Information-Seeking and Mediated Searching. Part 1. Theoretical Framework and Research Design

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Our project has investigated the processes of mediated information retrieval (IR) searching during human information-seeking processes to characterize aspects of this process, including information seekers' changing situational contexts; information problems; uncertainty reduction; successive searching, cognitive styles; and cognitive and affective states. The research has involved observational, longitudinal data collection in the United States and United Kingdom. Three questionnaires were used for pre- and postsearch interviews: reference interview, information seeker postsearch, and search intermediary postsearch questionnaires. In addition, the Sheffield team employed a fourth set of instruments in a follow-up interview some 2 months after the search. A total of 198 information seekers participated in a mediated on-line search with a professional intermediary using the Dialog Information Service. Each mediated search process was audio taped and search transaction log recorded. The findings are presented in four parts. Part I presents the background, theoretical framework, models, and research design used during the research. Part II is devoted to exploring changes in information seekers' uncertainty during the mediated process. Part III provides results related to successive searching. Part IV reports findings related to cognitive styles, individual differences, age and gender. Additional articles that discuss further findings from this complex research project, including: (1) an integrated model of information seeking and searching, (2) assessment of mediated searching, and (3) intermediary-information seeker communication, are in preparation and will be published separately.

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Introduction

The research reported in the series of articles of which this is the first, was the result of a marriage of two, separately funded investigations. The first, in funding and in time, was a project supported by the National Science Foundation and undertaken by Dr. Amanda Spink from the Pennsylvania State University. The aim of this project was to study the process of successive searching in information retrieval, investigating the nature, manifestations, and behavior of successive searching in IR, including the nature and extent of successive IR search episodes by a set of users over time, characterizing the changes that occur in user situational context, user information problem, cognitive and affective states of the user (Spink, Wilson, Ellis, & Ford, 1998).

The second project was supported by the British Library Research and Innovation Centre and was carried out by Dr. T.D. Wilson in collaboration with his colleagues, Dr. David Ellis, and. Nigel Ford (Wilson et al., 1997). The aim of this project was to investigate several aspects of information seeking and searching in the context of a theoretical model of the problem-solving process, and incorporating successive searching and models of information-seeking behavior, including Wilson's (1981) model and its later elaboration (Wilson, 1999) as well as the theoretical perspectives of Kuhlthau (1993) and Ellis (1989).

Both projects adopted a common theoretical framework so that commonly developed research instruments could be employed in the two projects. In evolving the theoretical framework we had in mind that information-seekers with a broad problem (as distinct from the search for a specific fact) often seek information in stages over extended periods and use a variety of information resources. As the time progresses, information seekers may search the same or different information environments, including digital envi-

ronments such as IR systems, on-line databases, CD-ROM databases, on-line public access catalogs (OPACs), the Web or digital libraries, as well as document collections of various kinds, and personal communication, for answers to the same or evolving problem.

The process of searching information environments in relation to an evolving, information problem is the focus of this research, which is presented in a series of related papers. The phenomena examined were *search episodes* within an information-seeking process. Our goal was to make a contribution to the modeling of information-seeking behavior, i.e., user modeling. Key variables in the analysis are changes in behavior such as search strategy or language use during search episodes over time, and a key constant is the same or evolving. The evolving problem, within the problem-solving model, is not simply an *information* problem—in the terms of our clients, it is a research problem. That research problem may give rise to more than one "information problem" and the successive searching phenomenon may be seen as the result of a series of information problems arising out of a substantive research problem. The process of problem resolution and the solving of associated information problems, along with other cognitive, affective, and situational variables, may be mapped and the interactions among variables explored.

A growing body of research is beginning to explore information-seeking processes over time, especially since the development of Web-based services and the migration of "traditional" on-line search services to the Web. IR and Web interfaces are designed to help users in various ways in their searches of digital environments, but IR systems generally follow a single search paradigm. That is, they are designed and operate on the assumption that an information seeker's search episode is an end in itself, unrelated to other searches or the information-seeking process more generally. Research in this area is growing in significance as the size and variety of information resources in IR systems, digital libraries, and the Web grow exponentially; the problem of searching becomes critical. Our research project presented in this article is oriented toward exploring the human dimensions in the design of IR interfaces and search engines as well as to a more general understanding of the processes of information seeking and their relationship to the nature of problems and the stages people go through in reaching solutions.

