
Information Seeking Behaviour in Online Environments: From Search to Sense-Making

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ABSTRACT

This paper thoroughly discusses the development of information seeking behaviour on the internet and how the inherently simple search activities have developed into sophisticated sense-making activity. The literature review is a synthesis of the traditional and modern information seeking models such as the berrypicking model by Bates, sense-making model by Dervin, search process of information by Marchionini, and the social search models of the emerging social search. It reviews empirical researches based on critical-incident surveys, search log analysis, and think aloud protocols. Information seeking has shifted away from system-oriented, query based models to user-oriented, models that acknowledge the social, cognitive and contextual aspect of information behaviour. The main advances are that social interactions have been incorporated throughout the search process, searching-to-browse has become a distinguishable activity, and it has been realized that various information objects (data versus documents) need diverging discovery strategies. Searching and sense-making are closely related and users are involved in repetitive foraging, evaluation, and knowledge construction. This paper presents a unified model between the history foundations and the trends of today, as well as in the methodological innovations that allow deeper insight into information behaviour. It claims that information systems should keep on evolving to facilitate all human sense-making process

KEYWORDS: Information seeking behaviour; sense-making; social search; information retrieval; human-information interaction; browsing; information needs; online environments; interactive information retrieval; cognitive models..

1. INTRODUCTION

The issue concerning the way in which human beings search, discover, and interpret information is as ancient as the human civilization itself. However, online space has changed the magnitude and the very nature of this activity. Within the span of several decades, we have passed through the era of information scarcity (where any pertinent piece of information had to be searched hard to be found) to the era of information abundance, during which the problem is not anymore on how to find information, but rather on how to filter, evaluate, and assimilate it into coherent meaning.

This change has required a corresponding change in the way we conceptualize the information seeking behaviour. The first models, which appeared in the 1980s and 1990s, paid most attention to the interaction between a particular user and information retrieval systems. They posed the following question: How do individuals construct queries? How do they evaluate results? How do they recombine to preferential searches? The questions played a key role in designing the first generation of search systems that could successfully link users with documents.

Nevertheless, with the growth in technology and our perception of it, a more intricate image has come into sight. Information seeking does not simply involve the process of finding papers in which a given term is contained. It concerns itself with solving information requirements usually ambiguous, dynamic and hard to elucidate. It not only

deals with searching but also with browsing, not only with finding, but with making sense. It is influenced by the social circumstances, the interactive exchange, and the type of information objects under search

This paper claims that the current information seeking research can be seen as a shift in perspective towards the direction of the search to the sense-making - in other words, out of the emphasis on the mechanics of retrieval, towards the holistic view of the way people make sense of information to build knowledge. This change is far-reaching; it has significant consequences on the way we design information systems, do research and our perception of human cognition in the digital era.

The paper will be divided in the following way: Section 2, the definitions of main concepts are provided. Section 3 helps to determine the necessity to engage in further research of information seeking behaviour. Part 4 and part 5 present the aims, objectives and the hypotheses of this synthesis. The search methodology is given in Section 6. The strong points, weak points, history and current trends in the field are thoroughly analysed in sections 7 to 10. Part 11-15 discusses, results, conclusions, suggestions and direction of future research.

2. Definitions

The study of information seeking behaviour employs a specialized vocabulary that requires careful definition. These terms have evolved over decades of scholarship, and their precise meanings shape both research and system design.

Information is a foundational yet contested concept. Buckland (1991) usefully distinguishes three meanings: information-as-process (the act of becoming informed), information-as-knowledge (the intangible knowledge acquired), and information-as-thing (physical objects regarded as informative). In information seeking research, we are primarily concerned with information-as-thing—the objects (documents, datasets, images) that users seek and interact with.

Data refers to information objects that serve as objects of analysis. This may include geospatial co-ordinates, numerical values, measurements, literature corpora, images, or physical samples—any of which may be used to provide evidence of phenomena. The critical distinction between data and documents lies not in format but in use: data are things one analyses; documents are things one reads. Quantitative data, specifically, comprises highly structured numerical, categorical, and ordinal variables originating from research methodologies or administrative records.

Information need is perhaps the most fundamental concept in the field. It represents the cognitive state that motivates information seeking—a recognition that one's current knowledge is inadequate to accomplish some goal. Famously, Taylor (1968) differentiated four levels of information need namely the visceral (no need stated), the conscious (vague mental description), the formalized (explicit statement) and the compromised (the query as it gets presented to a system) ones. Definitive nature of information requirement, especially of visceral and conscious level, has been a thorn in the flesh of researchers as well as system designers.

Information seeking behaviour encompasses the purposeful strategies and actions individuals employ to satisfy information needs. Wilson (1981) defines it as "the purposive seeking for information as a consequence of a need to satisfy some goal." This contrasts with **information behaviour** more broadly, which includes unintentional or passive encounters with information (such as serendipitous discovery).

