Users' Information Search Behavior in a Professional Search Environment: A Methodological Approach

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Abstract. Searching and retrieving information, especially in the context of a professional search environment, can be an arduous task. Professional search is defined as "interactive information retrieval performed by professionals in a specific domain" [1]. These searchers have competencies and skills in searching and as such demand high quality information retrieved and are willing to spend time to find the required information. This chapter aims to analyse research into users' search behaviors in professional search enviroments. The method of systematic review was adopted and two types of studies were identified "system-centered" and "user-centered" studies. An emphasis was placed on the methods each type of study adopted to meet its purposes. It was found that system-centered studies employed mainly quantitative methods (Log analysis) to evaluate system's performance and retrieval techniques whereas user-centered studies adopted mainly qualitative methods to provide an insight into users' behaviors. In addition, system-centered studies examined users' behavior as a series of clicks, search terms employed and features used to develop systems that satisfy user's information needs. In contrast, user-centered studies explored users' behavior with the view to identify the specific search processes, thoughts and decisions made while searching as well as the factors affecting their search behaviors. This chapter contributes to providing an understanding of both the methods and approaches adopted to study users' behavior in a professional search environment.

1 Introduction

Information is considered essential for task completion and for decision making. Searching and retrieving information is performed daily to address information

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needs ranging from general to specific and by searchers with diverse skills. However, searching and retrieving relevant information for a specific need can be an arduous task. Professional search is defined as "interactive information retrieval performed by professionals in a specific domain" [1]. Frequently these searchers are searching for specific information and as such are prone to spend a considerable amount of time retrieving and examining a significant number of the retrieved results [1], [2]. These searches occur across various disciplines and are more readily recognised in medicine, patent and academic document searches. In addition, they need systems that enable the creation and storage of their searches [1]. Their high demands for information derive from the understanding that failing to find the necessary information may have important consequences including huge financial losses and legal implications [2].

Professional searchers have diverse skills and competencies in searching information [3], [2]. As such, professional searching is sometimes outsourced to experts who play the role of intermediaries. In particular, professional searchers either instruct others how to develop the skills necessary to perform a professional search or perform the task of searching on their behalf [3]. This chapter focuses on the task of professional search for meeting specific information needs. In particular, this chapter reviews the literature on professional searches performed only in medicine, patent and academic document domains.

The complexity of professional searching and the diversity of searchers skills and competencies led to the realization that systems should guide the search. Developers ought to build systems which guided searchers to the right answer or to the use of the relevant information resources [2]. Therefore, significant attention has been given to developing novel systems and techniques for supporting professional search. There exists a variety of different systems designed and developed to address the needs of a professional searcher [4], [5], [6], [7], [8]. In terms of specific techniques developed to support professional search, research has focused on Boolean filters and Boolean query suggestions [9], [10], [1], clustering techniques [11], metadata exploitation [12], linked data and semantics [13], [14]. In addition, a series of specific tools have been developed [15], [16], [17], [18], models [19], [20], frameworks [21], [22] and approaches [23] to assist professional searching.

However, although these systems and techniques were developed to meet users' needs, the focus was placed more on systems' performance and features developed rather than on users' interpretation and thought processes while searching these systems. When users were considered, they were mainly employed to assess the effectiveness of retrieval techniques in these systems [24], [25], rather than inquiring into users' information needs, search behaviors and interpretations of the systems' functionality. As such this chapter sets out to analyse research that investigates users' search behavior while performing a professional search in the context of medicine, patent and academic document domains. An emphasis is given to research on the development of systems that support professional search to identify the approaches used in their evaluation. In particular, it aims to distinguish research that carries out a user evaluation of the system effectiveness

from studies of the information search behavior in a professional search environment that is users reporting on their perceptions and understanding of system's functionality.

This chapter is in relation to the goal and specific objectives of the **3rd Working Group** of the MUMIA Cost Action. Specifically, it addresses the main objective of this Working Group that is to identify and review research on the user aspects of next generation search systems. It reviews literature in the medicine, patent and academic document domains to assist information exchange across disciplines. In addition, this research makes use of **information retrieval (IR)** in context and more specifically, of **interactive IR (IIR)** to provide an insight into users' thought processes and overall understanding of the search mechanism. On the whole, this research contributes to providing an insight into the methods employed to investigate users' behavior in a professional search environment in the medicine, patent and academic document domains. In addition, it helps the work of system developers by outlining both the methods and approaches adopted to examine users' behaviors and thought processes to develop efficient and effective systems and retrieval techniques. Moreover, it describes the way each method was employed to assist the work of developers and evaluators.

This chapter is structured as follows. At first, the methodological approach adopted is presented with an emphasis on the specific criteria and selection process applied; this is followed by a thorough presentation of issues regarding users' information search behavior in a professional search environment. In particular, a brief outline of the term information seeking behavior and relevant models is provided. Then, the identified studies divided in system-centered and user-centered are presented focusing on the methods adopted. Finally, issues concerning methodological approaches adopted for exploring information search behavior in a professional search environment are critically discussed.