Our approach to this research is predicated on a theoretical framework drawn from previous studies that are outlined in the next section of the article.

Theoretical Framework

Our research is embedded in a theoretical framework that draws on previous studies in the fields of both IR and human information behavior (HIB). The field of IR has developed as two largely unconnected but related subfields: one that focuses on systems aspects, and the other that focuses on the human, cognitive, and interactive aspects. The field of HIB

is related to the cognitive approach to interactive IR and seeks to investigate the broader issues related to human processes for seeking and using information. However, interactive IR research and HIB research have been largely unconnected despite their mutual interest in areas of human information-related behavior. The appropriate integration of elements of both fields is growing in importance, particularly to further the development of more effective, theoretical models, and Web, and IR systems design and evaluation (Spink, 1999; Vakkari, 1999; Wilson, 1999b).

Interactive search episodes are represented by aspects from various interactive IR models, including models by Ingwersen (1992, 1996), Belkin, Cool, Stein, and Theil (1995), and Saracevic (1996a, 1997), and in studies by such researchers as Bates (1984) and Fidel and Soergel (1983). Over *time,* movements or shifts may take place during interactive search episodes and between searches, including changes in tactics, the definition of the information problem, strategies, terms, feedback, goal states, or uncertainty.

Time as a factor may be represented by:

(1) *Human problem solving processes*, represented in Wilson's (1999a) problem-solving model of information-seeking behavior in which interactive search episodes provide the informational framework to the problem-solving process through which the user's uncertainty level is reduced,

(2) *Human information-seeking stages*, represented by Kuhlthau's (1993) Information Search Process Model,

(3) *Information Seekers' successive searches over time* related to the same or evolving information problem developed by Spink (1996, 1999).

We suggest that our theoretical framework is a basis for the development of our theoretical and empirical research towards integration of interactive IR within information-seeking contexts, and for exploring information seekers' interactive search episodes within their changing information-seeking behavior.

Time

In our theoretical framework a set of situated actions occurs during IR interactions over time. Mizzaro (1998) also includes time as a key element in IR. An information seeker makes judgments during an evolving information-seeking process or during successive search episodes. We suggest that sets of problem-solving activities engaged in by individuals may be used as the primary means of examining the way *time* is used and that the problem-solving process also serves as the framework within which other aspects of information seeking and searching may be explored. Thus, problem solving may involve *information-seeking activities*, within which *search episodes* take place. Within those episodes *interactions* of various kinds occur, for example, the relatively mechanical tasks of entering search terms and pressing keys as well as the mental tasks of selection and

relevance judgment formation in response to retrieved items.

In our theoretical framework, the top-level process is the human problem solving process that is discussed in the next section of the article.

Problem-Solving Process

Problem solving is used as the top-level device to explain why people engage in information-seeking behavior. Wilson's Problem-Solving Model (1999a) presents information-seeking behavior as goal-directed behavior, with the resolution of the problem and/or the presentation of the solution as the goal. In moving through each of the stages of *problem identification, problem definition, problem resolution,* and *solution presentation*, "uncertainty" must be resolved, and individuals are seen as engaging in interaction episodes with information sources (including people and other sources as well as IR systems) to resolve uncertainty. Of, course, the attempt to resolve uncertainty may actually increase it and, therefore, the model provides for feedback at each stage. Within the problem solving process, information seeking is related to Kuhlthau's Search Process Model (1993) as a highly developed model of the information-seeking process. Ellis's (1989) behavioral characteristics are seen as applying to search activities at any stage of the problem-solving process at any Kuhlthau's search stages.

