he only has little knowledge about the news. He was particularly interested on how "bloody" the riot and the force intervention can be.

*Usually, I'm very easily distracted during Web search, for example, if I see these pictures, I'll open them to have a look, although I want to search for general information about Xinjiang first [01:01]*
*I'll also review the Wikipedia…to see about this place…or to get some ideas about this [01:21]*
*(switch to Google Image) Still…there are more of scenery photos [01:41]*
*Because I don't know much about the news, I'll start with those (images) have both text and visual information…but I'll ignore news paper images [02:45]*
*I actually want to see how bloody it was [03:25]…*
*I'm looking at the text descriptions of how bad the quell was, and with the images…oh, they are really bloody and make me sick [04:48]*
*This website really has a lot of images, which is sufficient for my need [05:16]*
*(in the same page of epochtimes.com, clicked links to related images from the recent Tibet riot) [05:42]*
*I opened the Wikipedia page because I don't know about the geographic and history (of Xinjiang), I want know more about the background information…nothing to do with my search, I don't think this will help my search but I just want to see [06:19]*

After reviewing several images of the victims and bloody pictures of the wound, he was **satisfied with the bloody criteria and decided to find more images about the conflict scenes**. He browsed through many news Web pages and used the description text along with the images to determine whether the particular picture suits his need. He also browsed through some images from the similar incidences such as the one in

Beijing, June 4th, and the recent Tibet riot. The results returned from "conflict scene" were not close to what the participant anticipated, so he decided the term **"conflict scene" may not be useful and replaced with "quell"**. This time the results were very similar to the previous results and nothing particular drew participant's attention.

*This is the riot in June 4th, 1989 [06:39]…because the news in Xinjiang…it makes me… after seeing this …interested in the prior news in Tibet, even the Tiananmen Square massacre at June 4th , 1989 [07:27]*
*Because the images I reviewed were all about the bloody quell…like the dead body…I'll change to "conflict scene" [12:47]…it should give me some less bloody images with the real scene when it happened [13:14]*
*Where's the "conflict"? It seems that "conflict" is not a good word [14:18]*
*Same, the results are not much different from the first query [15:06]*
*Because of so many irrelevant images in the results, I think it may be filtered by the (Chinese) government [15:38]*

<u>Question 2</u>
Participant wants to find the images about ski places in Melbourne. He is currently planning a trip to Melbourne. He is also interested in different kinds of ski activities and the stunts performed by the expert skiers.

(Google Image) Melbourne ski -> (Google Image Advance) Melbourne ski Melbourne -> (Google Image) Melbourne "ski" -> ski -> Melbourne snow scene -> "Melbourne snow" -> (Google Web) Melbourne ski -> (backpackers.com.tw) Melbourne ski -> Melbourne -> (Google Web) Melbourne ski

Participant first performed a general search using "Melbourne ski" as the initial query. The results included a lot of famous scenery photos in Melbourne, which were all interesting to participant. He then refined the search by using the advance search function and moved "ski" to exact phrase and "Melbourne" to related keyword because he thought the query should primarily focus on ski than on Melbourne. However this strategy did not turn out to be effective, so the participant broadened his search to all "ski" images as his original goal was to see the ski scenes. By using only the "ski" as query term, the results successfully showed many ski activity pictures that were satisfying to the participant.

*Good, I think I can review (these results) for 2 hours [17:45]*
*Images of professional skiers, people's blog or album, or like Melbourne city because I would also visit there, or the famous scenery spots like the churches are all to my interest [18:25]*
*Because I'm easily distracted by these (images), I'll go to advance search…"ski" is a must, and related to "Melbourne" [19:41]*
*Same…why?? [21:43] So…what should I do? [22:20]*
*Two ways to solve this…first, change my search direction [23:01]…(change query to "ski" only)…I'll look for all kinds of ski photos to see how people ski and do the stunts [24:11*]

He then searched for the snowy scenery in Melbourne. The result turned out fine despite still a noticeable proportion was irrelevant to snowy scenes. **After viewing**

**enough snow pictures, participant decided to search for ski information such as accommodation and transportation**. He used Google Web to search for "Melbourne ski" and surprisingly not many results appeared to be useful this time. In order to gather more useful information shared among Taiwanese people, he **went to *backpackers.com.tw* and searched for ski in Melbourne**. He chose this particular website because **he knew the website before and used it for gathering travel information**. However the website did not provide any result for his search. Finally he gave up on the website and went back to Google Web. By **using all query terms in Chinese**, he successfully found several useful links with plenty of ski information in Melbourne and thus concluded the search.

*Good, the results are not too bad [24:43]*
*If I don't see any good results, I may search on travel agencies' website [26:46]*
*I forgot the names of ski mountains in Melbourne [28:15]…*
*I'll go to backpackers.com.tw because people would share ski information there [30:06]*
*What? No results? Is this my problem?? [31:08]*

<u>Question 3</u>
Participant wants to buy a pair of Europeo Armani sunglasses. He needs to find the color, the variety of product range, and do some prices comparison.

(Google image) Europeo Armani sunglass -> (Google Web) Europeo Armani sunglass -> brand sunglass

The **first query returned with many pictures of Europeo Armani, the designer of Armani brand.** By switching to Web search using the same query, many online stores were retrieved and participant was able to see many product pictures from these sites. Image search did not appear to be an effective way of searching because **the results were all heavily associated with people photos**. The **online stores were useful for this search task because they provide images of the product**, the size, and price information all at once. Participant even further broadened his search to online stores that sell brand sunglasses. He was particularly happy with this search strategy and commented that he would keep doing browsing these online stores until he found the perfect sunglasses for him.

*I found that (image search) is not a good way to search…I should search from Web…it would be faster [43:38]*
*(on an online store website, framesdirect.com) Yap, this is much more efficient, I think [43:49]…I can quick spot on the one I want [44:01]*
*The previous image search result, you know, is not like this (showing one pair of glasses)...the designer's name is too strong, or there are too many things from the same designer [44:36]*
*(copied on particular model) Are you comparing the prices of this particular model? I'll look for other colors first, then compare the prices [45:21]*
*(My search) it becomes more focus on the online stores…just follow what they have on the website [45:51]*
*I now have two different (search) directions, either continue browsing like shopping around, or search the price for that particular model, then compare the prices, and*

*finally buy it [48:00]*

## Transcript for participant 25

<u>Question 1</u>
Participant wants to see the images of the recent Jakarta bombing. He is particularly interested the level of damage caused by terrorist at the hotel.

(Bing Images) Jakarta bombing -> Jakarta bombing marriot hotel -> Jakarta bombing mariott hotel -> jakarta bombing marriott hotel -> (Google Image) jakarta bombing marriott hotel ->

Participant used Jakarta bombing as the initial query for image search on Bing, already the results were showing plenty of images that appeared to be relevant to participant's search criteria, which are primarily of the bombing site and the damage itself. After viewing several bombing images with the news article description, participant **found that the Marriott hotel seems to be initial site and thus decided to focus on** the images taken at that hotel.

*I'm looking for the sites…not really people, I'm just to see how big the bomb is…so I can see the degree of damage [01:18]*
*That looks like the one…but it's just too…yeah, it's one of it but there's probably one that's bigger, like you can see the whole site [02:47]*
*Some photos are really irrelevant, like this one (a women standing in front of a plain black background) [03:44]*
*I'm not interested in the victims, just the site, just want to see the level of damage…like the physical or structure of the damage [04:12]*
*Yeah…something like this…this is massive, see all the cars…it's crazy [05:50]*
*But the thing is…for the news, if you start from images that derived from the news, you'll end up reading the news more than image itself [06:50]…but still interesting how they actually relay, or pick specific image for the news…I mean this is really just a random image it's probably got nothing to do with "find similarities in Bali blast" of this title and this article [07:10]*

He was not sure about the correct spelling of Marriott hotel, however Bing seemed to retrieve the intended images without any problem despite it did not prompt the user of the correct spelling. In fact, the retrieved images did not differ much using the three different spellings of Marriott hotel. Finally he found the correct spelling of the hotel's name in one of the retrieved images. He also compared the result with Google image but Bing seemed to have done a better job for this topic. The images retrieved **from news website such as BBC were particularly useful** and relevant to participant's intention.

*I thought it was the Marriott hotel, right? …I'm going to search for Marriott hotel…is that how it spells? [07:56]*
*Yeah…there you go…something like that [08:10] (open multiple images in new tabs)*
*No any more? …oh maybe because of Marriott, is it double "t"? [08:36]*

*This photo (in front of a burning high level building)…oh we got a set of images from BBC news [08:55]*
*(look at an image in front of Marriott hotel with a stele) Oh, it's this one…double "r" double "t" [09:10]*
*(switch to Google with same query) I didn't do "Jakarta bombing" first, just try to give an idea [11:40]*
*But I heard that there's actually two hotel was bombed…two Marriott hotel [12:05]*
*Comparing to Google…pretty much the same images…like this one [14:12]*
*(on the 3rd result page) There are some images that are also found in Bing but…like this one should be on the first page [14:48]*
*Anyway, I think I'm pretty satisfied with the search [16:15]*

<u>Question 2</u>
Participant wants find some previous seen images of the aurora in Antarctic. The images should show the night landscape of Antarctic with aurora floating in the sky.

(Bing Images) aurora Antarctica -> (Google Images) aurora Antarctica

Participant first searched Bing Image using "aurora Antarctic" as the query. The results showed plenty of landscape photos of the aurora, however the location in which the photos were taken required further confirmation by reading the description or article in the individual websites. Interestingly almost all of the images retrieved were taken in the night time with the aurora in the sky, thus there was little need to refine the query further using additional descriptors such as "night view" or "sky". Some of the images were taken from an aircraft or even outside the globe which were **not what the participant has anticipated**, however after viewing these images participant commented them as inspiring and still very relevant to his search. Again the same query was **searched on Google image to compare the results**. This time Google did a pretty decent job with at least the same accuracy and retrieval quality as Bing. Overall, the participant was very satisfied with his choice of query terms and was able to find plenty of images suitable for his criteria without any problem.

*Nice…check this out…there's so many [16:35]*
*Oh man, these images are crazy [17:56]…but these images are from NASA, you won't be able to take images like that [18:18]…but at least you'll be able to understand that it's actually above the hemisphere [18:23]*
*These are pretty much the sort of [19:01]*
*(In Google Image results) That's probably better images of the aurora [22:18]…(browsing on www.pahof.de) That's cool [23:04]…that's nice photo…wow cool, that's really cool [24:01]*
*Yeah, these are really good photo…they are pretty much the photos I was looking for…nothing more [26:01]*

<u>Question 3</u>
Participant has heard from a friend about a lomo camera made from card box paper. He wants to find the images of that camera to see whether it is real.

