Information Seeking and Mediated Searching. Part 5. User–Intermediary Interaction

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This article is the fifth in a series of articles from our study examining information-seeking behavior in relation to information-retrieval (IR) interaction. This article focuses on the examination of the interaction variables within Saracevic's (1989) triadic IR model. The analysis involved an examination of the information-searching behavior of academic researchers during a mediated interaction with an IR system, particularly concentrating on the interaction between the information seeker, the search intermediary, and the IR system. To explore the variables during mediated search interaction, two small-scale studies of mediated on-line searching were conducted at the University of Sheffield. The studies involved mainly qualitative data analysis of interview transcripts and on-line search results, together with quantitative data analysis of questionnaire results. The studies specifically investigated: (1) aspects of the mediated search process, (2) relevant information sources, and (3) interaction measures derived from search logs and tape transcripts, and related interaction measures. Findings include: (1) a number of different types of interactions were identified, (2) the presearching interactions between information seeker and intermediary aided the information seeker to identify their idea and problem, and (3) most information seekers in this study were at the problem definition stage or problem resolution stage following the search process. From this research, it is clear that the interaction did affect the search process. The intermediary helped the users to identify their search terms more clearly and focus on the references obtained. In most cases, the users and intermediary considered the communication process very effective, and the interactions that took place during the on-line search were found to affect the users' perceptions of the problem, personal knowledge, and relevance judgments. The interaction process aided the users to obtain very useful results with help from the intermediary. In general, the users gave a positive evaluation of the retrieved answers in terms of focus, completeness, novelty, and degree of nonrelevancy.

Introduction

The studies reported in this article arose from research undertaken by the Department of Information Studies, University of Sheffield, in collaboration with Dr. Amanda Spink from the United States, refered to as the Uncertainty in Information Seeking or UNIS project and the National Science Foundation (NSF) Successive Searching project in the United States. This collaborative project created a database of 198 mediated searching case studies, including interview transcripts, search logs, and questionnaire data. This article reports results from two analyses of the data set to explore the interaction between the information seekers and the search intermediary conducting the on-line search.

The collaborative study's theoretical background arises from work by the collaborators to intersect information seeking and IR models. Currently, several models of information-seeking behavior have appeared, including Wilson's (1981, 1997, 1999) model of information-seeking behavior, Ellis (1989), and Ellis, Cox, and Hall's (1993) behavioral model of the search process, Kuhlthau's (1991) model of the stages of information-seeking behavior, and Dervin's "sense-making" model (1983, 1992). Following Kuhlthau

(1993), Kuhlthau, Spink and Cool (1992), and Saracevic, Kantor, Chamis, and Trivison (1988), information seeking is described as behavior, including questions and dialogue, and situations, including social and cognitive, associated with a user's interaction with an IR system. Beaulieu (2000) also suggests that even though interaction between searchers and information sources is part of an information-seeking process, the concept of interaction is closely associated with how users interact with IR systems.

Previous research has explored aspects of the interaction between the user and the intermediary, the intermediary and the system, and the user and system (Saracevic, 1989; Vickery & Vickery, 1987). Saracevic (1996) argued that many interactions are at work in the IR process, many of which are not well understood. Saracevic suggests that the traditional IR model does not account for this complexity of interactions between users, search intermediaries, and retrieval texts. He proposed a triadic model for understanding the interactions in the IR process (Saracevic, 1989). This model is used as the basis for this study.

The study reported in this article will not attempt to analyze and explore all aspects of IR interactions, but will concentrate on examining the interaction variables highlighted by Saracevic (1989). Saracevic's triadic model illustrates the importance of interaction in IR processes, and also points out that any number of interactions may be at work in IR processes. Saracevic, Mokros, and Su (1990) assert that most studies in information science concentrate on discourse in user–intermediary interactions prior to the search. This study will employ the triadic model of user–intermediary–computer interaction rather than the more conventional dyadic model. Saracevic's (1989) triadic model (shown in Fig. 1) illustrates the importance of these interactions in the IR process process.

Related Studies

Academic Information Seeking

IR is embedded in a user's information-seeking behavior. Ellis (1989) explored the patterns of academic information-seeking behavior. Ellis (1989) makes no claims to the effect that the different behaviors constitute information-seeking stages. He uses the term of "features" rather than "stages." The features of model include starting, chaining, browsing differentiating, monitoring, and extracting. According to
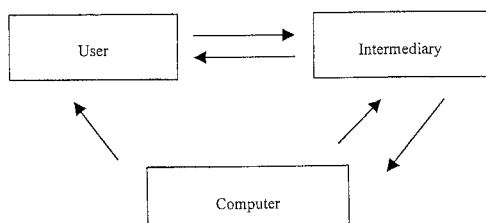

FIG. 1.   Triadic model of interaction in information retrieval.

Ellis (1989), the six features of the model together represent the major generic characteristics of the social scientists individual information-seeking patterns, and any individual pattern can be described in terms of the features of the model. The model was subsequently refined to include the categories or subcategories of verifying and ending following studies of academic researchers in the sciences (Ellis et al., 1993).

IR Research

Systems-centered approach

The relationship between information-seeking behavior and IR is obviously a close one: the use of IR systems is one possible strategy in the information-seeking process. Consequently, it constitutes a potential substage in the information-seeking process. The system-centered approach to IR has the longest history in IR research. This approach to IR has grown out of the problem of searching and retrieving relevant documents from IR. Algorithms for automatic IR functions such as indexing, output ranking, and abstracting have been developed along two separate directions: statistical methods and linguistic methods. Statistical methods seek to establish a set of index terms for document through world-frequency counts (Chowdhury, 1999; Ellis, 1996). Linguistic methods use syntactic or semantic parsing of the document text to extract highly descriptive terms or phrases. Linguistic methods represent a more recent development in the application of algorithms for IR (Chowdhury, 1999; Ellis, 1996).