2 Methodology

This study reviews the literature exploring users' information search behavior in a professional search environment such as the medicine, patent and academic document search domains. In this context, relevant search terms to professional search such as "professional searching", "user behavior", "information search" were performed on diverse databases (ACM Digital Library, Library, Information Science & Technology Abstracts (LISTA), Library & Information Science Abstracts (LISA), Citeseer, Google Scholar, e-prints in Library & Information Science (e-LiS), Digital Library of Information Science & Technology (DLIST), PubMed and OVID Medline). The searches were limited to 1990- 2014 and were carried out in October 2013. In total, 60 papers were retrieved and their references were also checked for any additional relevant papers. The inclusion criteria of this literature review focused on the relevance to users' seach behavior in a profeessional search environment and more specifically in medicine, patent and academic document search context. For the purposes of this chapter, studies reporting on legal and academic document search as well as library book search

were excluded. By applying and refining the inclusion and exclusion criteria nineteen papers were identified focusing on users' search behavior in professional search environments such as medicine, patent and academic document search. These papers were dated from 1994 to 2012 (see Table 1).

This study has followed the rules of systematic review [26]. In this context, the full-text of the papers was read in order to identify common themes and subthemes. The resultant categories and the assigned papers were then contrasted to resolve any discrepancies in the review process through consensus among the authors. As a result, two main themes system-centered and user-centered studies emerged. In particular, papers exploring users' judgements of a systems performance and effectiveness were defined as system-centered whereas studies focusing on users' own behaviors, perceptions and understanding of search mechanism while searching were referred to as user-centered. The relevant literature was equally assigned to the emerged themes (see Table 2). It should be noted here, that papers with more than one aim were assigned to more than one theme such as the study of Vibert [27].

This literature review reports the methods adopted in the identified research papers. As a result, the methods employed in both system-centered and user-centered studies were analysed and contrasted to report on possible emerged variations or preferences (see Table 3). In this context, the system-centered studies employed mainly quantitative methods such as Log analysis and Questionnaires whereas user-centered studies used mainly qualitative methods such as Interviews and Think aloud protocols (see Table 3). Finally, an analysis of the type of method employed each year did not reveal any significant findings (see Table 4).

A further analysis of the identified literature revealed that the nineteen papers fall into four types of publications namely journal articles, proceeding papers, reports and theses (see table 5). In an attempt to identify possible preferences for a specific source of publication, it was found that the majority of journal articles were published in *"Journal of the American Society for Information Science & Technology"* and *"Information Processing & Management"* (see Table 5). Finally, no preference to a specific type or source of publication was identified for the papers assigned to the two emerged themes of user-centered and system-centered studies (see Table 6).

3 Professional Search and Users' Behavior

For many years the development and evaluation of IR systems was the main focus of research. In this context, a variety of techniques regarding all steps of system development were adopted and tested with the view to enhancing their efficiency and effectiveness. Users assisted in the evaluation phase by judging the relevance and thus effectiveness of the data retrieved in predefined, task-based searches [28]. In most cases, users were not excluded or had minimal involvement in the development process. When they were involved, their main role concerned the improvement of system efficiency with little, if any, attention paid to users' behaviors and experiences.

For a long period, the same applied to the evaluation phase. Statistical techniques based on the use of a test collection were used to calculate the precision and recall of the retrieved results drawing on users' assessment of the relevancy of the retrieved hits. Even when users were considered, again the focus was on evaluating the system's overall performance rather than exploring users' search behaviors and system interpretation [24], [25]. Imaginary scenarios and pre-defined subject areas were given to users to search for and judge the relevance of the retrieved results. The concept of the 'simulated' user task [29] helped open up the field to allow both the evaluation of the system performance as well as the investigation of the user's behavior whilst conducting the search. However, at the same time, the distinct separation of the literature on users in retrieval system evaluation and in the study of information search behavior continued to be highlighted and questioned [30].

The complex patterns of users actions and interactions while seeking information of whatever kind and for whatever purpose is defined as Information Seeking Behavior (ISB) [31]. ISB is derived from the field of user studies and as such it can be traced back to scientific communication and information use studies. Its usage has altered over the years following developments in that field. In the beginning, the term ISB was used to refer to scientists use of formal and informal communication channels and relied in the main on quantitative methods.