To extend the theoretical framework, the problem solving process is seen as including one or more *information-seeking episodes*. In addressing the nature of searches during an information-seeking process, a major research effort has to be directed toward the development or adaptation of appropriate model or models of information seeking and interactive IR. We start with the information-seeking models summarized below. The objectives of use of these models are to: (1) identify a useful subset of the features or variables in search episodes, and (2) define content of questionnaires to enable collection of data related to these variables and to shifts and transition between episodes.

Information-Seeking Episodes

Results from information-seeking studies support the notion of successive searches of digital information environments over time by showing that humans progress through a series of stages, adopt different strategies, and exhibit different information behaviors at different stages of their information-seeking process (Ellis, 1989; Kuhlthau, 1993). Kuhlthau's Search Process Model (1993) is currently the most developed stage-model of the information-seeking process. Kuhlthau (1993) found that the information-seeking process of library patrons occurred in six clearly defined stages related to the cognitive, affective states and search activities of the users, including task initiation, topic selection, prefocus exploration, focus formulation, information collection, and search closure. Although Kuhlthau did not investigate the use of IR systems by library patrons, her findings suggest that IR system users continue to collect and seek information throughout their information-seeking process using or requiring different types of information, conducting different types of searches, and using different search terms and strategies at different stages of an information-seeking process (Kuhlthau, Spink, & Cool, 1992). Ellis (1989, 1993) define the following characteristics of information-seeking behavior, without typifying these as stages: Starting, Chaining, Browsing, Differentiating, Monitoring, Extracting, Verifying, and Ending.

The Ellis and Kuhlthau models may be viewed as closely related, if a stage process is imposed on Ellis's characteristics. Under this revision, the activities of Chaining and Monitoring are seen as a deeper specification of Kuhlthau's Collection stage. In Wilson's problem-solving model, the Kuhlthau and Ellis models describe behavior within one loop of a problem-solving stage.

The next section of the article discusses the relationship between uncertainty and information seeking in our theoretical framework.

Uncertainty

The concept of uncertainty has had little treatment in information science, except in defining information as that which reduces uncertainty. Under this definition, data that, for example, increases uncertainty is not information. Ingwersen (1992) has defined the relationship between uncertainty and information seeking as action undertaken to resolve doubts that cannot be resolved by thinking alone; this is broadly equivalent to Belkin et al.'s (1982) concept of the anomalous state of knowledge. Kuhlthau and Ledet (1996) suggest the need for further research on uncertainty from the user's perspective to understand the full range of impact of uncertainty in all of its manifestations on the information-seeking behavior of human beings in the conduct of their daily lives. This project is intended to contribute to that research agenda.

Cognitive Styles

Cognitive styles represent a class of variables, which may influence information seeking at all levels across our model. Witkin has noted how cognitive style would appear to exercise pervasive effects across intellectual and social functioning, extending even to basic perception (Witkin, Moore, Goodenough, & Cox, 1977). Theoretically, it would seem possible that cognitive style differences may influence problem perception and uncertainty tolerance as well as strategic and tactical approaches to problem solution (Ford, 1999). Empirical work within information science suggests that cognitive style differences can influence information-seeking dialogues with databases (Ford & Ford, 1993) and search tactics at the level of differential use of Boolean operators (Ford, Wood, & Walsh, 1994).

In our theoretical framework, the next level down process in the interactive search of a digital information environment within an information-seeking process. This is discussed in the next section of the article.

Interactive search sessions, depicted in interactive IR models, take place within human information-seeking processes. Research into the human or cognitive (user modeling) aspects of IR is also in its infancy with a growing body of research on users interactivity and measures for observing user interactivity (Saracevic, Mokros, Su, & Spink, 1991). Major interactive IR models have recently emerged. IR interactions related to search episode can be represented by different interactive IR models—Ingwersen's Cognitive Model of IR Interaction (1992, 1996), Belkin et al.,'s (1995) Episodic Interaction Model, Saracevic's Stratified Model of IR Interaction (1996a, 1997), Sutcliffe (Sutcliffe & Ennis, 1998; Sutcliffe, Ennis, & Watkinson, 2000), and Vakkari (2001). Researchers have also investigated the context of users' searches and evaluation (Bates, 1984; Ellis, 1997) and to identify key elements in a user's search of an IR system.