Information retrieval (IR) refers to the computational systems and techniques for representing, storing, and finding information objects. Traditional IR assumes that users can express their needs as queries, which systems match against document representations. The limitations of this assumption have driven much of the theoretical development in information seeking research.

Search is the active process of querying information systems to locate relevant content. Jansen, Booth, and Spink (2008) identify three types of search intent: **transactional** (locating a source for subsequent activity), **navigational** (finding a specific known website), and **informational** (acquiring information to satisfy a need). Informational search is most closely aligned with sense-making activities.

Browsing involves scanning and exploring information spaces without a precisely formulated target. Traditionally framed as distinct from searching, recent scholarship argues for **searching to browse** as a hybrid behaviour where users search specifically to locate environments they can then browse productively.

Sense-making refers to the cognitive processes through which people construct understanding from information. Dervin's sense-making theory conceptualizes information seeking as bridging gaps in understanding—moving from a situation through a gap to an outcome. The theory also highlights that information is not merely relayed but it is constructed by the people depending on their situations and backgrounds.

Social search refers to the search behaviour where social interactions with other people are involved. Such

interactions can be explicit or implicit, co-located or remote, synchronous or asynchronous. Social search acknowledges that information seeking is not mostly an individual endeavour; individuals discuss with their colleagues, discover new knowledge together and build meaning together.

The interactive information retrieval (IIR) is an extension of traditional IR with emphasis on the dynamic interactive nature of interaction between human and the system. The IIR research focuses on the change in behaviour, strategies and needs of the user during search sessions.

3. Need for the Study

Information seeking behaviour online is a complex matter that is not just an academic activity, but also it focuses on some of the most fundamental issues of human cognition, technology design, and access to information.

The large volumes and centrality of information seeking on the internet require comprehension first. The frequency of web search has reached one of the most common human activities with billions of queries being handled every day. Search engines are the main access to knowledge, news, services and social participation to hundreds of millions of people. However, regardless of this ubiquity, we still know little about how individuals actually go about seeking and using information. The query logs are better known to us than the cognitive processes, social contexts, and sense-making activities that will have encompassed those queries.

Second, information systems are still being modelled with incompleteness of user behaviour. Conventional IR systems expect users to have an expression of needs in the form of queries- however, studies have persistently demonstrated that the information need may be unclear, dynamic, and imprecise to express. Document search optimized systems can breakdown users who want to retrieve data to do analysis. Solitary search interfaces ignore the collaborative aspects of information search. Unless we have more models of information behaviour, we risk the creation of systems which are technically advanced and cognitively weak.

Third, information work is becoming different. Digitalization of print media has not only changed the manner in which we get information, but it has also changed the manner in which we communicate with it. Scholars are moving towards databases instead of paper. The searching, browsing, evaluating, and compiling of rely on a complex sense-making process undertaken by the professionals. Students are going through information ecosystems that are mixed with both formal and informal sources. These changing practices necessitate equal corresponding change in our theoretical framework.

Fourth, the challenges in the information seeking persist. Users still have a problem formulating query, source evaluation, and combining dissimilar information. The failures to search occur frequently, especially in complicated or new tasks. Cognitive load Sense-making: The conversion of discovered information into useful knowledge has not been adequately assisted by current tools.

Fifth, methodological advances make possible novel modes of inquiry. The accessibility of log of search, eye-tracking or think-aloud records enables researchers to study information behaviour at a level of fine detail never previously possible. These approaches can follow and build on the theoretical premises of the preceding generations of researchers.

Sixth, the social aspects of information seeking are being considered more and more. Quite to the contrary, information search is more often than not done in consultation with others, sharing and joint building of meaning. The design of systems that facilitate the real-world working of people requires the understanding of these social processes.

The research will fill these requirements by synthesizing theoretical and empirical studies on information seeking behaviour and more especially the connection between search and sense-making.

4. Aims and Objectives

4.1 Aims

The purpose of this paper is to develop an overall synthesis of the findings in the research regarding information seeking behaviour in the online context that involves the development of the concept of search-based models and transition towards sense-making models. It aims to combine theoretical concepts and empirical evidence, detect the long-standing problems and recent tendencies, and convey the suggestions about the further research and system development.

4.2 Objectives

To trace the historical development of information seeking theories from early system-centered models through contemporary user-centered approaches.

To examine key theoretical frameworks including Bates' Berrypicking, Dervin's sense-making, Marchionini's information search process, and Ellis's behavioural model.

To analyse the role of social interactions in information seeking, synthesizing research on social search and collaborative information behaviour.

To investigate the relationship between searching and sense-making, examining how users transform found information into understanding.