User-centered approach

In the past two decades, a second research approach has developed in IR: that of users and intermediaries interacting with IR systems. For users and intermediaries, the problem of finding useful documents from an IR system consists of. forming an understanding of a user's problem; and translating that understanding into a query to be presented to the information system. Ingwersen (1992) has referred to the new research approach as representing the "cognitive viewpoint" in information science. The cognitive viewpoint is the natural extension of a concern with the quality of human interaction with IR systems. The cognitive viewpoint assumes that cognitive processes are ubiquitous in IR.

Ingwersen (1992) argues that IR is concerned with the processes involved in the representation, storage, searching, and finding of information that is relevant to a requirement for information desired by a human user. He also explains that IR interaction is the interactive communication processes that occur during the retrieval of information by involving all the major participants. The major participants are the user, the intermediary, and the IR system. Ingwersen presents a high-level cognitive model of IR where the different components. That is, that the user, the information documents or objects and the system are perceived as cog-

Elements in IR Behaviour	Data Type
Pre-information searching behaviour	
1. User has a problem or goal which needs to be solved	User's situation User's goal
2. User's information behaviour arises from recognition of inadequate state of knowledge	User's characteristics User's knowledge
3. User seeks to resolve ASK by searching for information in system	User's problem Statement and User's expectations
Information searching behaviour	
4. "Pre-search" interaction with e.g. human or computer intermediary	User question/request Intermediary's Characteristics
5. "Pre-search" formulation of search strategy/source-selection/query	User/intermediary Interaction Query statement(s)
6. Searching activity	User/intermediary/system interaction
7. Initial evaluation of results	User/intermediary Assessment
8. Reformulation of problem/ info. Problem/ request/ query/ strategy	User/intermediary/ Interaction
Post-information searching behaviour	
9. Evaluation of retrieved text(s) (if any) by user	User satisfaction
10. Use of information	User satisfaction User's goals

FIG. 2. Categorization of information retrieval elements.

nitive structures, and interaction between these is defined in terms of processes of cognition.

Ingwersen (1988) outlines various types of the representative data the user-oriented research encounters in IR investigations. Figure 2 differs from the original by Belkin and Vickery (1985) by categorization of the 10 elements into preinformation searching, information searching, and postinformation searching behavior while the arrows are added to demonstrate the recycling possibilities of the elements within each category.

Saracevic (1996) notes several other factors that affect the interaction process including context. Context may be thought of as the situation, that motivates a user, seeks information. Saracevic points out the fact that there is no agreed upon theoretical framework for the study of on-line interactions. He also emphasizes the importance of having a model to base research on. Saracevic (1996) categorizes five main objectives that an interactive model should include: (1) enumeration of and distinction between different kinds of interactive processes in IR; (2) enumeration of major classes of variables in interaction; (3) relation to models of human–computer interaction; (4) applicability in evaluation of interactive IR; and (5) testability in a scientific sense.

User–Intermediary Interaction

The study of user–intermediary interaction has received considerable attention in the information science literature (Saracevic, 1989, 1996, Saracevic et al., 1990; Spink, 1993; Spink & Saracevic, 1997). The importance of the interaction between user and intermediary as a means to make effective IR possible is clear. During the pre-on-line search interaction, users and intermediaries develop models of each other and share understandings of user problems and goals, and of appropriate information system responses.

Spink (1992, Spink and Saracevic (1997) proposed a model of the search process that identifies user judgments, search tactics or moves, interactive feedback loops, and cycles as constituting the search process of a person in interaction with an IR system. Spink further states that much of the research on user–intermediary interactions only focus on specific techniques, such as neutral questioning, that might better facilitate communication between users and intermediary in the elicitation of users problems and goals. User judgments, search tactics, and interactive feedback loops link IR interaction with information-seeking behavior in general. The key elements of the interaction are the iterative cycles and feedback loops within the searching process.

Bates (1990) also argues for an IR model as an inherently interactive process, through which users progressively refine and reformulate their information problems as they interact with information resources. As Bates (1990) further points out, there is a need for research that investigates the role of the user's information-seeking process within the context of user–intermediary and user system interaction. Mokros, Mullins, and Saracevic (1995) identified two stages of search interaction. First, the presearch interview where there is clarification of the user's query, identification of databases, and translation and formulation of the search statement. Second, the on-line computerized search that includes evaluation of the information obtained.

Spink and Saracevic (1997) proposed that the selection of search terms is one of the key objectives and processes in IR interaction. Their studies have included analysis of the interaction between the user and intermediary before and during on-line searching and the interaction between the user and intermediary on one side and the IR system on the other (Saracevic, 1989, 1996; Saracevic et al., 1988; Spink, 1992, 1993, 1995; Spink & Losee, 1996; Spink & Saracevic, 1997). Their conclusions are that the selection of search terms for a question and the construction of queries is a highly interactive process, and that the selection of search terms is an important part of the interaction process.

All of the information-searching models are concerned with how searchers interact with IR systems and each of them represents user interaction at different levels of abstraction. At a lower level, Belkin illustrates different strategies for finding information, at a higher level; Ingwersen defines searching in terms of cognitive transformations. Spink points out the more procedural aspect of the searching process, while Saracevic demarcates the component parts involved. All in all, they provide complementary multiple views of a complex and highly dynamic process (Beaulieu, 2000).