ISB is a subfield of Information Science (IS) and belongs to the study of information behavior. Research in this field can be divided into three time periods: a) 1960-1985, b) 1986-1995 and c) 1996 and onwards. In the first period, four categories of study can be distinguished: user studies, use studies, information behavior studies and studies of information dissemination with a focus on information service and quality. In this context, the object of study was usually scientific behavior. Scientists seeking scholarly information tended to be the main focus of inquiry. Accordingly, the first model of information seeking regarded the user as a researcher affected by a variety of systems (see Paisley [32], Allen [33]). This model was further expanded and became more general and typically consisted of three components: the user domain, the information systems domain and the information unit domain (see Wilson [34]). This model suggested the possibility that information seeking and retrieval might be different depending on the technologies employed and on the information needs of the user. Most notably, it revealed a distinction between seeking information from human sources and retrieval behavior from information systems. Nevertheless, underpinning it was the assumption that rational information seeking behavior could be generalized to all domains. As a result, the model predicted that information retrieval would depend on information needs- and emphasized the need to investigate information needs by eliciting the reasons why users were acting in a specific way (see Taylor [35], Wilson [34]). We can characterize this research as information theoretic. That is, it is predicated on the assumption that information seeking and retrieval behavior will depend on need formation and development. Put simply, users may have specific information needs but their ability to find the information they require may be compromised in various ways. Thus and for

instance, interview techniques were used in the context of information seeking (see Ingwersen [36]) in terms of an Anomalous State of Knowledge (ASK) model (see Belkin et al. [37]).

The second period was characterised by a variety of empirical studies and activity models of information seeking processes. In particular, the sense making approach to information seeking was introduced (see Dervin and Nilan [38]) encompassing the notion of knowledge gap and the information needed for bridging the gap between information situation and solution [31]. Another approach introduced in this period was the empirically based phenomenological six-phase model (see Kuhlthau [39]). This model predicts that information needs and hence information seeking behavior will depend on the work tasks associated with different domains and the problems associated with them. The six-phases consist of the following: initiation, selection, exploration, formulation, collection and presentation.

At the same time, an empirically based stage-like model was introduced encompassing eight consecutive and interacting features (see Ellis [40]). This approach also integrated work task into the model (see Jarvelin [41], Bystrom and Jarvelin [42]). Models of this kind, then, rely less on highly generic views of information seeking behavior and rely more on versions of cognitive task analysis to distinguish behaviors in different domains. They nevertheless remain committed to the general rationalistic assumption that behavior is best understood through goals-means hierarchies.

The third period of research in ISB attempts to integrate information seeking and IR research by formulating comprehensive models or frameworks and to merge already developed information seeking models. In addition, longitudinal studies of information seeking were introduced (see Wang and White [43], Vakkari [44]). In this context, a four-dimensional episode framework focusing on sixteen information seeking strategies was introduced (see Belkin et al. [45]). Work task perception, introduced in Ingwersens cognitive model connects information seeking processes in the social and organisational context to the retrieval process. Users' perception of work task is what triggers the problem situation leading to a variety of information needs (see Ingwersen [46]). As a result, the integration of work task-based information seeking and IR is done for the purposes of the design and performance of IR systems. These models typically provide the context in which studies of user information seeking take place. Therefore, relevant studies are extensive spanning key professional domains of academic documents search, library book search, patent search, medical/legal document search.

This broad characterization of research periods can be associated with the adoption of different methods. Mainly quantitative methods were employed in the first period; methods such as questionnaires and interviews, regardless of their drawbacks. During the first and second period, there was a slow progression to more qualitative methods such as observation, diaries, critical incident analysis, talking and think aloud protocols, and so on. During the 1990s, and drawing on a more explicitly sociological literature, Discourse Analysis [47] and

Grounded Theory (GT) [48] were introduced for data collection and analysis. These moves were predicated on the recognition that context informed behavior, that context in turn was defined by the meanings that people ascribed to the situations people found themselves in (an insight which derives in the main from Chigaco- school symbolic interactionist sociology [49]) and that the discovery of context meant that the generation of theory, especially of the abstract kind, was problematised.

The shift to attention to users thought processes and understanding of system's functionality occurred when there was interest in developing interactive applications, in which it was intended that user and computer collaborate and exploit the strengths of each to search more effectively [50]. Interactive information retrieval can be divided into three stages: query formulation, search and browsing [50]. In this context, two types of studies exist in the literature [51]: a) the system-centered; that is, the studies which focus on exploring systems performance by recruting users to judge precision and relevance of the retrieved results, and b) the user-centered; that is, the studies which focus on the behavioral and cognitive aspects of users while searching and the way users interpret system's functionality. In this context, an indicative review of the papers published during 1994 to 2012 is critically presented below grouped under the headings of, system-centered and user-centered studies as defined above.