Our research initially uses the Saracevic Stratified Model of IR interaction (1996a) within our integrated model of information seeking and searching. The model views the interaction as a dialogue between participants, *user* and *computer* (system) through an interface at a *surface* level; furthermore, each of the participants is depicted as having different levels or strata. *Interaction is the interplay between various levels.* On the user side elements involve at least these levels: *cognitive, affective,* and *situational.* We include in our theoretical framework elements from information-seeking models and interactive IR models that describe the phenomena of successive and related searches of digital environments by humans during an information-seeking process.

Successive Searching Behavior

Important elements within single searches have been identified, including feedback types and effective search term selection strategies (Spink & Saracevic, 1997). Research has also shown that end-users perform different search sessions over time (related to a different information problem) including searches of successive databases or IR systems (Spink, 1996). Spink (1996) showed that successive IR searches are a fundamental aspect of users' behavior when seeking information related to an information problem. A recent study showed that Web users also perform successive searches of the same Web search engine when seeking information on a particular topic over time (Spink, Bateman, & Greisdorf, 1998a).

Our research takes a longitudinal problem-level of analysis as opposed to a single search level of analysis of searching behavior. Our research also encompasses specific processes or phenomena that play a crucial role in IR interaction.

Set of Situated Actions

Changes and Shifts

Finally, we have to deal with the difficult concept of changes and shifts; a widely discussed concept, which has not been specifically elaborated in IR. Information seeking and searching involves changes from one state to another of many variables involved, or from one phase or action to another, based on a reason and geared toward a result. Previous studies and models suggest some initial types of changes and shifts for analysis, including shifts in feedback behavior (Spink, 1997), types of search terms (Spink & Saracevic, 1997), interactive search focus (Robins, 2000), and interactive intentions (Xie, 2000). However, methodologically it is not clear how to record all given changes and shifts, and how to categorize and describe given changes and their outcomes. Thus, an important part of the research has been methodological in nature: examining various levels of changes and shifts related to information seeking and searching from the data obtained.

In summary, our research is embedded in a theoretical framework that draws on previous studies in the fields of both IR and human information behavior (HIB). Our research seeks to contribute to the further integration of interactive IR and HIB research.

Research Objectives

The broad objective of our research is to investigate human information-seeking and searching processes in the context of mediated on-line searching to derive models. In particular, our research seeks to characterize progressive changes that occur in users' information-seeking and searching processes, including: user situational context; user information problem; uncertainty reduction, cognitive and affective states of users; over successive searches, and consequently in their queries, and users cognitive styles.

Specifically, the following research goals relating to the following:

(1) Test whether the proposed model of information-searching as related to problem solving is valid for the population in question;
(2) Establish whether the use of Kuhlthau's (1993) model of information searching as a stage process fits the suggested model of multiple searches in a problem solving strategy;
(3) Examine whether Ellis's (1993) behavioral model of the search process is a more appropriate model in the problem-solving context, and
(4) Explore whether the concept of individual differences (e.g., cognitive styles) is valuable in explaining differences in problem-solving and searching behavior in searching.
(5) Extend our understanding of mediated successive searching process.
(6) Develop an integrated model of information seeking and searching.

Research Design

Data Collection

This empirical research is based on observation of real-life, as opposed to a laboratory, situations. The information

TABLE 1. Basic data table.

University of North Texas	University of Sheffield
87 participants	111 participants
3 search intermediaries	1 search intermediary
40 (50.6%) female	42 (37.8%) female
47 (49.45) male	69 (62.2%) male

problems driving information seekers in the research are user-initiated not imposed on our study participants, as in a laboratory study. Data were collected from a set of 198 information seekers engaged in tasks or problems that produce real information needs and, consequently, search operational IR systems with or without assistance by a professional search intermediary. Every effort has been made to preserve the reality of situations, observations, and recordings.