Discourse during Mediated IR

IR interaction behavior has been studied extensively and research has been extended to investigations of IR interaction to encompass end-users, intermediaries, and the on-line system (Blackshaw & Fishhoff, 1988). The most profound

empirical study of the triangular human–human-computerized IR system interaction has been in progress in the United States since 1988, performed by Saracevic and Su (1989). Their aim is to contribute to the formal characterization and better understanding of elements involved in information seeking and retrieving, particularly in relation to the cognitive context and human decisions and interactions in these processes. The objectives are to (1) observe and classify the elements in interactions between users, intermediary searchers, and computer in the context of on-line searching in libraries, and (2) observe the effects of different types of interactions on search results as judged by users (Saracevic, 1989).

Saracevic (1996) observed that IR systems emerged in the 1950s and 1960s as static, batch processing systems then in the 1970s due to a combination of computer and communication technologies, access to IR systems became dynamic and interactive. As a result, Saracevic proposed that interaction became the most important feature of IR, but that the IR interaction processes were incompletely understood (Saracevic, 1996). Ingwersen (1992) defined IR interaction as consisting of the interactive communication processes that occur during the retrieval of information involving the user, the intermediary, and the IR system. Saracevic points out that most of the research and development in IR has concentrated on the improvement of effectiveness in automatic representation and searching, and has treated IR systems and processes as static and noninteractive (Spink & Saracevic, 1997), and, that although, research in IR has been ongoing for over 30 years, research on the interactive aspects of IR has not reached maturity (Spink & Saracevic, 1997). According to Saracevic, traditional IR models imply interactions but do not address them directly (Saracevic, 1996). The traditional model consists of two sets—the system and the user; it allows straightforward isolation of variables, but interactions are not directly depicted; when human–computer interactions (HCI) are included, the complexity of the model increases (Saracevic, 1996).

Saracevic, Mokros, and Su (1990) carried out comprehensive empirical studies of the triangular model of the human–human-computerized IR system. The stratified interaction model considers interaction as a process involving the two sets: user and system. With both sets a number of levels of interaction have been identified. On the surface level users carry out dialogue by utterances and responses through interface with the system. At this level, the intermediary uses knowledge of the system. On the cognitive level users interact with texts and intermediaries clarify aspects of user modelling. On the situation level users interact with a given situation that leads from an information need to a result. The deeper level changes during interaction can alter the surface level, and new search terms may be used. Thus, there is a direct interplay between deeper and surface levels (Saracevic, 1996). The interaction process is realised and manifested on the surface level; the effectiveness of the search terms and user judgements is

established at the cognitive/situation levels (Spink & Saracevic, 1997).

IR interaction consists of a series of dynamic interplays and adaptations between levels. As the interaction progresses things change. For instance, on the surface level a query may be changed, terms added or deleted, different tactics employed, reflecting and affecting changes at other levels. In addition, interaction can also treated as interplay between different user and computers strata or levels realized on the surface level through the interface. On the user side, it can model surface, cognitive, affective, and situational levels. On the "computer" side it can also model levels: surface, engineering, processing, and content (Saracevic, 1997).

Saracevic et al. (1990) suggests the categories for the discourse analysis of the user–intermediary interactions as being :

(1) *Context*—user's problem or task at hand; information-seeking stage; information.
(2) *Terminology*— restrictions elaboration on and modification of concepts, terms, keywords, and descriptors; generation of terms; specification of borderlines; restrictions such as with respect to language, technical term, spelling.
(3) *Systems explanations*—workings and technical aspects of system used and technical explanation of searching; characteristics of databases and documents in system.
(4) *Search tactics*—selection and variation of terms, fields, morphology, logic in search statements; commands; selection, and variation.
(5) *Review and relevance*—review of search statements with respect to the output; evaluation of output sources or content; relevance judgments of and feedback from outputs.
(6) *Action*— description of an ongoing or impending activity.
(7) *Prompts and pauses*—communication prompts fillers, acknowledgments, formulaic expressions, etc., indicating listeners involvement, for example, "O.K.," "Wow!," "Uhhuh," "Right."
(8) *Extraneous*—utterances extraneous to the search interaction.

In addition, Saracevic et al. (1990) also suggest the categories for the search analysis in intermediary–computer interactions. They are:

(1) *File*—logon or logoff, database selection;
(2) *Terminology*—selection of terms;
(3) *Restriction*—language, year limitations;
(4) *Explanation and review*—review of command, results;
(5) *Answers*—displaying results, choosing format or range; and
(6) *Idle*— no computer activity.

As Saracevic (1997) points out, the utterance is a basic unit of discourse analysis in user–intermediary interaction. It also a basic unit in user modeling as a first step in deriving

a set of categories. Saracevic suggests a stratified model of IR interaction as a framework for user modeling. The categories defined can be mapped into the suggested user and computer strata or levels in the interaction model. Saracevic argues the categories actually represent interplays between different user and "computer" levels. The categories "terminology" and "restrictions" are realized on the surface level. However, the content level in texts also influences it. Moreover, the categories system "explanation" and "action" relate the cognitive level of the user with any level on computer side. "Search tactics" relate any user levels with the "processing" computer level. "Back channeling" helps the whole interplay process. The categories by and large characterize the interplay between levels in the interaction process.

Saracevic et al. (1990) continued studies on IR interactions the main aim being to come to develop a formal characterization and better understanding of elements and processes involved in information seeking, searching, and retrieving, particularly in relation to the cognitive context and human decisions and interactions involved (Saracevic et al., 1990). In this research three stages of interactions were identified: (1) the opening gambit at the beginning of the on-line search where, in the vast majority of cases, the intermediary governs the interaction working with the users problem and converting it into a search lexicon; (2) tactical maneuvring that involves specification of terminology and searching and display of results; and, (3) finally, the closing downdrift with increasing focus on output and relevance feedback (Saracevic et al., 1990). This research concluded that that the interaction process is driven by a terminological determinant, as it was discovered during the research that most topics of the discourse are concerned with the terminology of searching, actual search words, and their combinations (Saracevic et al., 1990).