(Bing Image) lomo cardbox camera -> lomo cardbox -> lomography camera paper -> lomography camera brown paper -> lomography camera brown card -> (Google

Image) lomography camera paper -> lomography camera cardbox -> lomography camera card box -> (Bing Image) lomography camera paper card box -> lomography camera paper box -> (lomography.com) (browse for shop categories) -> (Google Web) lomography japan website -> (lomography.jp) (browse for shop categories)

To participant's surprise, the initial query retrieved images without any camera or lomography pictures, so he broaden the search to only "lomo cardbox" but still not even any potential relevant images. Hence he thought maybe the camera was not called "cardbox" and changed the query to "lomography camera paper". This time the images appeared to be much closer to what he anticipated and he found a particular one called "lomography paper pinhole" camera that might be his target. **In order to confirm the result**, he add "brown" to his query because he recalled that there was one he saw before and it was of brown color. However the results did not show any potential candidate, so he tried other combinations by replacing paper with card or cardbox or card box, or by changing the search engine to Google image.

*Oh…that's nothing to do with "LOMO" anyways…LOMO cardbox? Nothing in there [27:08]*
*Maybe it's not called "cardbox" [27:15]…this one is close but the one I saw was brown [27:48]*
*Lomography paper pinhole camera [29:18]…I don't think you can actually take photo with this [29:31]*
*Alright, that's probably the image I'm looking for…[30:12]…it should be brown but it's not brown at all [30:20]*
*Or it could be on one of these Japanese websites because it's so specific item [35:02]*
*Let's try this first (switch to Google Image) [35:25]…same, same, same…[35:35]*
*What if I can't find it? [35:40]*
*Don't think I can find it [37:14]*
*Alright, forget it…cardbox…maybe "card box"? [37:34]*
*I can't find it, I give up…I'll go to some lomography websites [40:53]*

After failing playing with the different combinations, the participant **decided to go to *lomography.com***, a website he knew for selling lomography cameras. From there he **browsed through product categories** but still nothing was close to what he had in mind. Then he searched for lomography japan website and browsed through the product categories again, yet no luck this time. Finally he concluded that the paper pinhole camera he found at the initial stage of the search is the closest one he can get, despite it still appeared to be different from what he heard or what he had in his mind before starting this search.

*(on lomography.com| shop) (browsing for various lomo camera products)*
*I can't find it [47:19]…at least I've got one…the paper pinhole one [48:44]*

## Transcript for participant 26

<u>Question 1</u>
Participant wants to find images about the Jakarta hotel explosion. It is of her interest

to see how bad the explosion and the damages were. She has heard of the news before but did not see any pictures from the news.

(Google Image) jakata explosion ->

The first query returned some explosion scene images despite the spelling error of Jakarta city. Interestingly Google did not prompt the correct spelling in “Are you looking for?” function, but the results seemed to be correct. Participant was more interested in the explosion scene of the building and the destruction, with less intention to see the photos of the victims although it was not possible to avoid that kind of pictures in the results. She also **found a news gallery** from the query which collects many momentous images from the explosion and was very useful to participant’s search. Participant thus concluded that **news websites were particularly helpful** in searching for images from the important news event. She was very satisfied with the results as she was only interested in the general images about this news.

*Did I spell the wrong word ? [00:51]*
*I want to search for the explosion scene [01:19]…or the damaged or collapsed buildings [01:27]*
*So you don’t want to see the victims? I think I’ll see them anyway…but I’m more interested in the buildings [02:22]…I want to see how bad it was…I’ve heard about the news but haven’t seen any images of it [02:36]*
*Jakarta bombing gallery…ok, I’ve found a gallery [03:54]*
*(keep browsing the gallery of 29 news photos)*
*I think this is good, I can see many images in once [04:32]*
*I just want to have a look…don’t have specific goals, even after I saw all these images [06:39]*
*Because for me, as news, I only want to see the general situation…instead of just seeing the text, I also want to see the images [06:55]*
*(keep browsing Google Image results to page 6) hmm…not much difference, can’t think of any other…[07:03]*

<u>Question 2</u>
Participant is planning a trip to Taipei city, Taiwan, at the end of the year. She needs to know the famous places for sightseeing and activities she can do there. She has been to Taipei few years ago but has forgotten the name of the famous places in Taipei.

(Google Image) Taipei sightseeing -> Taipei sightseeing place -> (taiepi.travel-web.com.tw) (browse for food) -> (Google Image) Taipei cuisine

Participant used “Taipei sightseeing” as the initial query in the hope of finding the famous sightseeing spots in Taipei. She was particularly interested in the iconic places/attractions in Taipei because she wants to show the “typical” Taipei to her friend who has never been there before. After viewing some English travel website about the information on Taipei, the participant decided to use Chinese to search for more images because she thought it should retrieve more information using the local language. From that query she was able to find plenty of beautiful images of Taipei, especially the ones from people's blogs in Taiwan. Some pictures showed the famous dishes in Taiwanese food, which reminded the participant with delicious food in Taipei and decided to shit her focus on the things to eat in Taipei. Along the participant's search, she also found one particular website (taiepi.travel-web.com.tw) that provided enormous information about all kinds of food in Taiwan. So she stayed at the website and browsed for the various kind of food in Taipei, including the night market. She then searched for the famous cuisine in Taipei on Google image, in which one result led her back to the previous website and kept her browsing the same site.

*I only focus on Taipei city…and look for attractions [08:50]*
*I only have broad idea about where to go in Taipei, I'll remember them more specifically when I see the pictures [09:16]*
*(found a collection of iconic Taipei city pictures and kept browsing the collection) It didn't say (where the picture's showing) [09:53]*
*Would it be better if I use Chinese (to search)? [10:34]*
*Basically when I see the place that I know, I'll click on that [15:05]*
*This website is pretty good (Taipei.travel-web.com.tw) [20:08]*
*I want to search about the food [20:56] …ok, I'll keep search on this website [21:06]*
*Blog is really useful (for searching for food)…and they always put so many pictures in blogs which are all worth a look [25:45]*

Question 3
Participant is buying a wedding gift for her friend. She needs to do a bit of research on different kinds of wedding gifts so to get some ideas about what to buy and how much she will need to spend.

(Google.com.au image) wedding gifts ideas -> wedding gifts -> hallmark gift -> hallmark wedding gift -> Disney wedding gift -> (Google TW Image) wedding gift

Participant first focused on the ideas about wedding gifts, she was more concerned with the availability in Australia and thus started with Google.com.au. She primarily looked at the individual gift's appearance and generated some broad ideas from there. After reviewing several items such as the photo frames, plates, key chains, and salt-pepper cans, she decided to broaden her search to the gift itself rather than the "idea". However the results did not differ much from the initial query, so she came up with the idea of focusing on "hallmark" gifts because she knew the company produces many gifts for special occasions like cards, etc. She consequently refined her query by adding "wedding" to see more wedding gifts. From the results she found some gifts of Mickey Mouse from Disney, so she changed her search to Disney wedding gift. She also searched the wedding gift on Google TW to see if more ideas can be inspired. She found some images of Sworovski crystals and thought that could be one option for her. One image of a crystal ball with Hello Kitty couples also interested her because she was personally a fan of Hello Kitty. As the search went more and more diverse, she concluded that the idea was too general and it would probably take hours and a bit of serendipity to find the things that suit her needs, thus she decided to terminate the search session with little satisfaction and the sense of completion.

## Transcript for participant 27

Question 1
Participant wants to find some press images of Gordon Nuttall's corruption case. He is looking for the images right after the trial and presumably outside a courtroom.

(Google Image) Gordon Nutall corruption -> Gordon Nutall trial -> labour corruption -> Gordon Nutall court image

The initial query retrieved several images that were close to what the participant had anticipated, especially the images with Gordon Nuttall coming out/to the courtroom with press around him. He subsequently replaced "corruption" with "trial" and successfully retrieved more images of Gordon attending the trial with many presses in front of him and tried to interview him. Later he tried broaden his search using a general term "lobour corruption" to refer this case, however the results were very irrelevant and did not reflect what the participant intended to find. Participant was then happy with the results from the first two queries as his intention was to get some general images about this case without specific criteria on the background or the perspective of the images.

*I'm looking for images on the ex- parliament minister Gordon Nuttall's corruption case…just looking for images of people involved, people coming in their court…just to see their expressions and their feelings at the time [00:38]*
*This (image) is pretty much what I had…the idea of people coming out of the court…the press [01:45]*
*I'm looking for …not necessarily his profile or personal portrait…just the actual court case…the press and everybody outside and the lawyers, etc. [02:28]*
*Most if images coming out to start with just him by himself [02:35]*
*Change to "Nutall trial" specifically [03:19]*
*I'm pretty happy with the results…wasn't really look for hundreds of pictures…just a few to start to see what was going on…I'm happy with the ones that came up [04:30]*
*Some of the other concept I put in was "labour corruption" but I don't think that would be as specific to come up anything [04:50]*
*This is…anything, it's not really specific to…Gordon Nutall's case is very recent so I thought it may have related back to that…but it's nothing whatsoever [05:32]*
*Yeah…I think with his name in there, is the best the way to get what I was looking for [05:53]*
*(resume search after finished the 2nd and 3rd search topics)*
*Maybe the first one I can try something different [20:40]*
*It's Anna Bligh…not sure if it's related or not [21:39]…she was at the court to give evidence…so it's related to the trial but not to him specifically [21:48]*
*This is something I was looking for as well…he and his lawyer turn up in the court [22:31]*

*Guess that's really similar to any of the search I did [22:45]*

<u>Question 2</u>
Participant wants to see the images of Macau city. He is interested in the things to do and see there.

(Google image) Macau things to see -> Macau tourism -> Macau night views

Participant began with a generic query to see/probe how Google responds. He was hoping to find images of the sceneries or buildings in Macau. He reviewed some pictures of the landscape in Macau, in particular the old mansion and some night views. Then he found a webpage containing a list of the famous tourism sites in Macau, which was very useful to the participant. He then tried using "Macau tourism" as the query but the results contained more maps of the tourism sites other than the pictures of the actual scene. After seeing some night pictures of Macau, participant **refined his query with "night views"** as the search term. This time one result led to a website **showing images of Macau with Google maps on the side**, which is very useful for participant's exploration of the city because it provide a range of views in Macau, not necessarily constrained to night or buildings only.

*Just looking for…as a tourist… what things to do or what things to see [06:16]*
*It would be…pretty generic as itself [06:32]*
*Just looking for images of …sceneries, the buildings [06:43]*
*These are close to what I want…just the landscape and the buildings [07:53]*
*This is more of what I'm looking for…more of a list of what you can do and see with pictures of each [08:48]*
*This one is quite good…it's really good…probably about everything [09:20]*
*I'm just searching for the actual images of the buildings, not necessarily the maps or…[09:55]*
*I might just change my search…and find other things as well…change that to "Macau tourism" [10:33]*
*The results are fairly similar to last search (results), but I don't think this is as good as last results…this is more maps, not necessarily the pictures of place to go [11:15]*
*Just to see if I can find something more specific with the view in the night [12:10]*
*Oh good, it's even giving the map so we know where it is [13:25]*
*This one is quite good as well [13:48]…it's giving a bigger range of images in one page [13:59]*
*I still think my first search gave better result of what I'm looking for…but this is still quite good [15:10]*

<u>Question 3</u>
Participant is looking for the images of the latest iPhone 3gs. He is thinking of buying one and wants to familiarize himself with this product.