3.1 System-Centered Studies

System-centered studies employed professional users mainly during **evaluation phase**, users judged the **relevance of results** and **the effectiveness** of the systems. In particular, Spink [52] reported on a classification search term index which was developed based on users' judgements of the search terms relevance. The study employed an online interview and recorded the searches of forty professional searchers using the DIALOG database system. Analysis of log files was also conducted as a means to measure precision. It was found that search terms retrieved during term relevance feedback were more effective than those of the intermediary and database thesauri. In the same context, Spink, Goodrum & Robins [53] explored elicitations, that is verbal requests for information recorded in a triad dialogue-based model of information retrieval. Think aloud protocol was employed to explore professional searchers' actions on DIALOG. In addition, log-linear analysis was also used to observe the transitions between users' elicitations and their transactions performed. They were able to identify the different type of requests based on the elicitations of search intermediaries. In particular, these requests consisted of information on search terms, strategies, database selection, search procedures, system's output and relevance of retrieved results, users' knowledge and previous experience in searching. Based on the recorded elicitations, they could infer that systems developed to support the transactions were able to improve their perfomance.

Systems' **usefulness** and **performance** was the main focus of Tan [16]. Specifically, Tan [16] developed and tested a term relevance tool called Tag and Keyword (TKy) installed in a Web browser. It was thought to assist query

reformulation and thus reduce browsing. In this context, quantitative methods were employed to identify statistical significance in query reformulation and web browsing. In addition, interviews were conducted to gain an insight into users' opinion over the specific web tool and its usefulness. Tan [16] formulated four statistical hypotheses examining whether TKy increased query formulation, decreased viewing of search result pages, web sites and web pages. The study revealed that the TKy tool shifted users' search behavior from browsing to focused searching. In addition, users reported that the tool was useful and it saved time in finding information. In the same context, Kohn et al. [5] investigated the notion of professional search and why it differed from "public search". In addition, they presented the professional search prototype YASA (Your Adaptive Search Agent) and described the initial results gained through evaluation studies. Log analysis was conducted to measure the relative use of external and in-house search engines. Kohn et al. [5] found that in-house search engines were used less than external search engines. Google was the predominant search engine mainly because of its ranking performance and access to PubMed, US patents and Wikipedia. In contrast, low usage of the Google Search Appliance that indexed an in-house file share was found mainly due to the manual log-in and unsatisfying ranking results it provided. In terms of YASA, Google remained the first search engine used but YASA surpassed all the rest. However, authors agreed that log analysis was not enough to reach safe conclusions and further evaluations by conduting user studies and surveys were needed.

In the **medical search** context, Vibert et al. [27] explored the search strategies and behavior of professional searchers on PubMed. In particular, sixteen non professional and sixteen professional searchers were asked to perform five searches for references concerning neuroscience topics. Questionnaires were employed to collect data about users' characteristics, search experience and previous knowledge of PubMed. Think aloud protocols were adopted to shed light on users' search actions and strategies. However, the focus was placed on measuring the effectiveness of the system rather than on the users' behaviors. In particular, it was found that the neuroscientists could find a sufficient number of references in the time frame provided regardless of their previous knowledge of PubMed. Life scientists with lack of knowledge in neuroscience were also able to identify a sufficient number of references. However, differences between the search behaviors of the two types of subjects were identified. Specifically, life scientists needed more time to go through the task instructions and review more abstracts before selecting the necessary references.

In terms of **audiovisual material**, Huurnink [54] examined the creation of automatic shot descriptions for audiovisual records. Log analysis was employed to analyse the purchase orders of audiovisual material, catalogue metadata and the thesaurus created for this purpose. The aim was to explore the specific terms adopted by professional searchers to retrieve audiovisual material for reuse in new productions. It was found that professionals searched for program names, person names, general subject words, locations and other names, document, identifier codes and technical metadata. Extending this research, Bron et al. [55] tested

the efficiency of test tools developed for professional archivists being used by the general public online. In particular, they conducted a small-scale study with non-professional searchers performing exploratory search tasks on the Netherlands Institute for Sound and Vision (S&V), the Dutch national audiovisual broadcast archive. They argued that the search tools developed in archives were intended for professional searchers who understand the structure of the archival metadata. As such, non-professional users would find it difficult to adopt these tools and successfully retrieve the necessary information. Twenty-two first year university students carried out the searches using the advanced search mode. At first instructions on the study and a tutorial of the search interface were provided to participants. Then three specific tasks were assigned to users and a limit of fifteen minutes per task was given to complete the searches. Bron et al. [55] recorded users' search behavior and asked them to fill in a questionnaire after completion regarding their experiences with the interface.

The findings of the study were based on the results from the completed questionnaires and correct answers to the task. It was found that low precision of the retrieved results indicated that users had difficulty in finding the correct answers in the time frame given; searchers could not judge the correctness of an answer based on the metadata presented and that the amount of support offered for searching on the interface was marginal'. Users' behavior was judged based on performance. As such two groups were created based on performance, high and low performance groups. Both groups had an equal number of assigned users, eleven; either lower group did not use specific search interface components whereas the high performance group tended to go to program description pages more often but staying less time than the low performance group. Overall, it was found that there were differences in search behavior based on user's performance.