Saracevic, Mokros, Su, and Spink (1991) identified three types of responses made by the user when reviewing the results. They are monochromatic passive, monochromatic active, and polychromatic. Monochromatic passive is characterized by approval of individual items; monochromatic active included comments made on the bigger picture and polychromatic emphasized nonrelevance. Relevance judgments are used to enhance further retrieval of relevant answers. This is termed relevance feedback, as another form of feedback involved in the interaction process is magnitude feedback. Magnitude refers to the sheer size of the output of the posting display. Saracevic identifies three tactics employed in magnitude feedback. Sampling a display of contents, a complete display of contents, and nondisplay with tactical change in the search due to the large output. To reduce the output the intermediary used a variety of devices such as use of the not operator and the removal of duplicates.

Saracevic's research has subsequently been extended by many, including, prominently, Spink (1993; Spink & Goodrum, 1996; Spink, Goodrum, & Robins, 1998). Spink (1993) analyzed the types of feedback that can occur during the interaction process. She suggests that feedback in IR is regarded as a primitive concept based on the assumption that the meaning and use of the concept is widely understood (Spink, 1993). However, in Spink's study (1993), feedback was revealed to be a multifaceted phenomena. Five types of feedback were identified but magnitude and relevance feedback predominated. Interestingly, actual search tactics were more affected by the size of the output, the magnitude, which was generally followed by reductionist tactics to bring down the size of the output (Spink, 1993). Term relevance feedback was also identified in some interactions. Strategy concerns were exemplified by tactical review and terminological review feedback that occurred infrequently (Spink, 1993).

Later research by Spink et al. (1998) went on to study the elicitations or requests for information from the search intermediary to the user during IR interaction. The objective of this study was to help in the development and application of a dialogue-based model of IR interaction. Its premise was that there is a need for research into both user and intermediary elicitations to provide a more complex picture (Spink et al., 1998). Therefore, it concentrates on search intermediary elicitations during presearch and on-line stages. The definition of an elicitation used was that of a verbal request for information (Spink et al., 1998). It revealed that most elicitations during on-line search interactions relate to search terminology and search procedures by the user and search intermediary.

Spink (1996) carried out further research into the use of working notes during on-line searching to facilitate interaction with IR systems and to translate the user's problem. Due to the complex process that takes place between humans and the IR system, the creation of a record of the search output was found to be useful. It states that this is an important aspect of the human–IR interaction requiring further research. They also suggest the inclusion of an IR whiteboard in IR system design to store search terms, set numbers, results, and working notes as the search progresses. Spink et al. (1998) argue that the study of elicitation interactions should help in the design of IR systems. Systems should be designed for the user to elicit information on databases, terms, and give assistance in relevance judgements.

Research Questions

To explore these issues in more depth two studies of the mediated search interaction processes were carried out at the University of Sheffield (Burton, 1999; Lam, 2000). Twenty-five researchers were studied in two separate groups. The goal of the studies was to study the different types of interactions that take place during the information search and retrieval process.

Research Design

Data Collection

The two studies involved mainly qualitative data analysis of interview transcripts and on-line results together with quantitative data analysis questionnaire results. The 25 information seekers studied were at different stages of the information search process. Determining keywords, search strategies, and review and relevance were found to be the driving forces behind the on-line search interaction. In these studies qualitative analysis was used to derive interaction measure from the logs and tape transcripts, quantitative analysis involved assigning numerical values to questionnaire variables, and to determining comparable results between the clients.

Variables Analyzed

Saracevic (1989) suggests two specific aspects to studies of the information search process, the (a) effectiveness of the interaction process itself, and (b) effectiveness of the retrieved answers.

These aspects were analyzed in these studies. The following variables were chosen to analyze the effectiveness of the interaction process in the questionnaires:

(1) Effectiveness of communication: (a) explanation from user to intermediary; (b) explanation from intermediary to user about the system; (c) comprehension by user about the system; (d) comprehension by searcher about the search problem; and (e) nonverbal communication influences.
(2) Changes due to search interaction: (a) perception of the problem; (b) question; (c) personal knowledge; (d) relevance judgment.

In analyzing the effectiveness of the retrieved answers, some variables were chosen to ask in the questionnaire: (a) worth in time; (b) time and difficulty in evaluation; (c) focus and comprehensiveness of retrieved information; (d) contribution to the resolution of the problem; (e) problem stage; (f) uncertainty; (g) expectancy, novelty, serendipity; and (h) overall satisfaction.

In these studies, qualitative findings were presented with quantitative data. The follow-up interview results were also used with the questionnaire results. The questions in the follow-up interview about the interaction were compared with the answers gained from the postsearch questionnaires. The overall search process result was analyzed, and includes the overall satisfaction with the results and the changes made to the problem-solving stage.

Procedures

All users provided full descriptions of the search problems during the reference interview. In the reference interview, clients were asked: "What stage are you at in terms of

TABLE 1. Discourse analysis results.

	Burton (1999)	Lam (2000)
Review and relevance	21.5%	21%
Search tactics and procedures	21.6%	20%
Backchanneling	15.2%	15%
Terminology and restrictions	13.8%	14%
System explanation	11.8%	13%
Action	6.7%	7%
Context	4.7%	4%
Extraneous	4.4%	6%
Total	100%	100%

defining or resolving the problem, or in presenting the answer?" and given a list of problem solving stages with definitions. The intermediary helped the clients to define the search problem to establish a stage. Over half of the users defined themselves as being at the problem definition stage or problem resolution stage. A quarter of the clients located themselves in the problem definition stage.

The purpose of the search was to identify a real problem and define their search problem more closely. The remainder was divided roughly evenly between the problem definition stage and problem resolution stage, or between the problem resolution stage and solution statement stage.