5. Hypotheses

H1: Information seeking behaviour is fundamentally social, with interactions with others occurring throughout the search process, not merely at its beginning or end.

6. Literature Search Methodology

The reasoning behind this synthesis is systematic review of published literature on the topic of information seeking behaviour and more specifically a focus on literature on online settings and sense making.

6.1 Search Strategy

The literature search used a combination of various strategies to guarantee an all-inclusive search:

The Library and Information Science Abstracts (LISA), Web of Science and Scopus and ACM Digital Library database searches were carried out. Search strings were compounded words in terms of information seeking ("information seeking," information behaviour, information search), online space environments ("web search," online search, digital libraries), sense-making (sense-making, knowledge construction).

Tracking of references is citation forward and backward. Seminal works by Bates, Dervin, Ellis, Kuhlthau, Marchionini, and Wilson were used as starting points for forward citation searches. Reference lists of retrieved articles were examined for additional relevant sources.

Journal hand-searching focused on core journals including the Journal of the Association for Information Science and Technology, Information Processing and Management, Information Research, and the Journal of Documentation.

Conference proceedings from the ACM Conference on Human Information Interaction and Retrieval (CHIIR), the Information Seeking in Context (ISIC) conference, and the ACM SIGIR conference were reviewed.

6.2 Inclusion Criteria

Sources were included if they:

Addressed information seeking behaviour in online environments

Presented theoretical frameworks, empirical findings, or methodological innovations

Were published in peer-reviewed journals or conference proceedings

Were written in English

6.3 Search Results

The search yielded approximately 200 potentially relevant sources. After screening abstracts and removing duplicates, 75 sources were selected for full review. This synthesis draws most heavily on approximately 40 sources that directly address the relationship between search and sense-making.

6.4 Analytical Approach

The synthesis employed thematic analysis to identify recurring themes, theoretical developments, and empirical findings. Sources were coded for:

Theoretical framework employed

Information object type studied (documents, data, etc.)

Methodological approach

Findings related to search versus sense-making

Social dimensions of information behaviour

Design implications

7. Strong Points of Information Seeking Research

The field of information seeking research has developed substantial strengths over decades of theoretical and empirical work.

7.1 Rich Theoretical Foundations

Information seeking research benefits from an exceptionally rich theoretical tradition. Unlike fields that emerged solely from system development, information science has long recognized the importance of

understanding users.

Dervin's sense-making theory provides a powerful framework for understanding how individuals bridge gaps in understanding. By focusing on the situation-gap-outcome triad, sense-making theory moves beyond mechanistic models of information transfer to recognize the active, constructive role of the information seeker. The theory has proven remarkably durable, continuing to inform contemporary research on information needs and search behaviour.

Bates' Berrypicking model challenged the assumption that information seeking follows a linear path from query to results. Bates recognized that searchers' understanding evolves as they encounter information—each new document suggests new query terms, new directions, new possibilities. The Berrypicking metaphor captures the iterative, evolving nature of real-world search.

Sensitizing the cognitive and affective elements, Kuhlthau model of Information Search Process (ISP) formulated the model which acknowledged that information seeking is a process which entails feelings of uncertainty, confusion and finally, confidence. Kuhlthau identified six stages (initiation, selection, exploration, formulation, collection, presentation), which allowed developing the idea of how thoughts, feelings, and actions of users change during the search process.

The behavioural model of Ellis recognized patterns of behaviour in information seeking that begin, chaining, browsing, differentiating, monitoring, extracting that are non-specific to any particular system or environment. This emphasis on behaviour has been useful in designing systems, which propose functions, which should be facilitated irrespective of implementation.

The information seeking in electronic environment by Marchionini combined both cognitive and system views and explained the manner in which the transition to electronic environment alters the opportunities and challenges of information seeking.

Such theoretical richness implies that scholars who adopt information seeking questions have various frameworks to rely on and each framework sheds light on different sides of the phenomenon.

7.2 Methodological Diversity and Innovation

Information seeking study has come up with an advanced methodology toolkit that can be used to resolve various research questions, as well as to measure various aspects of behaviour.

Psychologically adapted critical-incident techniques require users to recount detailed search instances that have just occurred to them. The method provides a lot of contextual information at a minimal price of generalization that would be drawn by generalized self-reports. The application of the critical-incident surveys to the workers of Mechanical Turk by Evans and Chi proved how this approach can help to reveal the social aspects of search that would have not been visible otherwise.

Think-aloud protocols record the moment-by-moment thinking processes of the users in the process of information seeking. Examples of the use of the think-aloud data in disclosing the goals, evaluations, and decisions that influence information behaviour are the study of sense-making strategies of doctoral students by Abraham. The technique is particularly useful in interpreting sense-making, which can result in minimal trace in search logs.