The data collected during our research included: (1) search transaction logs, (2) numerical data and responses to given questionnaires, (3) texts retrieved and assessed relevance judgments, and (4) in Sheffield, responses to a standard test of cognitive styles. The research was conducted for 18 months in the United States and 2 years at the University of Sheffield.

Table 1 list the basic data from our study.

Data were collected on a total of 198 cases: 87 at UNT and 111 at Sheffield. The U.S. sample had a much higher proportion of female clients than that of the Sheffield sample but the difference is not statistically significant (chi-squared = 3.08, sig. >0.05). The age characteristics of the two sets of cases were as follows: the age range was very similar in the U.S. and UK participants, as shown in Table 2.

U.S. participants had a slightly higher proportion of clients aged under 30, and a slightly higher proportion of clients in the 40 to 49 group, while at Sheffield a higher proportion was in the 50 to 59 age group. However, the differences are very small and, overall, therefore, we can say that there was no statistically significant difference. The UK and U.S. clients were distributed over these four categories, as shown in Table 3.

Clients were classified by broad discipline, i.e., humanities; "pure" social sciences, such as economics, political science, sociology, etc.; applied social sciences, such as social welfare and social administration; pure science; medicine; and engineering. The number of humanities and medical clients were rather small and the former were incorporated into the pure social sciences group, while the latter were included in the pure science group. This gave four discipline categories.

Institutions

Information seekers participating in the research were primarily from the University of North Texas (UNT) [http://www.unt.edu] and the University of Sheffield [http://www.shef.ac.uk].

Search Intermediaries

Three trained search intermediaries performed mediated on-line searches at the University of North Texas and one search intermediary searched at the University of Sheffield.

Information Seekers

A total of 198 information seekers participated in the project. As an inducement, free mediated DIALOG on-line searches were offered. E-mail calls for participation were issued to recruit information seekers and to specify what was offered and required. In Sheffield, respondents to a regular call for research participants in the information searching teaching of students received an explanation of research undertaken and details of their engagement. Information seekers were generally engaged in research, development, planning, or a similar project, that created information problems and needed information support from IR systems, including searching of networked information resources, such as the Web.

Procedures

Presearch Interview: in this first interview, a detailed description of the participant's problem was obtained, together with responses to interview questions and responses to a questionnaire, which covered, for example, problem stage, Kuhlthau's (1993) stages, feelings about the progress of the work, other information-seeking activities, and uncertainty.

On-line Search and Postsearch Interview: immediately before the search, Sheffield participants completed a test mounted on the PC, which automatically recorded various dimensions of cognitive style (Riding, 1991). During the search, computer logs were kept, together with audiotapes of the interaction between information seeker and the search intermediary. After the search, the participants completed another questionnaire on aspects of the search and, again, on their certainty/uncertainty with regard to different stages of problem resolution. The search intermediary also completed a search assessment instrument.

Follow-Up Interview (Sheffield Only): conducted a minimum of 2 months after the search seeking an evaluation of

TABLE 2. Client age demographics.

Age (Years)	UK Clients		U.S. Clients	
	Frequency	%	Frequency	%
Up to 29	27	24.3%	18	27.3%
30 to 39	36	32.4%	20	30.3%
40 to 49	24	21.6%	16	24.2%
50 to 59	22	19.8%	11	16.7%
60 and over	2	1.8%	1	1.5%
Total	111	100%	66	100%
Missing	—	—	21	—
Total	111	100%	87	100%

TABLE 3. Distribution of clients over disciplines.

	Disciplines							
	Humanities and 'pure' soc. sci.		Applied social sciences		Pure science and medicine		Engineering	
Country	No.	%	No.	%	No.	%	No.	%
UK	20	18.0	40	36.0	23	23.7	28	25.2
US	14	16.1	39	44.8	13	14.9	2	2.3
Total	34	19.0	79	44.1	36	20.1	30	16.7

the retrieved material, and a repetition of the previously used instruments.