Unit of Analysis

The utterance is a basic unit of discourse analysis in user–intermediary interaction. The main utterances between the user and intermediary were identified as review and relevance. These utterances present possible changes in what is going on in searches, outputs, and their relation. The results of the discourse analysis of the search utterances are shown in Table 1. Review and Relevance and Search Tactics and Procedures are the largest categories. In other words, users get and exchange a lot of information about the immediate process concerned with the search itself. In contrast, context that covers the context of the question and user comprised only around 4–5% of all utterances.

Results

Table 1 provides the discourse analysis results.

In Burton's study, utterances about prompts and pauses were identified regularly. Prompts by both the user and intermediary indicated how the search was progressing. These are known as back-channels. Back-channeling is the third highest category in Lam's study. According to Saracevic et al. (1991), back-channeling consists of brief utterances that facilitate communication, indicate active participation, echoing questions, and the like. Ingwersen (1992) explains that these pauses are inescapable especially when users are looking through texts. Back-channeling seems to play a significant role in interaction. In this respect, back-channeling represents a unique human device and tactic that speeds communication and increases mutual under-

standing. Maybe communication with computers is limited and unsatisfactory because it does not involve this important human communication element.

Terminology and restrictions utterances were identified frequently. This involves elaboration on and modification of concepts, the search terms inputted and refining the results to specific years, technical terms, and languages as the user required. This category also included reducing the number of duplicated references that happened at regular intervals during the searches. The system explanation category was also identified frequently. This involves the user asking questions about Dialog system's characteristics. It also refers to the intermediary explaining the capabilities of the system and why certain databases were chosen. Action and extraneous utterances had a relatively low distribution in compare with the other categories. Action categories include a description of an ongoing or impending activity such as thesaurus lookup, output formats, printing, and typing.

Utterances extraneous to the search interaction included greetings, formulaic courtesies, social comments, and questions. Utterances about the context of the search problem were the lowest category. This included user's problem or task at hand, information-seeking stage, conversation about information collected so far, expectations, and aspects of the question. This took place usually at the outset of the search. During the search process itself the user and intermediary seemed to be more concerned with selecting suitable search terms and reviewing the results, while the highest commands to the computer concerned the input of terms and sets.

Most of the utterances were about terminology. The answer is the second largest category; this involved displaying the answers, specifically the range of references and selecting the format. Explanation and review is the third highest category, this involved reviewing the saving commands at frequent intervals and search sets inputted. The use of restrictions, file selections, and idle period comprise the other three categories. They occur relatively less frequently during the on-line searches. The use of restrictions refers to language and years. A file utterance refers to file selections, and that happened mainly at the beginning of the searches when Dialog was logged on and databases were selected. The idle periods occurred when the text on screen was being read (see Table 2).

Saracevic (1990) points out three main stages of interaction during the on-line search process. They are: the opening gambit where the intermediary works with the search problem to produce search sets; tactical maneuvering involves selecting terminology, displaying, and searching results and; the final stage is the closing down drift with a focus on the output and relevance judgments. Comparing the discourse and search category results, the frequencies of main discourse and search categories correspond to each other. The main utterance for the discourse analysis and the search analysis were review and relevance and terminology input, respectively. In summary, the main activities during

TABLE 2. Search analysis results.

	Burton (1999)	Lam (2000)
Terminology	43.1%	40%
Answer	26.3%	28%
Explanation and review	17.8%	18%
File	5%	5%
Restriction	3.9%	5%
Idle	3.7%	3%
Total	100%	100%

the on-line search were inputting the search terms, examining the records, and altering the search strategy.

A follow-up interview was normally conducted a minimum of 2 months after the search. The clients were asked to rate their participation and interaction in the on-line search in relation to its worth in relation to their time. The clients were also asked about difficulty in evaluation, focus, or targeting, completeness of retrieval, contribution to resolution, expectancy, novelty, serendipity, and overall satisfaction. In the postsearch questionnaire, various questions were asked in relation to communication process and about the changes made to the search process in relating the interaction with the intermediary. The clients were asked their opinion of the utility of the search, in terms of its "worth in relation to your time," the difficulty in evaluation, the amount of extraneous or nonrelevant information, and distraction caused by it. Only a small minority of the clients found that they were obtained relatively high nonrelevant information, while the vast majority of the users were satisfied with the relevant information of the search results, even where there was a high proportion of nonrelevant material this did not seem to be a major distraction or problem—as one searcher stated, although "about half the material included was not relevant but it was easy to eliminate (see Table 3)."

The overall results scored a high mark; the vast majority of the clients were satisfied with the retrieved answers. Although the searches were perceived as relatively low in novelty and serendipity, around 60% of the clients indicated that their problem solving had not changed after the search. and only around 40%, who were in the early stages at the time of the search, were in later stage at the time of the follow-up.

Discussion

Spink and Saracevic's (1997) studies analyzed real-life interactions with real users interacting with professional

TABLE 3. Search worth in relation to clients' time.

	Burton (1999)	Lam (2000)
Worth much more	40%	13%
Worth somewhat more	30%	40%
Equal to	20%	40%
Less than	10%	7%
Practically useless	0	0
Total	100%	100%

intermediaries. Their conclusions were that the selection of search terms was an important part of the interaction process, and that the selection of search terms for a question and the construction of queries are themselves highly interactive processes. The present studies are very similar in form to Spink and Saracevic's in that in these studies the data consists of records of interactions with real users interacting with a professional. The findings of the studies support those of Spink and Saracevic (1992) reinforcing the point that the selection of search terms is one of the most important aspects of the interaction process, and that this aspect of the process itself is a highly interactive one.