Evaluation of **clustering techniques** was another area of interest. Specifically, Jain & Mishne [11] proposed that users' professional searches would benefit from ordering word suggestions based on high-level of user intent rather than on predicting the next letters or words based on likelihood. As such they conducted a set of small-scale studies where users were employed to test and evaluate the clustering techniques. In particular, users were employed to express a preference for specific clusters and evaluate the automatic and manual clustering techniques. It was found that users' satisfaction can be substantially increased by extending the assistance layer so as to effectively group suggestions and label them. Finally, Lamm [6] focused on measuring the quality of search systems using the confirmation/disconfirmation (C/D) model that described user satisfaction. Two studies were conducted to explore the effects of users' expectations on the way systems were perceived. The users were introduced to the system and false expectations were created so as to guide users' expectations to either high or low expectations. Users were divided into four different groups which differ in expectations and system quality. Questionnaires were employed to measure users' satisfaction. Two questionnaires were distributed including statements regarding ease of use, efficiency, output display, precision, ranking of results, result quality and reuse probability. Measurements such as recall and precision were

also employed to evaluate users' and system's performance. Log analysis was also employed to identify users actions and judgements of relevancy based on their retrieved results. It was found that user's expectations were both dynamic and context dependent while agreeing that further research was needed to establish reliable methods to measure user satisfaction and performance in an information retrieval environment.

3.2 User-Centered Studies

As opposed to the system-centered, user-centered studies focus on users' cognitive thoughts, perceptions and understanding of system's functionality. As such, knowledge of the user context creates potential for improving a system's overall efficiency and ultimately users' experience [56]. In terms of **evaluation**, Barry [57] performed an evaluation study in which she asked 18 students from Louisiana State University to judge the relevance of retrieved results. A set of 242 documents were provided to students who circled the portions of each document they thought relevant to pursue searching but also which they judged as irrelevant. Then interviews with the participants were undertaken inquiring about the reasons why each participant had circled a portion of the text. Barry [57] found that the main criteria of relevance were information content of documents; the user's previous experience and knowledge; the user's beliefs and preferences; other information and sources of information within the environment; sources of documents; the document as a physical entity; and the user's situation.

In the context of **interactive information retrieval**, Spink & Goodrum [58] explored the notion of encoding and external storage (EES) processes performed by professional users during mediated, interactive information retrieval. An emphasis was placed on the notes taken by professional searchers while performing a search. A micro-analysis of the notes recorded by four librarians acting as search intermediaries were analysed. They found that subjects were extensively using encoding and external storage (EES) processes whereas three types of working notes were created such as textual, numerical and graphical. Creation of working notes was identified as the fundamental element of the mediated, interactive information retrieval process. Building on this, Spink et al. [66] explored the search process of mediated information retrieval performed by professional searchers. Their goal was to record information search behavior and to identify the procedural changes and shifts in users' behavior. A mixture of methods both qualitative and quantitative was employed. In particular, three questionnaires were adopted to assist pre and post interviews, interviews were conducted both after the searches to identify specific reasons for changing search behaviors, as well as a follow up after a couple of months of the searches. The searches on the DIALOG Information service by professional searchers were audio taped and transaction logs were analysed. Spink et al. [66] were able to identify the specific users' actions while searching for information as well as the changes occurred in user's behavior over time. In particular, for each situated action, levels and regions of relevance judgements as well as other user judgements were identified.

They also found that users spent more time on performing an action, deciding and making judgements than interacting with IR or other systems.

Furthermore, Bains [59] tried to identify **an effective way of measuring the impact** of novices on interactive search retrieval systems developed for professional searchers. A variety of quantitative and qualitative methods were employed. In particular, questionnaires were used to record users' experiences and characteristics, observation to look at specific elements of users' information search, analysis of search strategies and finally interviews to inquire about users' specific reasons for employing specific search behaviors. Bains [59] discussed the advantages and disadvantages of each method in an attempt to propose a specific methodology for exploring professional searchers search behavior. Extending this research, Vibert et al. [27] explored the search strategies and behavior of professional searchers on PubMed. Specifically, they identified possible factors affecting the bibliographic search performance of life scientists. Previous experience and knowledge of the database, non domain-specific knowledge, significant difference of number of references provided, general cognitive abilities and user's age were identified as the factors significantly correlated with users' performance. It is evident, that factors apart from the system itself affected users' search behavior such as domain knowledge, cognitive abilities. These factors are directly related with the user and therefore, provide a valuable insight into users' thought processes while searching.