(Google image) new apple iphone 3gs ->

Form the initial query, the participant successfully retrieved many images of the iPhone 3gs, particularly the sample product images. He is more interested in the appearance of the product than its functions. He browsed through the images that have “3gs” in the title or description in order to confirm the images were actually of the latest 3gs model. Because the query with the product name was specific and the results were accurate, the participant was satisfied with current results and felt no need to search further.

*Just looking for images of the iphone, what it looks like, basically…[16:00]*
*That's fairly old…this one there [17:13]…because of the “firmware 2.2” [17:21]*
*This one is the 3gs…I know form the title of the image it says “3gs” [17:37]*
*This is pretty much what I was looking for…some of the screens and what that can do [18:00]*
*This one is particularly good…quite a few shots [18:37]*
*I think I've got what I was looking for…first time or something [20:06]*

## Transcript for participant 28

<u>Question 1</u>
Participant wants to find the currency exchange rate diagram because he is investing some foreign currencies. The diagram will show the up-to-date exchange rate for the selected currency as well as a graph depicting the trend over a certain period. Such information is useful for him to decide his investment target.

(Yahoo Finance) -> (Finance News) -> (Australian Dollar) -> (Currency Rates) (select particular currencies and period to see the diagram) -> (HSBC HK) -> (Foreign Exchange) -> (Google Web AU) exchange rate diagram -> (Yahoo Finance) -> (Market Summary)

Participant **went straight to Yahoo Finance** webpage because he knew that it provides up-to-date currency exchange rate with a trend graph. From there he clicked through the categorized links which led him to the exchange graph. He has **done this many times before so no searching activity was required**. The graph allows user to select a period ranging from one day to up to five years, then displays the exchange trend accordingly. Participant compared the exchange rates between AUD – USD and AUD – HKD. Participant also demonstrated how to **find the similar diagram on HSBC HK's website**. Then he tried to **search exchange diagrams from Google**, however the results appeared to be the statistics of historical exchange rates rather than the daily updated exchange rates. Finally the participant also demonstrated to get the trend graph for stock market quotes from Yahoo Finance because he usually needs to cross reference currency exchange with stock market to make investment decisions. **Google Image search was not suitable for this type of task** because the images were much dated if not historical (unlike Yahoo Finance which provides minute-by-minute updates), not to mention the high proportion of irrelevant images which were retrieved only due to the “exchange rate” in their captions or descriptions.

*Usually, I'll go straight to Yahoo Finance, which is the first result from Google [00:36]*

*(in Finance News) Usually, you can see some exchange rate news here [01:10] [DS]*
*There's the graph…I usually need this exchange graph for the recent 5 days or 3 months data to see the trend [02:05] [REA]*
*I usually first look for the exchange rate between USD and AUD, then HKD [02:40]*
*Because this website…basically it updates every minute…so the information is the most up to date [02:58]*
*(in HSBC website) It's all text…don't they have the graph?...I'll search on Google [05:41] [REA]*
*Oh, these are fairly old (graphs)…it's on yearly base [06:52]*
*(Google Image result) but these are not up to date, they are mainly the historical data [10:14]…so it's better to use Yahoo Finance [10:21]*

<u>Question 2</u>
Participant wants to find the pictures of tourism places in Italy. The pictures should give him an idea on what the places look like.

(Google Web) Italy -> (Google Web HK) travel agent -> travel agent Hong Kong

Participant reviewed some image results from the initial Web search, such as the **maps** showing the geographical location of Italy. He is interested in **the general information** about Italy, including the location and the big cities in the country. He then searched for travel agencies in Hong Kong because he wanted to see different kinds of tour packages offered by the agencies. From their package brochure documents, he can see more **detail information about the itineraries with some sample images**. Despite only limited images were offered in these brochures, the participant was satisfied with these images as they provide key information corresponding to the tour, saving him the time from browsing/searching images of places that are not included in the package.

*I'll search for the location of Italy first…where its big cities are located [11:24]*
*For example, if I want to buy the tickets…because I may not fly directly from Australia, maybe go through HongKong…so I…(switch to Google HK) [11:53]*
*Yeah, there's a list (of most travel agencies)…usually you'll know the biggest agencies [12:31]*
*Because the travel information provided by these agencies would also include images…I'll browse from their websites [13:56]*
*Because every travel agency has similar packages…going to similar countries and places…it is enough to just review the images provided by one or two agencies [18:31]*

<u>Question 3</u>
Participant is interested in the latest IT product like the laptop. He needs to compare the look and feel of different products.

(umart.com.au) (browse for laptop prodcuts) -> (Yahoo shopping TW) (browse for laptop products with screen size smaller than 10-inch)

Participant went directly to an online computer shop (umart.com.au) because he knew that they offer competitive prices on a wide range of computer products. He browsed through some laptop product information pages of the big brands which he already had in his mind, such as Asus and Acer. He adopted this search strategy because he can easily compare the prices from the website, which was the priority concern for him when search task is potentially for future purchases. The pages also provide some thumbnail images of the product which assisted him to quickly judge the look and feel. He then switched Yahoo Shopping TW because he usually gets product prices there. The website provides abundant quality product images with detail descriptions, which is very helpful for him to make comparison and decision.

*You only look into Asus, don't you want to compare other brands like Acer, MSI, or SONY? But I'm focusing on the small laptops…because of the price…they are more expensive…I'll just have a look [26:12]*
*I only go to Umart.com.au and Yahoo TW because I know I will be able to compare prices easily from there [26:32]*

## Transcript for participant 29

<u>Question 1</u>
Participant wants to see images of Ekka because it is coming soon (Ekka 2009). Any photos about the products, shows, or the games in Ekka would be considered as relevant.

(Google Web) Ekka Brisbane -> Ekka photos -> (*ourbrisbane.com*) (browse archival images) -> (Google Image) Ekka photos -> Ekka strawberry ice cream photos -> Ekka show photos -> (ekka.com.au) -> (Google Image) Ekka Toyota V6 Hilux Heroes and Showtime FMX -> Ekka showtime -> Ekka car showtime

Participant first typed in "Ekka" as the initial query and selected Brisbane form the suggestion list. She followed several links that has "Ekka Brisbane" in the titles. She was interested in **the generic themes in Ekka**, such as the animal shows, car demonstration, and the various food and dairy products sold there. She spent quite some time browsed an Ekka website (ekka.com.au) for the event images but not many were found. Then she change her query to "Ekka photos" to find more images. The result led her *to ourbrisbane.com* which provided some special archival images for Ekka events and history. The participant liked this image collection because she can see many old photos which were not commonly seen from current news media. Having seen enough general images of Ekka, the participant decided to focus on the images from the animal shows performed on Ekka. However she did not know the name of the show. Thus she used Google image to perform a general search, hoping to find the images she want and to retrieve some particular names from there. One image with a little girl eating a big dagwood dog reminded the participant with the famous strawberry ice cream in Ekka.

After seeing the image of strawberry ice cream, the participant went back on track of finding the Ekka show images. However the results still did not provide any useful information, nor with some inspiring photos. So she decided to go back to the Ekka website (ekka.com.au) she visited earlier in this search session, and browsed the night time entertainment timetable. From there she found a car show named "Toyota V6 Hilux Heroes and Showtime FMX" and used the name for the new query but was unsuccessful to retrieve any images. Having realized the query failed from being too specific, she broaden the search to just "Ekka showtime" and subsequently add "car" back because she was focusing on the car show in Ekka. The two queries did not retrieve any relevant images but images of old cars. Thus she thought there was no recent Ekka car show images and terminated the search without full completion.

*Because I know Ekka is a place to play, it should have many photos such as games, animals, and some special shows…and like last year, I have seen the car exhibition, that sort of thing [01:55]*
*I'm looking at the entertainment at Ekka, what's on in the night time…[03:00]*
*(looking at the map of Ekka show ground) at least I know the overall arrangement…like I can go here to see the animals…where I should go to see the things I want to see [04:00]*
*(in ourbrisbane.com) OK, I've found the animal photos…and there's the games…and some historical photos which I didn't expect [05:50]*
*Did I close the timetable I just found? That timetable should say what time is the show and the name of the show [06:51]*
*For the food, I mean the free giveaway food in Ekka like milk [09:41]*
*Why is this strawberry ice cream different from the one I had last year…oh it's not from Ekka [10:18]*
*Oh this…this is the dagwood dog…and this is where to buy showbags…they are all typical Ekka [11:08]*
*Are you looking for more show photos? Because we haven't found (the photos of) the grandstand [12:05]*
*Didn't I see the timetable just then [12:16]…these photos are pretty much the same…the playground equipment [12:39]*
*So there's the timetable…I want to see if it has the program name of the show…if it does, I can search on the name [13:28]*
*(copy the whole name from the show timetable) maybe too many words [14:58]…(delete keywords to "Ekka Car showtime" only) it doesn't seem very relevant [15:38]…maybe it does not have car show this year [15:46]*

<u>Question 2</u>
Participant wants to find images of Egypt. She is planning a trip to Egypt. The images should include popular sightseeing places, things that portraits the local life there, traditional dress, famous buildings or structures, etc.

(Google Image) Egypt -> Egypt capital city -> Egypt people images -> Egypt traditional dress images -> Egypt food images

Participant began with a broad query to see the wide range of Egypt images. From the results she can see the iconic photos of Egypt such as the pyramid and the sphinx. She also found some maps of Egypt useful from which she can clearly see where the capital city is located. She further **refined her search intention on the images of the capital city** because it is then easy for her to evaluate the living standard there. Having seeing enough of the capital city images, she **changed her direction to the people in Egypt**, particularly their **traditional dresses**. The queries returned pretty promising images where the participant was able to see a range of different traditional clothes on both men and women. She changed her **focus to the food** in Egypt, and the retrieved images successfully showed many delicious Egyptian dishes. Participant was very happy with all the results as all the images she intended to find about Egypt (primarily the pyramid and traditional dresses) were retrieved with ease with useful additional information.

*I want to go to Egypt…the dessert, pyramid…these must be the sightseeing (images), sphinx…and related historical wall paintings…maps of the capital city [16:31]*
*(found a link for more history about Egypt) History…actually I don't need this, I just need the images [17:03]*
*Capital city…there it is, Cairo [19:39]…the previous maps were good, at least I know where it is located…some images of the capital city are good as well, for example…(pointing to the night views of the capital city)…you can see how the buildings there look like, and based on the buildings in the capital city, you can roughly tell the living standards there [18:12]*
*I want to see the people there…will this give me anything?...oh there is…it's their modern dresses, but like this, it's what I mean by traditional clothes [18:45]*
*(the dress) in wall paintings as well [19:49]*
*Oh, this…is this what the dress for beauty contest? [21:32]*
*What else?...let's search on food…see if it suits me well [21:56]*
*This one…is it meat?...it's looks not bad, and this one too…this one as well…[22:20]*
*For Egypt, I mainly want to see the pyramid and the dress…so it's been completed [23:33]*

<u>Question 3</u>
Participant is interested in the HTC PDA mobile. She is looking for a new PDA phone which has dictionary function.