The main utterances between the user and the intermediary were identified as review and relevance and search tactics. This comprises review of the search tactics due to relevance judgements that are made by the user on the output of the search. Three kinds of responses were made by the users when reviewing the results monochromatic passive characterized by approval of individual items, monochromatic active that includes comments made on the bigger picture, and polychromatic, which emphasises nonrelevance. In the discourse analysis, one of the predominant utterances concerned reviews of the results that resulted in relevance feedback and magnitude feedback. These types of utterances play a significant role during the interaction process between the user and intermediary.

Utterances about search tactics and procedures produced almost equal results to the review and relevance category. These two categories accounted for almost a half of the conversations between user and intermediary. This category involves discussions about the search tactics, explanation of the terms, and commands used in the discourse analysis; one of the predominant utterances concerned reviews of the results that resulted in relevance feedback and magnitude feedback, this in line with the results of the studies of Saracevic, Mokros, Su, and Spink (1991).

The results from the discourse analysis demonstrate that many elicitations during the on-line search interaction relate to search terminology and search procedures. Utterances about prompts and pauses were also identified regularly. Prompts by both the user and intermediary indicated how the search was progressing. Terminology and restrictions utterances occurred with similar frequency as prompts and pauses. These two categories make up nearly a third of the total conversation. This involved elaboration on the search terms inputted and refining the results to specific years and languages as the user requested. This category also included reducing the number of duplicated references, which happened at regular intervals during the search. The systems explanation category was identified frequently. This involved the user asking questions about the dialog systems characteristics and the intermediary explaining the capabilities of the system and why certain databases were chosen and explaining document features.

Utterances about the context of the search problem occurred infrequently, usually only at the outset of the on-line search. This included conversation about information collected so far, expectations, and aspects about the question. As the search progressed, the user and intermediary seemed more concerned with selecting appropriate search terms and reviewing the results. Only occasionally did they relate these utterances to the overall search problem/statement. Action and extraneous utterances had relatively low counts when compared to the other categories. Action categories include a description of ongoing or impending activity, undertaking activity—thesaurus lookup, typing, printing. Utterances extraneous to the search interaction included courtesies.

By far the highest commands to the computer concerned the input of terms and sets; almost half of the utterances were about this category. The next most frequent responses from the computer concerned the category of answers. This involved displaying the answers, selecting the format, and specific range of references to be examined. The utterances consisted of search commands to the computer and responses in the form of results. The use of restrictions, file selections, and idle periods occurred infrequently during the on-line searches. File utterances concerning file selections happened mainly at the start of the searches when dialog was logged onto and databases were selected. The use of restrictions as to language, and years varied due to the specific search problem. Idle periods occurred when the text on screen was being read.

The main utterances for the discourse and the search analysis concerned search tactics and terminology be review and relevance that relates to the display of answers, and explanation and review computer commands; this, again, is in line with the findings of Saracevic et al. (1988). Utterances about search tactics and procedures produced almost equal results to the review and relevance category. These two categories accounted for almost half of the conversation between user and intermediary. This category involves discussions about the search tactics, explanation of the terms, and commands used. Back-channelling is the third highest category. These are brief utterances that facilitate communication, indicate active participation, echoing question, and the like. It seems to play a significant role in interaction. Back-channelling represents a unique human device and tactic that speeds communication and increases mutual understanding. Terminology and restrictions utterances were identified frequently. This involves elaboration on and modification of concepts, the search terns inputted and refining the results to specific years, technical term, and languages as the user required. This category also included reducing the number of duplicated references that happened at regular intervals during the searches.

The system explanation category was identified frequently. This involves the user asking questions about dialogue systems characteristics. It also refers to the intermediary explaining the capabilities of the system and why certain databases were chosen. Action and extraneous utterances had a relatively low distribution in comparison with the other categories. Action categories include a description of an ongoing or impending activity such as the-

saurus lookup, output formats. printing, and typing. Utterances extraneous to the search interaction included greetings, formulaic courtesies, social comments, and questions. Utterances about the context of the search problem were the lowest category. This included user's problem or task at hand, information-seeking stage, conversation about information collected so far, expectations, and aspects of the question. During the search process, the user and intermediary seemed to be more concerned with selecting suitable search terms and reviewing the results.

The highest commands to the computer concerned the input of terms and sets, with nearly a half of the utterances being about terminology. The answer was is the second largest category. This involved displaying the answers, specific the range of references and selecting the format. Explanation and review is the third highest category. This involved reviewing the saving commands at frequent intervals and search sets inputted. The use of restrictions, file selections, and idle period comprise the other three categories. They have relatively less frequently during the on-line searches. The use of restrictions refers to language and years. File utterances refers to file selections happened mainly at the beginning of the searches when dialogue was logged on and databases were selected. The idle periods occurred when the text on screen was being read. Compared with the discourse and search category results, frequencies of certain discourse and search categories correspond to each other. The main utterance for the discourse analysis and the search analysis were review and relevance and terminology input, respectively.

The present studies confirm and reinforce the findings of Saracevic and subsequent studies. In that both studies indicate the critical importance of terminology in the search interaction, dominating the search analysis results and having a significant position in the discourse analysis results. Again, the present studies confirm the importance of feedback in the interaction process with different aspects of feedback, in particular, relevance and magnitude feedback, having a prominent role, particularly in the discourse analysis results in relation to the categories review and relevance and search tactics and procedures. These constituted the two top discourse categories identified in both studies. The results of the present studies again underline the importance of terminology in the search analysis results, by far the largest category, and, of search tactics and procedures in the discourse analysis results. Traditional consideration of feedback in IR studies concentrate on the role of users' relevance judgements in search strategy formulation through automated relevance feedback techniques, and neglect helping users deal with the problem of magnitude, again identified as a critical issue in relation to the most important category identified from the discourse analysis results.