Building on this research, Tucker [3] investigated **the learning experiences** of information professionals and **acquisition of expertise** while searching for information. An emphasis was given to novices who aimed to acquire expertise and develop searching skills and knowledge. A mixture of both qualitative and quantitative methods was adopted to capture users' information search behavior and thought processes. In particular, think aloud protocols were employed to explain the actions and the reasons provoking specific search behaviors; interviews to further explore the reasons behind users' behaviors; and screen capture software so as to video tape the specific search behaviors of all participants. Finally, Grounded Theory was employed to identify conceptual knowledge and attributes of professional searchers. Tucker [3] identified six emerged categories describing users' search behavior such as "Broad view", "Subject domain", "Nature of Learning", "Qualities/approaches", "Tools/search knowledge", and "Work-related experiences". Threshold concept theory was employed to further justify users' search behavior. In particular, three major themes were identified such as **Concepts** adopting the attributes of threshold concepts; **Praxes** which incorporated practices, approaches and strategies; and **Traits** which referred to qualities, characteristics and attitudes.

Moreover, Iivonen & Sonnenwald [60] proposed **a model for term selection** during the information retrieval process. Thirty two professional searchers were asked to form queries based on real-life search requests. Interviews explored users' reasons for formulating the specific queries and thus search behavior. They were able to identify **six different discourses** that are users ways of talking and thinking about a certain topic. These discourses consisted of controlled

vocabularies, documents and the domain, the practice of indexing, clients' search requests, databases and the users' own search experiences. Analysis of the selection process on the basis of different discourses provided another view on the way users' select of specific search terms. Building on this, Patterson et al. [61] **modelled the potential vulnerabilities** in inferential analysis under different conditions. Ten professional searchers were asked to analyse a request outside their base of expertise. The methods of think aloud protocols to capture users' search strategies and interview to identify users' characteristics and previous experience were employed. The use of software features was explored as a mean to understand the professional searchers' behaviors and reasons why they searched in specific ways. Patterson et al. [61] found that these users were prone to use narrow tactics and refine their initial results so as to reach a manageable volume of results. These results were treated as a base failing to perform additional searches or expand the results in other ways. In addition, the users articulated three different types of inaccurate statements such as assumptions that that did not apply, the incorporation of inaccurate information and reliance on outdated information. Furthermore, some of these users' adopted strategies in an attempt to reduce inaccurate statements. However, these proved to be difficult, resource-intensive and time-consuming. Finally, users presented a prematurely closed analysis process. As a result, professional searchers could degrade the quality of the final outcome, respond less effectively to the question and feel less confidence of the final outcome.

In addition, Ehrlich & Cash [62] explored **the richness** and **complexity** of professional searchers behaviors with the view to inform development of software tools. Observation of these users' search strategies as well as interviews were conducted in order to gain an insight into users' search behaviors. They found that the experience and expertise of intermediaries performing the professional searches was often invisible to the company in which they worked. Moreover, Robins [63] investigated the information problems while interacting with retrieval systems and how professional searchers change their focus during interactions. Observation was employed to record conversations between real users and professional search intermediaries while interacting with the system and performing the searches; and think aloud protocols to gain an insight into real users' and professional search intermediaries' perceptions and thought processes. Robins [63] argued that users and search intermediaries collaborate to achieve search goals in a nonlinear way. Discourse analysis showed that they changed topics on average every seven utterances. Six major focus categories of these utterances were identified such as documents, evaluation of search results, search strategies, IR system, search topic and information about the user.

Finally, Gschwandtner et al. [64] explored the information needs and search behavior of **health professionals** in the context of the KHRESMOI European Union project. The quantitative method of questionnaires was employed to explore internet access, information needs, and adoption of online resources, barriers in online searching, preferences and information search behavior. They found that physicians searched for information on drugs, treatment and medical

education and empoyed mainly widely known search engines such as Google. In addition, specialists searched for information about clinical trials and expressed a preference for medical databases and professional society websites. Both physicians and specialists needed immediate and up-to-dated information. They employed search terms and were prone to go through the first three pages of the results clicking on the most relevant results. Date range and language were the main two features employed while on advanced search. Quality was judged based on source and date of last update. The ideal search engine for these users would provide access to relevant and trustworthy results.

4 Discussion

Users' information search behavior in a professional search environment is a research area of growing interest. As such, a variety of studies have been conducted exploring the characteristics of a professional search from different perspectives. The majority of studies focused on the development of systems [5], [6], [7], [8], information retrieval techniques [9], [10], [11], [1] and models [19], [20]. As such, little attention has been given to users' and their search behavior and strategies for addressing their professional information needs.

In this context, two types of studies were identified. System-centered studies employed professional users but focused on measuring systems' performance [16], [5], precision and recall [55]. As such, professional searchers were employed to judge the relevance of retrieved results and assist the work of developers and evaluators to create efficient and effective information retrieval techniques [52], [27], [6], [11], [55]. Users' behavior was documented as a sequence of searches and clicks used as a basis to extract results on systems' performance and as a way to enhance retrieval techniques [16], [52], [5]. User satisfaction was solely judged based on system's performance and amount and relevance of retrieved results [16], [55]. The same applied for all contexts of search (archival, medical) and systems [27], [54].