(Google Image) htc touch diamond -> htc pda phone -> (Google Web) htc company site -> (HTC.com) (browse for product range)

Participant selected "HTC touch diamond" as initial query from the suggestion list after she typed in "htc". She knew this PDA phone but was not sure about the exact model name. Thus query term suggestion was very useful for her because she can quickly determine that it was the correct one. She was interested in the design and appearance of the phone. Some images demonstrating the functions were also considered relevant as they helped the participant to know more about the product. She then broadened her query to search for all PDA phones by HTC, and the functionality difference among different models. Participant then formed a strategy of going directly to HTC's company website to browse their products. Hence she used Google to find the link of the company website and browsed through their product range. More quality images were retrieved there which also showed the user interface of the phone. Participant was particularly happy with this result and completed the search.

*I've heard of the HTC touch diamond but I have never seen one, and I'm not sure whether it's called "diamond" in English [24:02]*
*I want to see…first its look, secondly the demonstration of its functionalities [24:19]*
*And…I'll search later because it may not only be the HTC diamond that has the PDA function [24:43]*
*So (form the images)…I know not only the diamond phone from HTC has the PDA function, there are also other models that have the same function [25:23]*
*I'm thinking if I want to see the different color (choices), I may need to go the HTC's official website, but I don't know the address, so I'll Google it [26:15]*
*(in HTC.com | products) Photo gallery…it tells me the interface…but I want to see the colors [27:45]…does it only have one color? doesn't it also have the white color [27:50]*
*(in HTC.com | all phones) All the company's products are here…so the "magic" has two colors…looks like not many choices, it seems that HTC doesn't have many color choices in their phones, either black, grey, or silver [28:19]*
*This one is Ok…HTC touch pro…although it's not the diamond, but at least it's got bigger keypads that's easier to use…if I don't have time to go in to the shops, at least I can filter out the ones that have small keypads first, just by the images [30:40]*

## Transcript for participant 30

<u>Question 1</u>
Participant wants to find the news image of the recent tsunami in Indonesia. The anticipated images can be tsunami at the beach, damage to the house, or the actual tsunami images.

The first query returned with many maps showing the region of the tsunami, which were regarded as irrelevant to participant's need. Then the participant found some interesting images of the tsunami hitting the coast line or houses. Having seen the damage of the tsunami, participant **used "wave" to modify the query to see the actual tsunami itself**. However not many results were showing relevant images to the query. Participant then **switched to advanced search to only search on news images**. One image showing a destructed house in the tsunami drawn participant attention and he followed this image to a news article which has several high quality images about the damages and casualties caused by tsunami. He then broadened his search by dropping "2009" out of the query to see more pictures of tsunami. He was focusing on images showing the tsunami hitting the coast line and some even with people running away from the scene. Overall, participant was pretty happy with the results he found and claimed the search was successfully completed.

<u>Question 2</u>
Participant wants to find images about London and France, especially some attractive locations such as Eiffel tower. He is planning for a trip there during the holidays.

(Google Image) effiel tower in London -> Eiffel tower in London -> eiffel tower in paris -> eiffel tower in paris fountain -> bottom view of the eiffel tower

Participant first **used "Eiffel" suggested by Google** to correct his spelling. He was looking for interesting pictures of Eiffel tower with people in the scene. Then he **realized that the true Eiffel tower should not be in London** and replaced "London" with "Paris". The result now became more accurate as the participant has expected. From the images, he **found there looked like a fountain in front of Eiffel tower and consequently search on the images of the fountain**. Having seen enough pictures of the fountain, the participant **creatively searched on photos taken from the bottom of Eiffel tower.** Some of the images were not showing the bottom of Eiffel tower, but the overview of the Eiffel tower and its surroundings. However participant still find these images very interesting and carefully reviewed many of them, especially one collection with people using photoshop to put some interesting objects onto the Eiffel tower.

<u>Question 3</u>
Participant wants to find the cover image of Michael Jackson's latest single album, "This is it." He has heard of the news and wants to find the image so he can import to his iTunes library.

(Google Image) "thi is it" album cover -> wiki michael Jackson -> (Google Web) wiki michael jackson -> wiki michael jackson this is it -> wiki michael jackson this is it single -> (Wikipedia.org) this is it -> (Google Image) "this is it" "michael jackson" single -> "this is it" "michael jackson" single music -> "this is it" "michael jackson" cover -> this is it album -> this is it cover -> this is it michael Jackson -> this is it michael jackson single

Participant used "this is it" as one search term because he already knew this is the album name. Right from the initial query, many images were showing the same album cover. However, the participant was not sure whether this is the correct album cover and thus broadened his search to the background information of Michael Jackson in Wikipedia. He was hoping to find a list of Michael Jackson's albums which would usually show the album cover as well. However the Wikipedia showed another image that was different from the ones from Google Image and the participant finally realized that the images from Google Image search was actually the movie's cover, not the single album cover. As the result he went back to Google image and tried various combinations of keywords to find the query that would retrieve the correct album cover. Finally the query "this is it Michael jackson single" retrieved one correct album cover, and this is the only best query that participant can get.

# Transcript for participant 31

Question 1

Russian hydro-power plant accident. The participant wants to know what happened on the site.

(Google Image) hydro-power plant, Russia, accident -> Sayano-Shushenskaya, Russian, accident

Participant has heard of this accident and wanted to follow this news up. He has seen the footage of the accident and has a vague memory of the name of the plant, but cannot spell it. He is interested in the accident site, the damages to the plant, and how and why it happened. Participant then focused on the extent of the damage and copy/paste the power plant's name into the query to perform a more specific search. He also carefully read the text descriptions of some images and found what happened to the plant. The use of the power plant's name did return more accurate and specific results, which the participant seemed to be quite happy with.

*I'm starting with the new I'm interested in…the hydro-power plant accident in Russian…heard about it about 4-6 weeks ago and I'll chase that up…so just to have a look [00:40]*
*I see a list of images and with the name of the hydro-power plant that I'm interested in [01:35]… Sayano-Shushenskaya…I don't know the name, I just find out now [01:50]*
*I've seen the footage of the Russian power plant…I think was discovery or national geography…I can't remember but I've seen it before [02:13]*
*I'm interested in finding out what exactly happened, not the exact details but what happened…and also the interest in why it happened [02:24]*
*I'm clicking on an image of a diagram…a picture of how the hydropower plant works [02:43]*
*It just confirms what I know about the power plant…it doesn't tell me what happened or why it happened [03:14]*
*That must be the power plant, because it shows the background of a power plant and a zoom-in on the hydraulics [04:15]*
*Just want to know the extent of damage [06:30]…and if possible…why it happened because hydro-power plants are fairly developed technology and it shouldn't happen…most of time is maintenance related [06:48]*
*So…I'm not sure why it happened [07:40]…this one looks like the debris and some twisted metal…and that's a turbine…far out, this thing weights 700 tons [08:06]*
*A faulty turbine…well, at least we know it's not a terrorist attack [08:49]*
*I'll use the name of the power plant just to find out exactly what happened [09:25]*
*I'm putting in the name of the power plant just to bring up more specific images and hopefully more relevant [10:11]*
*By typing in the name of the power plant, gives more specific info [12:18]*
*That's the original photo…where the damages is…all these blew up [13:03]*
*I think it's enough for me [13:45]*

Question 2

Participant wants to travel to various countries in Europe. He needs to know the famous attractions, accommodation, and transport.

(Google Image) Europe, recommended destinations -> Europe, recommended destinations, review -> Europe, must see places, -> Europe, back-pack, transport

The initial query returned with many scenery pictures of famous destinations/attractions in Europe. Before knowing which is where, the participant only clicked on the images that he thought were beautiful and interests him. Participant also judged the potential interestingness by the website domain where the image came from. He found some images with a list of recommended destinations very useful. By adding "review" to the query, he intended to find more images from traveler's perspective other than commercial descriptions. However this particular keyword did not work well so the participant changed to "must see places". There was one travel agency website that listed up packaged tours based on the length of stay and the participant found this website very useful. Participant then focused on the transportation in Europe and the buses available around (*busabout.com*).

*I'm just looking at anything that's ...pretty…basically [15:08]*
*Destination 360, looks interesting…it looks pretty but it doesn't tell me where it is [16:12]*
*(clicker on a map) At least this would help, countries of Europe [16:43]*
*I'm gonna add "review" to my search…I just want to see what people think, not just one sided website review or website description [18:48]*

<u>Question 3</u>
Participant wants to see images of iPhone, especially the physical appearance in comparison with other products. Some close-up photos showing various features of the phone would also be good.

(Google Image) iphone -> iphone, review -> iphone 3gs, review -> iphone, smart phone comparisons -> -> iphone, smart phone, photos -> iphone, physical feature -> (Apple.com.au) (browsed for iPhone functionalities) -> (Google Web) iphone, new release -> iphone, new release 2010

The initial query returned with many images of iphone but nothing specific suits participant's need, so he added "review" to the query. Participant then found a comparison chart of several smart phones but the information was dated. The **model name "3gs" was added to the query** in order to find the latest reviews on the latest iphone model. Participant later on searched the comparison between iphone and other smart phones. He also concentrated on searching for images that illustrate the physical features of iphone but no relevant results were found, so he **switched to Apple website** to look at the offical images. Finally he **shifted his interested on the rumors** of new iPhone release next year.

*I just clicked on an iphone image and it takes me to ANZ website…[34:26]*
*What's the latest? 3gs…[36:56]*
*Why don't they just take out the old ones…or just put a date on it, makes it easier to tell the latest resources [37:16]*

*This guy…looks like he's comparing different generation of iphones…but look all the same to me [37:31]*
*Can you tell me which one is the 3gs only by the look of it? [37:40]*
*I just want to see how does this phone compare with other smart phones [41:58]*
*It's good that they show the actual phone that they were comparing to [42:35]*
*I just want to see whether you can get more shots or the features of the phones, the one with the actual iphone was pretty good [47:41]*
*I want to go the Apple website to see the official images, if there's anything, they should have it there [50:47]*
*See…I want to see when is the new iphone's coming up [53:10]*
*I think I had enough [55:09]*

## Transcript for participant 32

Question 1
Participant wants to find the person who is having an affair with Taiwanese actor, 翁家明. She wants to search on this news purely out of curiosity. Images of this particular female or the couple are considered as relevant.

She discovered the name of the female form her initial Web search and used in the subsequent query.

Question 2
Participant is planning a holiday to Japan, especially around Tokyo city. She is interested in the photos of the Tokyo city, 箱根, and hot springs where she can enjoy the outdoor views of Fuji mountains.

Participant started with Google Image search and carefully reviews the images that interested her. She then found a travel agency website which provides many hot spring tours in Japan. This website is particularly useful for her search. She also found that hot springs with mountain views particularly interests her and after seeing a section with images of snow around the hot spring, she decided to search on hot springs that have snow views (used the exact term from the website). After tried several searches of snow view hot springs, the participant felt she had seen enough and switched back to the original query to continue exploring hot springs in 箱根. When browsing for the hot spring photos, participant sometimes followed images of Japanese food served in the hot spring resort, of which the participant think also important to her trip. Participant also commented that images from people's blogs can be very helpful for her search needs.

Question 3
Participant wants to find images of "Sophie le Giraffe" for infants. She heard of this product from a friend and knew this is a popular product. She wants to see the actual images of the product, how it is been used, and the stores/places that have it for sale.