The clients in this study were at different stages of the problem-solving process. That meant their required result and expectations were not similar. The problem stage can used to show the progress of clients of the change in information seeking and use process. The majority of users defined themselves as problem definition stage or problem resolution stage. Around half of the clients were at the problem resolution stage. They had a clear idea of the background to the problem and requirements of the search. On the other hand, a quarter of the clients located themselves at the problem definition stage. The purpose of the search was to identify a real problem and define their search problem more closely. However, there were also clients who were between the problem definition stage and problem resolution stage. They needed to define the search problem more closely. A small number of clients were between the problem resolution stage and solution statement stage. They needed a search to help them to define their research objectives and enable them to proceed with and complete their work.

The follow-up interview, normally conducted a minimum of 2 months after the search was intended to elicit an evaluation of the retrieved materials, and feeling about the problem or project. In the follow-up interview, the clients were asked questions about any changes made to the search process in relating the interaction with the intermediary. These included changes due to interaction, changes in perception of the problem, changes in the question, changes in personal knowledge, and changes in relevance judgement. Generally speaking, in this study, some of the clients had changes their opinion of their perception of the problem, the question, personal knowledge, and relevance judgements. In this respect, it is interesting to compare the results of these studies with those of Hert (1996).

Hert explored user goals in relation to user interactions with and OPAC. She found that user goals were not greatly modified during the course of the interactions with the OPAC. In contrast, the results of the studies here do indicate some changes in some user goals, albeit relatively modest. However, this apparent contrast in the results of the studies needs to be qualified. First, the great majority of the researchers reported no major change in their goals. Second, any changes reported were over the time period of the studies not simply, as in Hert's studies, at the time of the interaction. Finally, there is an important difference to be borne in mind in relation to the different sample populations. In Hert's studies of the 30 respondents, only one was not involved with a specific class assignment or degree requirement, which is very different from the present studies where the subjects were all engaged in original research. In this respect, it is not surprising that the goals of subjects in Hert's study should be found to be more constant than those of the researchers in the present studies. This also represents an interesting contrast between the kinds of information-seeking behavior that may be associated with student class assignments and those associated with original research, and thus explain the differences between Ellis's (1989) and Kuhlthau's (1991) models of the information-seeking process.

Conclusion

The two studies reported here have analyzed observations of the search process and categorized the interactions that took place. A number of different types of interactions were identified. The preinformation searching stage involved interactions between the users and the intermediary to determine a concise problem statement and problem stage category. The presearch interview aided the users to define their ideas more precisely. Around half of the users in these studies were at the problem resolution stage and, hence, had a well-defined search problem. That is, in most cases, the user problems were well defined before the on-line searches were carried out.

During the on-line search, the problem statement was developed by suggestions from both users and intermediary in determining keywords and in terms of magnitude and relevance judgements during the display of results. This resulted in an observation of the main utterances that occurred between the user and intermediary and the intermediary and the system. These utterances were categorized into interaction types. During analysis the following observations stood out. The predominant utterances focused on search tactics and review and relevance on the discourse side, and on terminology and answers on the search side.

From this research, it is clear that these interactions did affect the search process. Although the users studied declared that not many changes were made to their search problem due to the interaction process, some stated that the intermediary did help them to define their search terms more precisely and focus the references obtained. The interactions that took place during the on-line search were found to have variable effects on the users perceptions of the problem, question, personal knowledge, and relevance judgements, and in most cases, the users and intermediary considered the communication process to be very effective.

An analysis was also made of the user judgements of the search results. In terms of the search results, all users thought that the search was useful, and many believed it to be worth much more than the time it had taken. Some found a greater difficulty in evaluation of the results than others. This did depend on the number of items retrieved. The interaction also focused on relevance and magnitude feedback. The interactions concerning review and relevance centred on reducing output and increasing relevance. The discourse analysis results revealed the user concerns in this respect, and the intermediary search tactics mirrored them. The interactions did alter the results obtained because only the most appropriate results determined by relevance feedback were downloaded for future analysis.

The follow-up interview allowed the users to reassess their problem solving stage and to comment on the search process as a whole. The interaction process helped the user obtain very useful results due to the intermediary's experience in defining search statements and reducing or refining outputs. This specific interaction aided the users significantly. Overall, the users gave a positive evaluation of the retrieved answers in terms of focus, degree of nonrelevancy, completeness, and novelty. All were fully satisfied with the results of the search process. In some cases, problem-solving stages did change due to the interactions and results received. The intermediary improved focus, completeness of retrieval, reducing nonrelevancy, and therefore increasing overall satisfaction. User intermediary interactions were important and a big determinant in the overall satisfaction of the search process. The computer–IR system was an important part of the interaction, in terms of the intermediary explaining the process, databases used, and formulation of search sets.

These studies have not examined all the possible interactions that were identified, but they do confirm that that search interactions are complex, and involve a number of interwoven variables. The results reported here, based on analysis of a variety of data, support the results presented in research by Saracevic et al. (1990). In their studies, they state that prevailing theories do not conform with observed reality, due to a lack of real-life observations. It is hoped that the full UNIS research project, of which these studies are only a small part, will contribute to a greater understanding of the information search process and the important interactions that take place. It is also hoped that the studies will lead to recommendation to improve IR system design. Saracevic (1996) has observed that although interaction practice is flourishing, interaction research is not. To enhance computer–IR systems, we must study and understand the interactions that take place involving the user, intermediary, and computer. The problem or weakness with current IR systems is that they are made to answer well-defined questions, not uncertain ones. In general, IR systems should be designed to handle a range of user problems, certain and uncertain.