Log analysis was the main method employed to explore users' search actions and behaviors [52], [53], [5], [54], [6]. Analysis of the log files revealed valuable insight into users' search terms used, number of pages viewed in the search results, adoption of specific features of the system, time spent among others [6], [5]. However, there is a common belief that reliable evaluation methods are needed in system-centered studies to extract safe results on users' behavior and search strategies especially in the context of professional search environments [6], [5]. When qualitative methods were employed such as, interviews [16] and think aloud protocols [27], the focus again was on system's characteristics and performance.

In contrast, user-centered studies focused on professional users' search behavior and strategies with the view to gaining an insight into their thought processes while searching and retrieving relevant information. These studies employed mainly qualitative methods such as interviews, think aloud protocols, grounded theory, observation to explore users' search behavior [59], [61], [62],

[63], [66]. An emphasis was placed on the user, not the system, with the view to understand users' interpretation and experiences of the system and offer efficient and effective systems [57], [58], [60], [63], [66], [3].

This critical review is somewhat limited by the specific terms relating to professional search resulting in the nineteen papers found spanning two decades. Whilst this restricts the depth of the investigation, the findings discussed in this chapter serve to suggest that overall, there is still an emphasis on system development and evaluation based on measurements such as precision and recall. Users are employed to judge system's performance and effectiveness and thus mainly quantitative methods are employed. When interviews and think aloud protocols are adopted, they are used to extract quantitative data and thus are analysed as such. Professional users' search behavior in terms of their thought processes and experiences while searching is less explored. Although, when considered, the use of qualitative methods rather than quantitative is notable, placing an emphasis on understanding user search behavior through their thought processes, experiences and perceptions of the systems and of the search strategies developed to satisfy their information needs.

The methods used to study the user with respect to the 'system' performance, perhaps on the impact of a search tool or feature, thus focused on the users' activities or use of the system features in the process of finding information. In contrast, the methods used to study the user, particularly the professional searcher, focus on the cognitive aspects of the search, what the user is doing, or thinks they are doing, their resources and strategies and the impact the interaction has on them and their actions. In particular, identification of utterances [63] and discourse analysis [60], [63] provided a valuable insight into users' thinking and decision making. In addition, they highlighted the changes that occur over time in a users' behavior affecting decisions and as such search strategies. Factors affecting professional searchers behavior such as previous experience with the search interface, domain knowledge, cognitive abilities [27] were identified mainly due to the user focus in these studies and to the qualitative methods employed.

Understanding professional search is essential for the development of system and techniques designed to support this activity and, in this respect, the different approaches to the study of users are essential as well as complementary. This review, specifically distinguishes the research based on user evaluation of system effectiveness from studies of the information search behavior in a professional search environment providing a distinction into the methods employed. In addition to the potential aid in helping the work of system developers by outlining the methods adopted to examine users' behaviors in both system and user-centered studies, the review of these literatures side by side also provides essential insight into professional search behavior and the potential interrelation of system and user influences for the development of efficient and effective systems and retrieval techniques.

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5 Annex 1. Tables

Table 1. Year of Publication

Year	No. Paper	Papers
1994	1	Barry [57]
1995	1	Spink [52]
1996	1	Spink & Goodrum [58]
1998	3	Bains [59], Iivonen & Sonnenwald [60], Spink, Goodrum, & Robins [53]
1999	1	Ehrlich & Cash [62]
2000	1	Robins [63]
2001	1	Patterson et al. [61]
2002	1	Spink et al. [66]
2005	1	Tan [16]
2008	1	Kohn et al. [5]
2009	1	Vibert, Ros, & Bigot [27]
2010	3	Huurnink [54], Jain & Mishne [11], Lamm [6]
2011	2	Bron et al. [55], Gschwandtner, Kritz, & Boyer [64]
2012	1	Tucker [3]

In Table 1, the identified relevant literature was grouped according to year of publication. The years range from 1994 to 2012. In total nineteen papers were considered.

Table 2. Emerged Themes

A/A	Themes	No. Papers	Papers
1	System centered	9	Spink [52], Spink et al. [53], Kohn et al. [5], Vibert et al. [27], Huurnink [54], Jain & Mishne [11], Lamm [6], Bron et al. [55], Tan [16]
2	User centered	11	Barry [57], Spink & Goodrum [58], Bains [59], Iivonen & Sonnenwald [60], Ehrlich & Cash [62], Patterson et al. [61], Robins [63], Spink et al. [66], Vibert et al. [27], Gschwandtner et al. [64], Tucker [3]

In Table 2, the relevant papers were categorized in themes based on their expressed aims. As such, two themes emerged such as system-centered and user-centered studies. Both themes concentrate an almost equal number of assigned papers.