Participant first used the product name to search for the images of the product. The results were very satisfying given the product name is a very precise query. Participant then switched to Web search to find more similar products and one particular website has the online boutique store for all “Sophie the Giraffe” products. Participant was very happy with this website and comment that she would come back later and browse for more similar products.

## Transcript for participant 33

<u>Question 1</u>
Participant has heard the news about recent earthquake in Indonesia, therefore he wants to see the extent of the damage, the severity of the earthquake, how the rescue operation was going, and how people were affected.

Participant started with Google Web search which led him to the Yahoo News page. Participant then **found a collection of the earthquake images and videos in Yahoo News** website which he commented as useful to his search. He then switched to Google Image search. However the images were not specifically showing the recent earthquake so he added “news” to his query. Participant **wanted to use Web search to find news articles** with images, but many articles did not come with any images. Participant likes **to follow links from well-known news website** such as Yahoo News , BBC, or CNN. In this particular search task, the strategy has been effective as most of the news websites have good collection of images on this particular news.

<u>Question 2</u>
Participant is planning to travel to Singapore. He would like to see how beautiful the city is, how is the lifestyle there, how is the weather and environment, as well as the transportation there.

Participant **started with Wikipedia** because he would like to retrieve some general information about Singapore first. This is also a habit for him when searching on a specific **domain of interest**, especially for search on countries. He then reviewed some images on Wikipedia. He used Google Web to find some information about travel in Singapore. There was one result from **Lonelyplanet.com** particularly useful as it provides well-organised/categorized information about traveling in Singapore. Participant was particularly interested in the pages that have text descriptions with images. Participant then focused on “Santosa island” in which he **found the place from browsing the attractions** in Singapore.

<u>Question 3</u>
Participant is looking for buying a new car. He would search for images of the car’s design, color, size, etc. The retrieved images should also give him a broader idea about the interior of the car, as well as some initial impression about the product.

Participant put Toyota Camry in his initial query because he has done some preliminary search and **decided to focus on the Toyota cars**. He followed a link to ***carsales.com.au***, which is a famous website he knew for selling 2$^{nd}$ hand cars. He browsed some cars within his budget. He seemed to be more concerned with the color and interior. For him, some colors are unpopular and may be difficult to resale. He used the interior images to judge the condition of the car. The **images are essential** to his search task as it would be difficult to judge a car’s condition based on textual descriptions.

# Transcript for participant 34

Question 1

Participant wants to find images of the recent flood in Taiwan. She is focusing on the damage of the village that was buried by the mudflow and landslides caused by the flood. The images of the rescue operation would also be useful.

(Google Web) 88 水災 -> (Google Web TW) 88 水災 -> 88 高雄 村莊 -> 莫拉克颱風 -> 莫拉克颱風 高雄村落 -> (Google Image TW) 莫拉克颱風 高雄村落 -> 莫拉克颱風 高雄掩埋村落 -> 莫拉克颱風救援 -> 莫拉克颱風災後重建情形

The first result showed many results from Japanese website despite participant was using Google AU, so she **decided to switch to Google TW for more localized information**. By reviewing some image of collapsed houses, she decided to focus on the little village that she heard was buried by the mudflow. Participant added "Kou-Hsung village" to her query to find reports of buried village since she **only knew that the village was in Kou-Hsung** but did not know the name. She reviewed some news pages and looked for the village name or pictures of the village being buried. However this query did not retrieve many relevant results. She then used the name of the typhoon in conjunction with "Kou-Hsung village" to search. Participant then **found the suburb's name "甲仙"** from one search result. She then switched image search and subsequently added "buried" to her query. After reviewing three pages of results, she found one image collection with many press pictures and rescue operations which the participant commented as very useful. Finally the participant exploratively tried to search the rescue operation and reconstruction status of the village, but no particular images retrieved clearly indicated the progress on this aspect.

*I want to find the images of scene of the recent flood in Taiwan [00:09]*
*How come many results were Japanese? [01:08]*
*I want to find the village was buried by the mudflow [01:43]*
*I know which village that was buried [03:10]*
*I want to change to the name of the typhoon [04:57]*
*It seems no information about the village after using the typhoon's name [06:01[*
*They seems pretty similar…most of them are the mudflow or the collapsed roads [09:02]*
*Like this one…the comparison before and after the typhoon [09:16]…it's very clear and that's what I wanted [09:28]*
*This is actually the flood…because of the mudflow in the mountain…it's all been washed [10:05]*
*This one is rather explicit…because of the collapsed house and roads [11:37]*
*This website looks pretty good…it has many pictures…like the rescue team [13:47]*
*These should be the news images from press…it's a very nice collection [14:30]*
*Actually…I think there's been less (of the news) now, because it's been a while (since the news first came out) [16:05]*
*Are you looking for the rescue operation? Like the rescue team?...(I'm looking for)*

*the rescue situation now…or the reconstruction status [17:14]*
*All (images are) about the meeting…why do I need to see you guys having meetings [18:02]*
*So I think…to date, the reconstructions haven't been finished…maybe just have cleared the mud [19:09]*

Question 2

Participant wants to go to Fiji. She needs to know the geographical location of Fiji and nearby countries. Images of tourism attractions and landscapes are also important to her search.

(Google Image TW) 斐濟地理位置 -> 斐濟群島 -> 斐濟觀光景點 -> (Google Web TW) 斐濟觀光景點 -> (Google Image TW) 斐濟小島

Participant started with the "Fiji geographical location" and retrieved a map depicting its location in relation to Australia straight after. Many scenery images were retrieved by the first query and thus participant became interested in the islands of Fiji. She used "Fiji island" as the query and found some maps of Fiji Islands very useful. Then she searched on the "tourism spots" of Fiji and **switched to Web search for more detailed information/introduction** of the tourism attractions. Finally she switched back to Image search for a quick look of the beautiful scenery on Fiji Islands.

*I want to know the geographical location of Fiji island…I think it's also in Oceania…how long would it take if departure from Australia [23:10]*
*Oh, it pretty close, just beside Australia [23:53]*
*How big it is?... seems that it has many small islands…I want to see how many islands are in Fiji [25:08]*
*I want to know the tourism spots in Fiji [26:47]*
*Oh…so beautiful…it's very different form previous result [32:45]*
*So it also have churches there…maybe many people go there to get married [38:46]*
*OK, I'm very satisfied with the results [40:48]*

Question 3

Participant is interested in the latest iPhone, including its functionalities and corresponding demonstrations. Comparisons of the old and new models are also helpful.

(Google Image TW) iphone 3g -> iphone 新一代 vs 舊一代 -> iphone 新舊比較

Participant used "iphone 3g" suggested by Google as the initial query. The results were many similar images of the appearance of iPhone 3g. Thus the participant went on to see the "new generation vs old generation" but many of the results were showing irrelevant images such as other mobile phones or laptops. She refined her query to "iphone new and old comparison" and many images now correctly showing the new and old model side-by-side.

*I can't tell the difference…maybe I need to see the comparisons [41:57]*

*What…what is this? I can't even see any iphone in the results [42:45]*
*The results seem better [43:41]…so…the new one is 3gs…but there's no difference from the look of it [44:13]*

## Transcript for participant 35

Question 1
Participant is interested in the relationship and affairs between Beckham and Victoria. She wants to find images of them attending parties, going to shopping for presents, picking up children, and maybe Beckham caught for hanging out with other women or having fights with Victoria.

(Google Web TW) Beckham Victoria fashion party -> (Google Image TW) Beckham Victoria fashion party -> Victoria Birkin bag -> Victoria Beckham -> Victoria Beckham flight estrange separate -> (Google Web TW) Victoria Beckham fight estrange separate -> Beckham scandal -> (Google Image TW) Beckham scandal

Participant used "Beckham Victoria fashion party" as the initial query because she remembered seeing some pictures of Beckham and Victoria couple attending fashion parties. She began with Web search because she **felt more comfortable to start with Web** and this is what she usually does. She is mostly interested in the images that have both of them in the scene. Participant **opened multiple windows to accelerate the search** while the pages were loading in the background. She reviewed some Web news results that have these keywords in the title. She quickly scanned through the text content while looking for the images of the couple. Many of the images in the news were photos of Victoria and lacking of the images of Beckham. Thus participant switched to Google Image TW to see the images directly.

*Because the scene I can recall was in a fashion party [00:55]…the photos also show the dress, shoes, and handbags she carried to the parties…but this is not what I want…I want the photos of both of them [02:02]*
*I hope to find the images of the couple, but it seems most of the photos are Victoria because it is natural to see girls in fashion shows [02:22]*
*For the party…I think just Victoria in the scene is enough…because my purpose was to see the dress [03:55]*

While seeing the images of the couples attending parties, she also became interested in the Victoria's dress and jewelries, such as the expensive handbag Victoria has. Thus participant also searched on "Victoria Birkin back" because she recalled a news that reported on the highly expensiveness of Victoria's handbag. The image search was spot on by returning the image of Victoria holding her silver Birkin bag. For the gossip/affair between the couple, participant first **used terms "Victoria Beckham" suggested by Google**. Surprisingly the results included many images of Victoria and their children, which suits participant's previous need of finding images of their family. Finally participant tried to find images of the couple fighting by using all keyword she can think of (i.e. "fight estrange separate"), but was unable to find from image search and subsequently switched to Web search. Web search results gave a lot of report on their fighting but did not contain any images in this regard. The participant then concluded it was difficult to have such images on the Web. Finally participant tried to find images of Beckham's affairs, but no images can be retrieved except some news reports.

*I'm interested in her Birkin bag because it was said that this bag was extremely expensive and there are diamonds on it [06:29]*
*This is the one I'm after…the silver white bag…worth 4.9 million Taiwan dollar! [07:06]*
*I now search for the scandal of the couple…(from the Google suggestion list) Ok, I'll use this first and see what it will return (select "Victoria Beckham") [07:50]*
*Their child…and the photos from their wedding although I didn't mean to search this previously [08:01]…but it also interests me when I see it because it also depicts their relationship [08:11]*
*Fight, estrange, separate…I'll use all of them, can I ? [11:21]…because I want to see all the related pictures [11:25]*
*The fighting pictures may be very difficult to find [12:12]*
*This one was unsuccessful because my search direction may be wrong... [12:43]*
*I'm more used to Web search because for the affairs…I don't think it will have pictures…if there is, it would be a really big news [14:11]*
*No…nothing particular I can find on his affairs…there's no pictures leaked [14:50]*

<u>Question 2</u>
Participant wants to search on the ski places. She needs to know which country is suitable for ski, the equipment needed, and possibly the famous tourism attractions nearby.

(Google Web TW) world famous ski places -> (Google Image TW) world famous ski places -> Korea ski tour -> (Google Web TW) Korea ski tour -> (Google Image TW) ski equipment

As usual, the participant started with Web search. The results showed many famous ski places around the world, and participant opened **up to five web pages concurrently.** Some of the images accompanied with the web pages were already satisfying for participant's need. Then she switched image search to see pictures from ski places directly. Participant also commented **image results with detailed descriptions of the ski place very useful, such as pages from travel agents** which include daily schedule and equipments needed. Many results were from Korea and hence participant went on to focus on ski tours in Korea. She was hoping to find some information about the ski tour accommodations. She then switched to Google Web for more information about the ski tour package. Finally she searched on the images of ski equipments to fulfil her search needs on this topic.