Questionnaires

Three questionnaires were used to record various aspects of context that are connected to context and not record able in transactions: an *information seeker presearch (reference interview) and postsearch, and search intermediary postsearch*. The aim of the pre- and postsearch questionnaires was to capture the information seeker's state in a number of areas before and after their search. This allowed the measurement of changes or shifts by information seekers resulting from their search. The questionnaires were based on those used in major studies of on-line searching by Saracevic, Kantor, Chamis, and Trivison (1988) and Saracevic (1989), with the addition of items relating to uncertainty, problem-solving state, Kuhlthau's (1993) stages and affective states, and Ellis's (1989) behavioral characteristics, and with changes to wording and scale type. In most cases a "visual analog" scale was adopted where the respondent marks a point on a line connecting the polar points of an item. One advantage of this type of scale, which makes it appropriate to a longitudinal study, is that it is potentially sensitive, making it useful for measuring phenomena before and after some intervening event. Again, appropriately for this investigation, when a measure is used more than once, it is difficult for respondents to remember exactly how they marked at item on the earlier occasion, so that a respondent bias towards consistency in responding is avoided. (Copies of the questionnaires are available at http://www.shef.ac.uk/~is/publications/unis/appl.html.)

The Sheffield team also used a questionnaire to collect information on changes in relevance judgments on retrieved items some 2 months after the initial on-line search, after the information seeker had acquired the documents. These questionnaires capture answers to cognitive, affective, situational, relevance, and process variables suggested by the reviewed models, and were pretested and revised during pilot applications. Before the mediated search each information seeker completed a *consent form (U.S. only)*, a *demographic form* and a *presearch questionnaire*. After the mediated search each information seeker completed a postsearch questionnaire.

Cognitive Styles Test

Holist/serialist differences: a shortened version of Ford's *Study Processes Questionnaire* (Ford, 1985) was used to assess the holist and serialist information processing differences identified by Pask (1979). Measures consisted of (a) holist scores (b), serialist scores, and (c) a measure of bias to holist or serialist (computed by subtracting serialist from holist score).

Field-Dependent/-Independent Differences: Riding's (1991) Cognitive Styles Analysis (CSA) is a measure that offers computerized administration and scoring. The CSA measures Witkin's field-dependence/-independence (Riding & Sadler-Smith, 1992).

Information-Seeking and Searching Context Variables

Saracevic et al. (1988) provide a general model of information seeking and retrieving. In Figure 1 we present an extension to this general model that is used as a basis for our data collection.

The model provides a general overview of the variables selected for our study. Information seekers were asked to give their perceptions on a number of issues discussed below.

Event	Variables
Information seeker has an information problem to resolve	Information seeker pre-search characteristics Cognitive style Problem statement Knowledge level Problem-solving stage Information seeking stage Uncertainty level
Information seeking process related to information problem	Information seeking behaviors Information seeking models
Information seeker formulates their information problem into a question	Question statement Question analysis
Pre-search interaction with a search intermediary	Intermediary characteristics
Formulation of the search strategy (terms and tactics)	Pre-search characteristics: information seeker
Searching activity and interactions	Search strategy Search characteristics Search processes Successive Searches
Delivery of responses to the information seeker	Items retrieved Forms delivered
Evaluation of output	Relevance Utility
Information seeker evaluation of impact of search	Information seeker post-search characteristics Problem statement Knowledge level Problem-solving stage Information seeking stage Uncertainty level

FIG. 1. General model information seeking and searching process.

Information Problems: human information problems were a key element in our study. To analyze the participant's information problems we sought to capture the context of the problem by asking the clients to describe the problem. At UNT, this was done by asking the clients to write a description of their information problem and the search terms they envisaged, while at Sheffield the whole context was obtained through the detailed presearch interview with the client. The context of the information problem included the presearch, problem-solving stage of the information seeker.