Table 3. Type of methods employed in each emerged theme

A/A	Themes	No. Papers	Papers	Methods
1	System centered	9	Spink [52], Spink et al. [53], Kohn et al. [5], Vibert et al. [27], Huurnink [54], Jain & Mishne [11], Lamm [6], Bron et al. [55], Tan [16]	Automatic multimedia content analysis, Interview, Log Analysis (2), Questionnaire (2), Role Specific ranking, Task, Think aloud protocols
2	User centered	11	Barry [57], Spink & Goodrum [58], Bains [59], Iivonen & Sonnenwald [60], Ehrlich & Cash [62], Patterson et al. [61], Robins [63], Spink et al. [66], Vibert et al. [27], Gschwandtner et al. [64], Tucker [3]	Content analysis (5) Grounded theory Interview (6) Observation (4) Questionnaire (5) Relevance Search strategy analysis Think aloud protocols (6)

In table 3., the methods employed in each emerged theme are illustrated. In terms of system- centered studies, Questionnaire and Log analysis was the most methods adopted whereas user- centered studies employed Interview, Think aloud protocols, Content analysis and Questionnaire. As such, the user- centered

studies adopted mainly qualitative methods whereas system- centered studies mainly quantitative.

Table 4. Methods employed per year

Year	Methods
1994	Content analysis, Interview, Questionnaire, Relevance
1995	Log analysis
1996	Content analysis
1998	Content analysis, Interview, Observation, Questionnaire, Search strategy analysis, Think aloud protocols
1999	Content analysis, Interview
2000	Content analysis
2001	Observation, Think aloud protocols
2002	Interview, Questionnaire, Think aloud protocols
2005	Interview
2008	Role-specific ranking
2009	Questionnaire, Think aloud protocols,
2010	Automatic multimedia content analysis, Log analysis
2011	Interview, Questionnaire (2)
2012	Grounded Theory, Interview, Observation, Think aloud protocols

In table 4., the methods adopted each year are illustrated. A mixture of both qualitative and quantitative methods were employed with no conclusive remarks over a specific tendency documented over the years to a specific method.

In table 5., the identified literature was further analysed based on type of publication. In particular, four type of papers were identified such as journal articles, proceeding papers, reports and thesis. The majority of the relevant papers were journal articles. In addition a tendency in terms of a specific journal was identified since five out of the eleven articles were published in the Journal of the American Society for Information Science & Technology and three in Information Processing & Management.

In table 6., the identified literature was further grouped based on specific source of publication. System-centered studies more often appeared in conference proceedings and theses, while user-centered studies more often appeared in journal articles and reports.

Table 5. Type of publication of each paper

Kind of Papers	**No. Papers**	**Papers**	**Specific source**
Journal article	10	Barry [57], Spink [52], Spink & Goodrum [58], Bains [59], Iivonen & Sonnenwald [60], Spink et al. [53], Ehrlich & Cash [62], Robins [63], Spink et al. [66], Vibert et al. [27]	*Computer Supported Cooperative Work (CSCW),* *Information processing & management(3),* *Journal of the American Society for Information Science & Technology(5),* *New library world,* *Western Journal of Nursing Research*
Proceedings paper	4	Kohn et al. [5], Jain & Mishne [11], Lamm [6], Bron et al. [55]	*Proceeding CIKM 10 Proceedings of the 19th ACM international conference on Information and knowledge management,* *IADIS International Conference WWW/Internet* *PQS'10, Proceedings of the 3rd workshop on perceptual quality of systems* *EuroHCIR, volume 763 of CEUR Workshop Proceedings,*
Report	2	Patterson et al. [61], Gschwandtner et al. [64]	
Thesis	3	Tan [16], Huurnink [54], Tucker [3]	

Table 6. Specific source of publication for each emerged theme

A/A	Themes	No. Papers	Papers	Kind of papers	Specific source
1	System centered	9	Spink [52], Spink et al. [53], Kohn et al. [5], Vibert et al. [27], Huurnink [54], Jain & Mishne [11], Lamm [6], Bron et al. [55], Tan [16]	Journal article (3),Proceeding paper (4), Thesis (2)	EuroHCIR, volume 763 of CEUR Workshop Proceedings, IADIS International Conference WWW/Internet, Information processing & management (2), Journal of the American Society for Information Science & Technology, PQS'10, Proceedings of the 3rd workshop on perceptual quality of systems, Proceeding CIKM 10 Proceedings of the 19th ACM international conference on Information and knowledge management, Western Journal of Nursing Research
2	User centered	11	Barry [57], Spink & Goodrum [58], Bains [59], Iivonen & Sonnenwald [60], Ehrlich & Cash [62], Patterson et al. [61], Robins [63], Spink et al. [66], Vibert et al. [27], Gschwandtner et al. [64], Tucker [3]	Journal articles (7), Reports (3), Thesis	Computer Supported Cooperative Work (CSCW), Information processing & management, Journal of the American Society for Information Science & Technology (3), New library world