*I'll use Web search first [15:32]*
*I see Korea, winter Olympics, America, Canada, Japan, and New Zealand…[16:14]*
*Like this one, although it looks ordinary, but it has the typical ski theme and a little church in the background [16:42]*
*I'll switch to Google Image to have a look [18:25]*
*I assume this should give me some pictures of the popular ski locations, then I follow the images…if lucky, I'll get the detail description about the place [19:27]*
*For example, this one (the travel agency website) provides all the information I need*

*at once [20:25]*
*I'll focus on Korea now, because I found many ski places in Korea [22:43]*

Question 3
Participant wants to find images of wedding/engagement rings. She wants to see the various design of the rings and what brands are available.

(Google Image TW) Tiffany wedding ring -> diamond gia -> (Google Web TW) diamond gia

Participant first searched on "Tiffany wedding ring" to see what styles or designs on the famous Tiffany rings. Despite using "wedding ring" as the search term, she was also interested in the engagement rings, in fact, any kind of rings from Tiffany. She reviewed some images with the ring and Tiffany boxes, not just the ring itself. She also found other branded wedding rings interesting from other than Tiffany rings, such as Cartier and D-Side. Some **images showing the GIA certificate for diamonds drawn participant's attention** and consequently decided to search on the classification of diamond grades. She became interested in the specifications in GIA certificate and switched to Web search for more detail information. Overall, she comment **people's blog was very useful for her exploration** in seeing the variety of wedding rings and understanding the corresponding specifications.

*I know tiffany is known for its famous green-blue box, so it's very easy to tell from images [31:02]*
*Many people also put the photos of their rings, so I can easily tell which style is more popular [31:26]*
*This is what I want to find, D-Side rings [34:12]*
*If I want to buy a diamond ring, I'll also need to know about the classification of diamond qualities, like the GIA [36:46]…I just want to know what will appear…like the one sold in stores [37:01]*
*The image search results are hard to understand…I'll switch to Web search [37:16]*
*(on a website that teaches how to tell a fake GIA certificate) Like this one…yes, I've found the pictures…oh…this is really perfect, this is exactly what I want to find [38:58]*
*I found this website (verywed.com)…many people are asking about diamond rings…it's very easy because people share their experience on the website, I can simply see the pictures in their blogs…but I don' t need to do that now…I know if I want to find out more details, I can just follow the links to their blogs [39:31]*

# Transcript for participant 36

Question 1
Participant wants to find the news images of the MacLaren stroller accident in US. The stroller was reported as potentially dangerous for chopping off children's fingers. She is interested in the recall announcement and which part caused this problem.

(Google Image) maclaren recall parts -> (Google Web) maclaren recall parts ->

maclaren recall stroller's hinge mechanism -> (Google Image) maclaren recall stroller's hinge mechanism -> (Google Web) maclaren recall stroller hinge cover -> (Google News) news maclaren stroller recall -> (Google Web) news maclaren stroller recall -> (Google Image) maclaren stroller hinge dangerous -> (Google Web) maclaren stroller hinge dangerous

Participant used all nominated keywords to search for the parts that caused the accident but the image results only showed many strollers **and the photo of Maclaren's designer.** Because she did not know which part that caused the problem, she **switched to Web search and discovered that it was the hinge of the stroller** from the official recall announcement. Participant then **copied the exact term** "stroller's hinge mechanism" from the official recall announcement to search for the images of the hinge. The Web search results have some images about the hinge but were not clear enough for participant's need, so she **tried image search but the result appeared to be worse** with many irrelevant images. Then participant tried to search on the **"hinge cover" that was mentioned in the official recall** announcement as a fix to the faulty hinge.

*It shows a lot of car images…did I spell it (Maclaren) wrongly? [01:13] [KEI]*
*(switched to Google Web)*
*I'm looking at the recall notice from Maclaren's official website [02:03]…so it is the stroller hinge mechanism, I'll copy it [02:21] [TD]*
*Cover that hinge…would they have the image for it? [04:15]*

Given the unsatisfactory results in searching for the hinge cover image, participant **changed search direction to the recall news** and hope to find some news images the clearly depict the part on the stroller of the faulty hinge. Finally **one news video clip demonstrated how the hinge can amputate fingers** and participant was pretty satisfied with this particular result. She also **tried to use both Image and Web search to see if clearer and more direct results can be retrieved** by specifying the faulty hinge part, but was unable to retrieve anything as good as the video showed. Then she concluded that it might be the latest news so Web and Image content have yet to be updated.

*I'll search for the (recall) news first [06:12]*
*(clicked on news articles) No images…maybe I should focus on hinge, because every news mentioned about hinge [07:57]*
*There it is…but it's a video [08:08]*
*So…it's actually the images I've seen before [09:17]*
*I think there's none (relevant images)…maybe this is a very recent news, the image search may not have been updated yet [11:03]*
*How come they don't have images in their news (articles) [11:50]*

<u>Question 2</u>
Participant wants to find some places in Japan that are suitable for travelling with little children. The ideal places should around Tokyo and Osaka area.

(Google Web) japan 親子旅遊 -> 橫濱人形之家 -> (Google Image) 橫濱人形之家 -> 日本 hello kitty 樂園 -> (Google Web) 日本 hello kitty 樂園 -> 日本 海洋 disney -> 日本環球影城 -> 日本 親子餐廳 -> 日本旅遊 適合 小孩

Participant **began with Web search to explore the potential tourism places** in Japan for parents and children. She then **discovered the "Yokohama Doll Museum"** from a travel agency website and decided to search on this place. She copy-pasted the keyword and found someone's blog article talking about this place, however the images were not attractive enough and thus participant decided to search on other places.

*Oh, there's a travel agency website…I'll check what's there in Yokohama Doll Museum [15:38]*
*For image search, I'll review other's blog…usually it is useful to review other's blog for travel topics…but this one doesn't have many pictures…it's not good [16:17]*
*(Switched to image search) Obviously the pictures were from the blog I just saw…it seems not many people going there…so it's not worth going? [16:39]*

She **recalled the Hello Kitty Park** may be suitable for children and searched for more information on Web search. The images of **the Hello Kitty Park reminded the participant of Disney Sea and Universal Movie World**. She subsequently explored these particular places on the official websites and found many interesting activities there. She also searched on restaurants that are suitable for families and saw some pictures of children in front of the restaurant. However she discovered that some of the restaurants were not in Japan and thus paid more attentions to results with Japan big cities in their titles such as Tokyo or Odaiba. Eventually the participant broadened her search to the tours in Japan that is suitable for bringing kids along but nothing particular was found.

*I'll look for the official website [18:50]*
*What else? I'll search for Disney Sea [22:20]*
*So where is this restaurant?...hang on, it's not in Japan…Raffles City Mall…it says star nation…maybe it's in Singapore [29:07]*
*It's always about Tokyo or Disney…so theme parks are more suitable for children [32:57]*

<u>Question 3</u>
Participant wants to find some images for baby shower invitation. The target images should be some cute hand drawings that are suitable for baby girls. It would be best if the retrieved images can be import into Adobe illustrator.

(Google Image) vector baby shower -> vector baby shower girl -> (iStockPhoto.com) vector baby girl -> (Google Image) vector art baby girl invitation -> vector graphic baby -> vector graphic baby drawing -> vector graphic baby simple -> (Google Web) vector graphic free -> vector graphic -> (VectorStock.com) baby -> baby girl -> baby girl cute -> baby bird -> (Google Web) vector stock image baby bird

Participant **used image search directly because she is only interested in the appearance** of the retrieved images. She wanted to find something like the hand drawings or simple vector illustrations. She **used "vector" as the core concept term** to indicate that target images must be vector image format. The term "baby shower", "girl" and "invitation" were subsequently added to the query to refine her intention for the search. She found one image on *iStockphoto.com* was close to what she had in mind and thus searched on the website. However the website lacked the hand drawing style images that she preferred, so she went back to Google Image and added “art” and “invitation” to the query. By including “art” in the query, the participant thought it might return more results on the hand drawing images. Again the result was not satisfying enough so the participant **tried adding “graphic”, “drawing”, and “simple” to her query to best describe her need**. To this point the participant was **endeavor to find the best combination of terms** that suits her need to hand drawing style vector graphics.

*I go directly to image [34:06]…this one is pretty good, it’s cute [34:15]…it suits my criteria for the hand-drawing style…and it’s simple [34:35]*
*I want to find (specific to) girls…(add “girl” to query)…these ones are not bad, iStockphoto…but they are not really like hand drawings [35:31]*
*Can I search on this website? [35:46]*
*So you don’t need any particular “thing”? As long as it’s related to baby shower [36:39]…the drawing style should be simple lines [36:51]*
*This image collection didn’t give me much hand-drawing feeling [37:19]*
*I’ll delete “shower” and add “art”…by adding “art”, it might give me more hand-drawing styles [38:14]*
*But it’s still not very hand-drawing [38:46]*
*I think I need to describe “hand-drawing” in my query [39:43]*
*(on the 5th result page) the results now become less and less “drawing” (style) [40:49]*
*What if I add “simple”? like simple design…[41:02]*
*I feel Google (Image) is not really useful [42:08]*

Having reviewed many pages of image results without particular satisfying image, the participant deemed **Google Image not useful for her search and decided to use other strategy**. She **used Google Web to find websites with vector graphics**, as many graphic designers would utilize this kind of websites to demonstrate or sell their creations online. She then found *VectorStock.com* with many quality vector images and thus **searched on this particular website**. She **came up with several terms to describe the feelings** she required from the images, such as “cute” and “bird”. After being quite explorative on the website but without any suitable images, she went back to Google Web and searched for more vector stock website. Finally she found a useful image from one of the Web results (*shutterstock.com*) and browsed several images in the website. She was very satisfied with the images that this website provides and commented that she would search on this particular website later on.

*I’ll try to find websites for vector images first [42:16]*
*Hmm…another point is that I need “free” (images) [42:32]*
*(clicking on one free image website) I don’t want the “free” now…because it would be very limited to the “free”…it only has very limited images in the free database [43:12]*
*This bird looks pretty…I’ll search on this creator [45:37]…so I know his style [45:42]*
*(on VectorStock.com) I don’t like the database now…I’ll change to another one [46:17]*

*(on Shutterstock.com) Yes, this is what I want [47:17] ...there's the creator's name…they are really cute [47:54]*
*Ok, I decide to use this creator's illustrations [48:30]*

## Transcript for participant 37

Question 1
Participant wants to find the news image about the "China Boom". He knows the boom involves with WA and QLD state's trading with China government. He wants to know what resources does China need? What benefit can WA and QLD obtain. Images about both sides signing an agreement or some infrastructure illustrations/graphics will be relevant to the search.

(Google Image) China and Australia Economy -> Australia mining industry with China -> China and Australia mining industry

Participant first looked for some **diagrams depicting the economical trading growth** between China and Australia because he thought it is the best way to show the relationship between the two countries. However only limited images were showing diagrams and many of them are irrelevant as they did not correctly showing relationship between the two target countries. From the initial query, quite a few conference images were retrieved as well. Participant also considered images from past conferences between the two countries as relevant and reviewed many conference photos. Participant then tried to **focus on the mining industries that he knows for having strong bindings with China economy**. The results did not show any particular images that have a clear implication of mining industry with China, thus **participant reformulate the query to a simpler format** hoping to find more relevant images. The query successfully retrieved some conference images that satisfied participant's need. Interestingly, participant also found some useful diagrams from this query.