Data Analysis

Most of the analysis to date has been quantitative in character, employing standard statistical tools from the SPSS package. The focus has been on identifying relationships in the data and in testing hypotheses. In addition to this introductory artilce, three more are in preparation: one deals with correlations between uncertainty and other aspects of the client's search for information such as the Kuhlthau stages and affective variables; the second deals with the relationships between personal characteristics, including cognitive style, and information-seeking behavior; and the third explores the limited amount of data available on clients who carried out successive searches over the duration of the project.

Qualitative data were also collected, in the form of the presearch interviews, the tape-recorded interactions between client and intermediary, and the search logs. These data will be used in further articles, and will also be drawn upon, as appropriate, to illuminate aspects of the clients' information-seeking behavior.

Qualitative methods include: content analysis, structuring of taxonomies depicting structure and relations of various types of actions and specific variables, derivation of various diagrams and structures to describe shifts, derivation of semantic roadmap diagrams, and principles and criteria derived from grounded theory research (Strauss & Corbin, 1990). Further articles on specific issues will describe the methodologies employed, as appropriate.

Conclusion

In this article we have presented a theoretical framework that underpins our exploration of the actions taken by information-seekers in their search for information, including the actions involved in the interactive search process, where an intermediary was employed. We have explored the changes that take place over time in the problem stage in which they are engaged and in their level of uncertainty about the enterprise, and we have related these variables to other variables derived from the work of other researchers such as Kuhlthau and Ellis. We have a limited number of cases of clients who returned for more than one search and, in these cases, have data on the changes that took place in the variables of interest.

Our theoretical framework consists of a set of situated actions, including levels and regions of relevance judgments and other human judgments, within interactive search episodes over a period of time. The period of time consists of interaction time (i.e., that involved in the on-line search process) and information-seeking time (i.e., the total time spent in seeking information from any source), and can be represented as human information-seeking stages and successive searches over time related to the same or evolving information problem. Acts, decisions, and judgments take up more time than the interactions with IR or other systems. For example, judgments about the relevance of documents may continue beyond the interaction period, and decisions to use IR systems clearly must predate interaction with them. Furthermore, the *interactive search episodes* are not *instances* but *periods* of time, of varying duration.

The integration of theoretical framework with that of Wilson (1999a) links *interactive search* episodes to his *uncertainty reduction episodes* and the problem-solving process, over time, provides one explanation of the need for successive interactions. The implication of the proposed model is the potential ability to isolate a user's situated actions at particular points in time, assessing levels of relevance, regions of relevance, and problem process (represented by information-seeking stage and successive searches). This could lead to major implications for system design and design criteria. In particular, a user's *successive interactions* could be analyzed in terms of *relevance judgments, uncertainty reduction,* and *problem solving stage.* The resulting complex picture, if derived through interaction with the user and displayed graphically as an aid to searching, could improve the interactivity of IR systems and, when logged, could provide a rich source of data for research.

The further development of the theoretical framework for research to: (1) integrate interactive IR research within information-seeking research, (2) explore users' interactive search episodes within their changing information-seeking contexts, (3) examine relevance *judgment*s within users' information-seeking processes, (4) broaden relevance research to include the concurrent exploration of relevance *judgment* level, region and information-seeking or problem-solving phase, and (5) conceptualizing and exploring interactive IR evaluation with an information-seeking context. Such research would allow the development of an integrated view of a user's interactive IR processes within their changing information-seeking context.

Our theoretical framework has strengths and weaknesses. A key strength of the theoretical framework is the focus on the larger picture that embraces information seeking and information searching, and the drawing together of major concepts—situated actions, relevance, IR interaction and time. Other concepts, such as feedback, representation, information problem, and context, are also incorporated into the framework. The theoretical framework can integrate existing and future research and models from IR and information seeking. A further strength is the framework pro-

vided for gathering, plotting, and testing data from users. Theoretical frameworks also have weaknesses. The framework often tends to focus on major dimensions and not specific differences in information-seeking contexts, and is also specifically related to the IR context, not information seeking in general. Our approach area should be considered exploratory. Despite these limitations, the authors believe their framework derived from previous studies to provide a reasonable and heuristic approach from which to build further theoretical and empirical research.

Acknowledgments

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