Finally, although, the focus of the study is on the concept of uncertainty, it should be emphasized that the concept of relevance is neither ignored nor out of place in this investigation. Indeed, the notion of dynamic situational relevance is one that is central to the research design employed in these studies. However, as Saracevic and others have argued the static notion of relevance judgment and IR interaction employed in the traditional IR model is inadequate either as a description or explanation of what really takes place in real time, and over time, interactions of users with IR systems. In this respect, studies of user interaction with IR systems that employ concepts and findings from user studies, in the form of empirical studies of information-seeking behavior; represent a departure from most research in the IR field. The employment of empirically derived models of user information-seeking behavior to attempt to analyze interactions with IR systems, approaches the general problem of information-seeking behavior and IR interaction, not only from a different perspective of that of IR research, but also represents an attempt to integrate the two major strands of LIS research, IR, and user studies, in one research design.

Acknowledgments

References

Bates, M.J. (1990). Where should the person stop and the information search interface start? Information Processing and Management, 26(5), 575–591.

Beaulieu, M. (2000). Interaction in information searching and retrieval. Journal of Documentation, 56(4), 431–439.

Belkin, N.J., & Vickery, A. (1985). Interaction in information systems. Library and information research report, 35, Boston Spa: The British Library.

Belkin, N.J., Brooks, H.M., & Oddy, R.N. (1982). ASK for information retrieval. Journal of Documentation, 38, 61–71.

Blackshaw, L., & Fishhoff, B. (1988). Decision making in on-line searching. Journal of the American Society for Information Science, 39, 369–389.

Burton, R. (1999). A study of user–intermediary–computer interactions during the information search process. MSc Dissertation. Department of Information Studies, University of Sheffield.

Chowdhury, G.G. (1999). Introduction to modern information retrieval. London: Library Association Publishing.

Dervin, B. (1983). An overview of sense-making research: Concepts methods and results to date. In International Communications Association Annual Meeting. Dallas, TX.

Dervin B. (1992). From the mind's eye of the user: The sense making qualitative-quantitative methodology. In: J.D. Glazier & R.R. Powell (Eds.), Qualitative research in information management (pp. 61–84). Englewood, CO: Libraries Unlimited.

Ellis, D. (1989). A behavioral approach to information retrieval system design. Journal of Documentation, 45, 171–212.

Ellis, D. (1996). Progress and problems in information retrieval. London: Library Association Publishing.

Ellis, D., Cox, D., & Hall, K. (1993). A comparison of the information seeking patterns of researchers in the physical and social sciences. Journal of Documentation, 49(4), 356–369.

Hert, C.A. (1996). User goals on an Online Public Access Catalog. Journal of the American Society for Information Science, 47(7), 504–518.

Ingwersen, P. (1988). Towards a new research paradigm in IR: Knowledge engineering. London: Taylor Graham.

Ingwersen, P. (1992). Information retrieval interaction. London: Taylor Graham.

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

Kuhlthau, C.C. (1993). A principle of uncertainty for information seeking. Journal of Documentation, 49(4), 339–355.

Kuhlthau. C., Spink, A., & Cool, C. (1992). Exploration into stages in the information search process in on-line IR: Communication between users and intermediaries. Proceeding of the Annual Meeting of the American Society for Information Science, 29, 67–71.

Lam, H.M. (2000). A study of user–intermediary–computer interactions during the information search process. MSc Dissertation. Department of Information Studies, University of Sheffield.

Mokros, H.B., Mullins, L.S., & Saracevic, T. (1995). Practice and personhood in professional interaction: Social identities and information needs. Library and Information Science Research, 17, 237–257.

Saracevic, T. (1989). Modeling and measuring user–intermediary–computer interaction in online searching: Design of a study. Proceedings of the Annual Meeting of the American Society for Information Science, 26, 75–80.

Saracevic, T. (1996). Modeling interaction in IR. Review and proposal. Proceedings of the Annual Meeting of the American Society for Information Science, 33, 3–9.

Saracevic, T, Kantor, P., Chamis, A.Y., and Trivison, D. (1988). A study of information seeking and retrieving. I Background and methodology. II Users, questions and effectiveness. III Searchers, searches and overlap. Journal of the American Society for Information Science, 39, 161–216.

Saracevic, T., Mokros, H., & Su, L. (1990). Nature of the interaction between users and intermediaries in on-line searching: A aualitative analysis. Proceedings of the Annual Meeting of the American Society for Information Science 27, 47–54.

Spink, A. (1992). Recognition of stages in the user's information-seeking process during online searching by novice searchers. Online Review, 16(5), 297–301.

Spink, A. (1993). Interaction with IR systems: Reflections on feedback. Proceedings of the Annual Meeting of the American Society for Information Science, 30, 115–121.

Spink, A. (1995). Term relevance feedback and mediated database searching: Implications for information retrieval practice and systems design. Information Processing and Management, 31(2), 161–171.

Spink, A., & Goodrum, A. (1996) A study of search intermediary working notes: Implication for IR system design. Information Processing and Management, 32, 681–695.

Spink, A., & Losee, R.M. (1996). Feedback in information retrieval. Annual Review of Information Science and Technology, 34, 37–78.

Spink, A., & Saracevic, T. (1997). Interaction in IR: Selection and effectiveness of search terms. Journal of the American Society for Information Science, 48(8), 741–761.

Spink, A., Goodrum, A., & Robins, D. (1998). Elicitation behaviour during mediated information retrieval. Information Processing and Management, 34, 251–273.

Vickery, B.C., & Vickery, A. (1987). Information science in theory and practice. London: Butterworths.

Wilson, T.D. (1981). On user studies and information needs. Journal of Documentation, 367, 3–15.

Wilson, T.D. (1997). Information behavior: An interdisciplinary perspective. Information Processing and Management, 33(4), 551–572.

Wilson, T.D. (1999). Models in information behavior research. Journal of Documentation, 55, 249–270.