Question 2
Participant wants to travel to London. He is particularly interested in the local food, the heritage landmarks (both cultural and natural) there, and popular sightseeing and shopping destinations.

Participant used "London travel" to search on the general theme about travel attractions in London. He reviewed some maps because he also would like to know about the local transportation such as the bus and metro rail trains. He then went on to see the "cultural heritage" in London. From the results, he found one image of London tea tins with some heritage buildings very interesting and thought that it would be a good souvenir if he got a change to visit London. He also reviewed some night scene images, especially the ones that looked like around the **London Bridge.** He **came up with the idea to see the churches in London** as most of them are also well-known historical heritage. He was looking for unique churches that convey a historical feeling, such as the churches that looked like castles. Participant replaced "church" with "sightsee and tourism" to see more tourism attractions. However the results were not very precise and did not appear to be useful by using these keywords. Participant then **tried using “old building” to express his need for heritage buildings.** Some map images also drawn his attention because he thought it may be useful for his travel planning. Interestingly the simpler term “old building” appeared to be more useful than using “sightsee and tourism” in searching for the images participant wanted. He then used “shopping”, “shopping mall”, and “local food” to explore the activities in London.

<u>Question 3</u>
Participant wants to search one the iPhone market in Japan, including the place to buy, its prices, and popularity, and the functionalities to see whether it is different from here.

Participant started with “iphone in Japan” as the first trial because he expected the search might be more difficult as not many information about the Japanese using iPhones. Surprisingly the results from the initial query already showed the iPhone release in Japan with people queuing and waiting to get their first iPhone. Participant also learned from these images that iPhone was with the local carrier, “Softbank”. He reviewed some image with people dressing 和服 while using iPhones. He then tried to see the comparison between iPhone and Sharp mobiles because he knew this is the most popular phone brand in Japan. However the results only showed many Sharp products without iPhones in the images. He reformulated the query by replacing “comparison and” with “compare with” to make the query more natural language. Again, the result did not seem to improve and the participant terminated the search without total satisfaction.

## Transcript for participant 38

<u>Question 1</u>
Participant wants to find images of the Christmas in southern sphere. She has never experienced a summer Christmas and would like to see what is different from winter Christmas.

(Google News) brisbane christmas news -> brisbane christmas firework -> brisbane christmas fire work -> brisbane christmas party -> christmas party -> (Google Image) christmas party -> christmas party au -> christmas au -> (Google News) christmas au -> christmas summer -> (Naver Web) brisbane christmas -> australia christmas -> (Naver News) australia christmas -> australia brisbane Christmas -> australia christmas

Participant first **used “Brisbane Christmas” as the core concept** because she mainly wanted to see pictures of Brisbane people celebrating the Christmas. She also tried to search on “firework” and “party” but no satisfying results can be retrieved. She broaden her query to “Christmas party” and consequently switched to Image search to see if more results can be retrieved and later on added “au” to limit to Australia events. Due to the lack of relevant images, participant **switched between Image and News search back and forth to compare which search gave her the better results**. However the results were still very limited which frustrated the participant.

*I'll go to the news section [00:47]*
*I want to see about people…not tree or gift [01:04]*
*I'm looking for the celebration of Christmas [01:17]*
*(after deleting "Brisbane") Yeah…yup…yup, these (are) good [02:07]*
*Where is this…looks like America [03:26]*
*Ok, I put "au" (to find images from Australia) [03:38]*
*Just Christmas [03:52]…hmm…it's not what I thought…(switched to Google News) [04:13]*
*I'm only looking for images like crowds, parades, that sort of thing [04:36]*
*Nothing [04:58]…in Australia, they don't party on Christmas? [05:21]*

Participant then **switched to Naver**, a Korean search engine which she usually trusted more than Google, **using her initial search concept, "Brisbane Christmas**". By searching on "Australia Christmas", participant finally found the images she wanted from one travel agency's blog, promoting the summer Christmas parties on Australia's beach. Participant also tried to use Naver News to search for Christmas news in Australia. Because Naver puts **a thumbnail in front of each news result**, it was very easy for the participant to judge whether the news contains an image she wanted.

*I'll go to Naver, a Korean website [05:33]*
*Normally, I trust Naver better than Google [06:34]*
*It's not in the news…but this is exactly what I want…people celebrating in their swimsuits, bikinis [06:58]*
*It's from the blog of an education agency for Australia [07:22]*
*Going for another one…this is also from education agency…"Yonhap" means in Korean news [07:57]*
*See? Naver is better [08:51]*
*This is the news section, and for every news they put a news image there [09:40]*
*I choose "photo news" in Naver and I found these (news of) Australia beach Christmas in Sydney [11:40]*
*The photo news is very useful for people who are more interested in photo [12:23]*
*I'm satisfied with this [12:38]*

<u>Question 2</u>
Participant is planning to go to Japan next year. She needs information about accommodation and tourism attractions in Tokyo city. She is particularly interested in the place where Kattun concert will be held.

(Naver Web) tokyo kattun concert -> (Naver Blog) japan kattun concert -> japan tokyo travel -> japan tokyo accommodation -> (using Korean characters in query) travel japan -> japan tokyo travel -> japan tokyo travel accommodation -> japan tokyo accommodation -> Khaosan Tokyo accommodation -> japan travel accommodation -> kattun concert -> kattun concert 09 -> kattun concert 10 -> kattun concert 2010 -> kattun concert 2010 place -> jin concert nissay theatre -> (Naver Web) nissay theatre -> (Naver Image) nissay theatre -> (Google Image AU) 明門日生劇場 -> (Google Image JP) 明門日生劇場 -> 日生劇場

Participant started with Naver Web search because she felt more comfortable and confidence in Naver. The first query did not return any results that particularly interested the participant, so she replaced "Tokyo" with "Japan" and switched to search on Blogs. Again no useful results can be found, so the participant broadened her search to "Japan Tokyo travel". She was interested in finding the accommodation and the place for the Kattun concert and thus subsequently changed the query to "Japan Tokyo accommodation". She **focused on blog search because she thought this would be useful for her intention** and in fact, this was the way she would search on similar topics. Some people's blog list some useful links for accommodations in Japan, and the participant followed the link to find a hotel website that have many images about their guest rooms. However she later found out that these rooms were for rental and thus not suitable for her need.

*I'll probably use Naver again [12:50]*
*Why they don't have anything…I'll change to "Japan Tokyo travel" [14:29]*
*I want to find the accommodation [14:51]…and I want to find the place for the concert, which I'll find later [15:17]*
*Oh…no photo [15:43]…*
*They have a list of websites about the accommodation [16:50]…that was in people's blog…I think blog is more useful for this kind of search and actually I use blog for searching [17:10]*
*(on sakura-house.com) yeah, it's good [17:35]…how much is it per night…oh it's monthly so it's for rental [17:50]*

Having been limited by the retrieved results, participant **used Korean to search for more localized information** in blogs as Naver is a Korea based search engine. She first used "travel Japan" as the query and **gradually tried the combinations** including "Tokyo" and "accommodation" in the query. She was interested in finding youth hotel in Tokyo, such as YHA. She **found an accommodation called "Khaosan Tokyo"** closed to her need and searched on people's review about this particular place. Finally she broadened her search to "Japan travel accommodation" and found some more useful reviews of the accommodation. She then moved on to search the Kattun concert place. For the first two queries she was unable to find any useful information. After following a link to the timetable of Kattun concerts, **she realized that the concert will be held at 2010, not 2009**. Hence she gradually changed "09" to "2010 place" and successfully found the correct concert place. She then **used concert place "nissay theatre" and one of the singers' name "jin"** to find more information of the concert. At the end of her search, she searched for the images of the Nissay Theatre to complete her search.

*If I can type in Korean, maybe it's easier [18:13]…I now typed "travel japan" in blog search [19:10]*
*(in related keyword, clicked "Japan Tokyo travel" for search) [19:23]…there's one blog is about free travel to Tokyo, I'll have a look [19:32]*
*I'll add accommodation [19:58]*
*I like this kind of blog…first they said how to get there [21:21]…and what's provided and how much is it [21:37]*
*I want to stay at…kind of like youth hotel…like YHA [22:34]*
*I want to go to the official website of this hotel, Khaosan Tokyo [23:56]*
*This one is pretty nice…traditional Japanese accommodation…* tatami *[27:26]*
*This is what I thought (of accommodation images) but they don't have any*

*information on the cost [27:40]*
*About the concert place…it's very easy [28:12]*
*I don't know about the name…Katton is not famous in Korea so even they have concerts, we don't have information [29:02]*
*Oh, I put the wrong keyword, it's not 2009, it's 2010 [29:35]*
*I found this information…and the concert place's name [30:30]…I use the place "nissay theatre" to search [31:41]*
*I used to know the theatre before search, but I forgot [33:06]…and I found it during my search just then [33:14]*
*I need the images of nissay theatre, so I choose to search "all" in the search engine [33:30]*
*(looking at a floor plan image of the theatre) This is nissay theatre [33:52]*
*I'll go image search [34:42]…where's nissay…this is it, it's a very famous theatre in Japan [35:15]*
*I need the Chinese character of Nissay theatre [35:34]…and I'll go to Google because I can't find images of the (outside of ) Nissay theatre, all I found were from inside [35:58]*
*Is this one right? It looks like an old building [37:12]…maybe we try Google Japan [37:26]*
*(on Google JP Image) same…exactly same [38:00]*
*Oh…it looks like just a normal building ...for me, it's enough [39:08]*

<u>Question 3</u>
Participant likes photography and is looking to buy a DSLR. She wants to find if there is any DSLR that is compact, simple and cheap.

(Google Web) DSLR -> (Naver Web) DSLR -> (Naver Image) DSLR -> DSLR review -> DSLR review light -> DSLR review small -> DSLR review compact -> (Naver Web) DSLR review compact -> DSLR review compact light

Participant first used Google Web with **"DSLR" as the core concept** to conduct a general search. The results did not show anything particular interesting to her, so she **switched to Naver which she was more familiar with and would be able to use Korean for search**. She switched to image search and looked for small DSLRs that are suitable for women to carry. She also tried to see some images from DSLR reviews. Because she was concern about the size of the DSLR camera, she **gradually used "light", "small", and "compact" to describe her criteria**. The participant found the Panasonic G1 suitable for her need and continued to search for more by adding "light" back to her query. Finally she found the Olympus EP-1 and claimed that this was the one she had in mind before conducting this search session, she was so happy she found this camera and completed the task with satisfaction.

*(back to Naver.com) coz it's familiar for me…in Korea I always use Naver [40:17]*
*I go to image section [40:41]*
*I need small, or light (DSLR cameras) [41:10]*
*I want small ones…but they are not small [42:51]*
*I put "compact" [43:49]…oh, it's the Panasonic [44:00]*
*Oh yeah, there's another one…this is exactly what I want [46:23]*
*(looking at the images of Olympus EP-1) Oh…I really like it [46:53]...finished, I'm so happy (of the results) [47:12]*

# Transcript for participant 39

Question 1

Participant wants to find out the recent out breaking volcano in Iceland. He is interested in the location of the volcano and the area affected by the outspread ash. A map depicting such information would best suit participant's need.

(Google Image) iceland volcano ash spread -> iceland volcanic ash spread -> (**Google Image Advance** for large images) iceland volcanic ash spread -> iceland volcanic ash spread map -> iceland volcanic ash spread map Europe -> iceland volcanic ash map -> iceland volcanic ash map Europe -> (Google Web) iceland volcanic ash map Europe

After briefly reviewing the result from the initial query, participant decided to use the suggested term "volcanic" to replace the original "volcano" for better search results. He found one map of the ash spread in northern Europe very useful. Participant then focus on the maps that clearly give the idea of how the ash spread out. He then used the advance search function to limit the results to large images. After viewing some satellite images, the participant decided to add "map" and "Europe" to refine the query. However the results did not seen to improve much with most of the maps retrieved were irrelevant to the volcanic ash spread. As a result, participant deleted "spread" from the query, and subsequently decided to do a Web search for the volcano name. Right from the top the result the participant found a link to the Google map with an overlay depicting the ash spread. He was very satisfied with this result as it clearly showed what he was looking after with some nice zoom-in/zoom out and dragging interaction.

*I'm using Google.com rather than Google Australia because it's kind of a world images [00:28]*
*It gives me the "Iceland volcanic ash spread" as did you mean…I'll use that because it's suggested and I may get better results from putting in that query instead [01:01]*
*This could be what I'm looking for…I have some ideas like it would be something like a map that it would have kind of the spread in different color [01:10]…*
*I can tell it's a map of Europe, rather than something like…obviously this is the States…coz I'm not looking for pictures and that sort of things, just generally maps [01:28]*
*I might get a larger image [02:03]…(change to Large images only in advance search)…ok, cool…this image here is quite big so gives me more detail [02:25]*
*I might actually put in "map" to my query just so I can refine the search results [02:41]*
*I can't get anything like the first one…I guess it's because it's a fairly recent news [02:55]…but I thought there would be more maps [02:59]*
*Putting in "map" gives me more map results, which is good…but hasn't given anything that's related [03:22]*
*I guess I should find the name…I'm not sure of the actual name of the volcano [04:00]…I'll probably do a quick Web search [04:16]*
*Here's the big picture, cool…ok, cool, seems almost like a drag map…I know it's not*

*quite an image to that but that shows me the (ash spread area) [05:00]…that's really useful…it's a Google map that's filtered with something over the top [05:10]*
*That satisfy me [05:30]*

<u>Question 2</u>
Participant wants to find some images about the *Remarkables ski* resort in New Zealand. He went to other ski resort in New Zealand last year and is planning to go to the *Remarkables* this year. He is particularly interested in the ski run maps so he would know the overview of the resort and can make decisions by the number of beginner's runs.

(Google Image) remarkables ski run new Zealand -> remarkables ski run new Zealand map -> (Google Image Advance for large images) remarkables ski run new Zealand map -> (Google Image) remarkables ski run jumps -> remarkables ski jumps -> remarkables new Zealand ski jumps -> remarkables new Zealand ski jumps map

The initial query returned with one map of the *Remarkables* ski resort, but the quality was way below participant's expectation. He added "map" to the query and the results became much better with many maps showing the *Remarkables* ski trails. He was satisfied with the result and decided to explore the photos taken from the ski trail. He focused on people doing ski jumps and therefore deleted the term "run" as it may confuse the search results. After viewing some ski jump photos he also searched for the "map" for jump sites, but was unable to find any. Nevertheless he was quite happy with the results he got so far.

*This is finding the images of a ski run…I'm going Queens town later on in the year…I want to find what ski runs they have for beginners coz I'm not very good at ski [05:50]*
*I'm looking for a map of what there is available on this one called the "remarkables"…kind of a map of the ski slopes [06:00]*
*I went ski last year to a place nearby [06:25]*
*So that's the image there [of what I want], except that it is really bad quality [07:06]*
*I can barely make up the texts so it's not really helpful…it's good though at least it gives me some ideas [07:23]*
*I'm putting in the "map"…I look into the size of images so it gives me an idea [07:53]*
*Ok, this is perfect, that's what I'm looking for [08:10]*
*If I want to see something on the remarkables…(added "jumps" to query)…coz I know there are few jumps there [09:13]*
*So basically I'm now just looking for ski jumps [09:33]…if I'm looking for images like these, I'll open the images in new tab and keep the result (tab) open [10:01]*
*I put into "map" so I can see maybe where the ski jumps are [11:44]*

<u>Question 3</u>
Participant wants to see the inside of the new iPad. He is interested in the spacing arrangement of the mainboard and components inside. He assumed some pictures with a broken iPad may be useful too.

(Google Image) inside an iPad -> broken apart iPad -> taken apart iPad

The initial query did not return images with the whole iPad inside except some showing the A4 cpu chip. Participant then tried "broken apart" and "taken apart" to express the meaning of inside an iPad and finally found some useful images from Engaget.com. Participant stated that he knew this website well and thus believed tha they might have some images about the inside of an iPad.

*I'm interested to see what's inside an iPad…it's kind of more like a general search…I want to see what's the different components inside [12:19]*
*I'm looking for images showing an iPad broken apart and have lots of details…not smashed but just taken apart [12:32]*
*None of the images really have it…like this one only shows what the (A4) chip is but it's not really helpful [13:06]…I'm actually looking for iPad broken apart so…I'll replace "inside" with "broken apart" [13:17]*
*I'm just trying to find something which has it [13:22]…yeah…so I'm trying to think of the word…broken apart, inside…taken apart? Maybe? [13:31]*
*I'm not sure what this image is but I'll view it [13:49]…it's not very help…it looks like maybe a base of an iPad…but I can't really tell [14:01]*
*I guess I'll look at the images first…I will look at the context of the image but I just want to make sure it's the right image first [14:45]…as long as I found the right image, and then I'll probably go back to check out the text around it [14:49]*
*Oh yeah…here we go, I know engadget.com is a pretty good source [15:43]…ok, this is something I'm looking for [15:55]…here we got like a gallery down here…this is exactly what I'm looking for…I'm looking for a set of images of broken down (iPad) [16:32]*

## Transcript for participant 40

<u>Question 1</u>

(Google Image) afghanistan war people victims 2010 -> (Bing Image) afghanistan war people victims 2010 -> afghanistan war victims -> (Google Image) afghanistan war smile women -> afghanistan war women

Participant first looked for general pictures of Afghanistan war and victims there. From the initial result, many images appeared to be relevant to participant as most of them correctly showing the people in the war area. Participant also reviewed some images taken in the battlefield of the soldiers and troops. Although these images were not in participant's initial intent, he still found some of them interesting. One image of the children there smiling to the camera inspired participant and hence he decided to search on **more "positive" images such as people smiling in the war**. Participant then quickly **compared the results with Bing Image**, but the results were very different as not many images were showing victims or people there despite the term "victim" and "people" were in the query. Participant then modified his query by dropping "people" and "2010" in order to get similar results as in Google Image. The results became better but after reviewing some images, the participant decided to switch back to Google as he still thinks Google provides better results. Participant focused on the "smile" from the war, especially smile from women because he thought woman is the strongest creature in the world. However not many retrieved images were showing women smiling, so the participant broadened his search to see women images in the Afghanistan war. Overall, participant's search was around "Afghanistan war" with few modifications such as "victim", "smile", and "women" that reflected predicant's ever-changing intent.

*I think this is one of them (three children sitting in dessert who appeared to be the victims of the war) [01:40]…I'm focusing on the victims…most of them are relevant [02:12]*
*I'm more interested in people, particularly showing in Afghanistan, not only soldiers without clear background [02:48]*
*This makes me want to know how the women dress there [03:02]*
*(clicked on an image showing the battle field with a group of soldiers looking a helicopter in the sky) I want to see the situation…of the battle field [04:30]*
*I want to see their expression in their children…some of them still appear to be happy…even in very tough situation [05:14]*
*Actually I think they've become accustomed to the situation [05:26]*
*Oh…very different results [08:43]*
*They are more prone to people's faces, soldiers…in the battle field [08:55]*
*Between Google and Bing, I think Google gives me the better results [09:29]*
*(after deleting "people 2010") Yeah, there's more relevant results [10:14]*
*I'm more interested in people's expressions…like how they reveal their fear or sorrow [12:41]*
*I'll go back to Google, Google still better [12:55]*
*I know…I think that women are the strongest human…or creature [13:56]*
*Maybe I know this…very famous photo…I think the picture was taken in the area around Afghanistan and Pakistan…but not related to the war [15:21]*
*That particular image was good, but not my original intention [15:39]*

<u>Question 2</u>

(Google Image) angkorwath cambodia beautiful -> angkorwath cambodia dinner -> angkor wat cambodia dinner -> angkor wat cambodia performance -> angkor wat residence -> (Bing Image) angkor wat residence -> (Yahoo Image) angkor wat residence community -> angkor wat residence -> angkor wat people community -> angkor wat community

Participant searched on "Angkorwath" city in Cambodia with "beautiful" to describe the overall requirement. He knew this was an ancient city in Cambodia and he would like to see the images of the old building and surroundings. After reviewing several images of this deserted city, he **shifted his focus on the "dinner" place** there because he heard that there was a stage for dancing performance during dinnertime. Due to the irrelevant results showing on the first result page, he **used the term "Angkor Wat" suggested by Google** to find more images. The participant then replaced "dinner" with "performance" to see more images of dancing performance yet no images can be retrieved. Participant then **shifted his interest to local residence**, such as their lifestyle or people's dress. However, most of the results still showed the landscape of the city building, even after **switching to Bing Image or Yahoo Image**. He **tried several combinations of "residence", "community", and "people" by using "Angkor Wat" as the core concept**, however the results did not appear to improve and finally the participant had to terminate the search without satisfaction.

*This is the ancient city [20:26]...people said it's a heritage and lost city because it's been found after hundreds of years which people didn't know the existence of the city [20:54]*
*The building itself in the image interested me most…these (images) are from the same building but different angles [23:15]*
*This is the temple…actually, not temple, this is a city in south Asia [23:52]*
*Where is this…it's very beautiful, with the jungle and river around the city [24:30]*
*You don't seem to read the captions of the images…you just look at the image itself? Yes [26:18]*
*I still can't see this place from above…there's a big tree that you can see from the city above [26:55]…but there's no tree [27:03]…I've seen the pictures before, there's a big tree [27:18]*
*I imagined that because the city's in the jungle, there should be many trees around the city [27:38]…*

<u>Question 3</u>

(Google Web) ebook reader reviews -> (Google Image) ebook reader reviews -> I rex digital reader -> (Google Image Advance – Large images) I rex digital reader -> noble nook e-book reader

Participant started with Web search to see what are the models that are currently available on the market and to pick one that he would like to focus on. He then switched to image search to see the appearance of a particular e-reader. After reviewing the images of "I rex digital reader", the participant also went on to search for"nooble nook", the reader he knew before.

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