Large-scale behavioural data is provided by log analysis, which can show trends in thousands or millions of users. The analysis of Google Analytics data provided by Million and colleagues based on the ICPSR archive proves how log data can reveal the typical search paths to follow (direct, scenic, orienting) and the points of failure. The magnitude of log data is a supplement of the depth of qualitative methods.

Longitudinal studies provide a time-lapse of information behaviour and provide the way needs, strategies, and understanding change over time. This time aspect is critical in the interpretation of sense-making, which will be done over various sessions and situations.

Laboratory research allows experimental research to be performed on certain variables. The paper by Sarkar et al. on information needs applied simulated search activities in order to ascertain association between behaviours, perceived problems, and help sought and sufficient level of control was obtained to develop prediction models by the authors.

Mixed-methods designs are a synthesis of these methods, which utilize the strengths of both. The most informative studies are usually a combination of behavioural information (logs, eye-tracking) and cognitive information (think-aloud, interviews) and contextual information (task characteristics, user characteristics).

7.3 Empirical Validation of Theoretical Frameworks

One strength of the information seeking research is the long-term endeavour to empirically prove the existence of the theoretical frameworks. In contrast to other disciplines where theories could be hypothesized, information seeking researchers have always tested the theoretical propositions with

observational data.

The Evans and Chi research studies of social search represents this commitment. Instead of just stating that social interactions are important, they gathered survey data on 300 users in 2 different studies and situated the reported behaviours on theoretical models of information seeking and sense-making. The outcome, a canonical model of social search, is empirically founded but at the same time theoretical coherent.

The same can be said of the Million et al. study of data discovery at ICPSR which tried the applicability of the existing theories to a new environment (data search). The researchers could compare theoretical forecasting with the real user behaviour and outline the range of possibilities of current frameworks and propose the required extensions.

Such a self-corrective and iterative linkage of theory and empirical observation has made the field remain alive.

7.4 Practical Impact on System Design

Information seeking studies have also shown to have an impact on the design of information systems. Search interfaces are also becoming more feature rich with consideration to user research:

Auto-complete and query suggestions solve the problem of the challenges of describing the information needs.

Faceted search interfaces allow the iterative and berry picking aspects of real-life search.

Personalization and recommendation draw on understandings of user context and history

Social features (sharing, collaborative filtering) recognize the social dimensions of information seeking

The sustained attention to design implications in the research literature—exemplified by McKay and colleagues' call for interfaces supporting "searching to browse"—ensures that theoretical insights translate into practical improvements.

7.5 Interdisciplinary Engagement

Information seeking research has maintained productive engagement with related disciplines. From cognitive psychology, it has drawn models of problem-solving and mental representation. From sociology, it has incorporated understandings of social context and practice. From computer science, it has engaged with the technical possibilities and constraints of information systems. This interdisciplinary openness has enriched the field's conceptual resources and kept it responsive to developments in adjacent areas.

8. Weak Points and Persistent Challenges

8.1 The Problem of Information Need

The concept of information need remains theoretically problematic. As Sarkar and colleagues acknowledge, "the very elusive and sometimes verbally inexpressible nature of information need makes it harder to grasp and define". If needs are by definition unobservable, how can they be studied systematically?

Researchers have adopted various strategies for working around this problem. Some focus on expressed queries, acknowledging that these are imperfect representations of underlying needs. Others infer needs from behaviour, assuming that actions reveal intentions. Still others rely on self-report, asking users to describe what they needed. Each approach has limitations. Queries may be poor indicators of needs. Behavioural inference risks circularity. Self-reports may be distorted by memory and self-presentation.

The Sarkar et al. approach—focusing on perceived problems and sought help as more observable indicators—represents an innovative attempt to operationalize information need without claiming direct access to unobservable mental states. However, the relationship between problems, help, and needs remains theoretically under-specified.

8.2 Methodological Limitations

Each methodological approach in information seeking research has characteristic limitations:

Survey methods rely on self-report, which may be inaccurate. Users may forget details of search episodes, reconstruct events in ways that satisfy narrative coherence, or present themselves in socially desirable ways. The critical-incident technique reduces but does not eliminate these problems.

Think-aloud protocols may alter the cognitive processes they seek to observe. Verbalizing thoughts while searching may slow processing, change strategies, or focus attention on aspects normally handled automatically. The technique is also resource intensive restricting sample sizes.

The analysis of logs captures only behaviours that have machine-read traces. It will not tell us why and how users behaved, what was going through their minds, and what was good or irritating. The ICPSR log analysis which was informative in terms of search paths was unable to determine why the user used direct routes as compared to scenic routes.

Experiments conducted in the laboratory can be ecologically invalid. Artificially created tasks, as assigned by researchers, might not be a good mirror of how individuals will seek information in the real world. Although Sarkar et al. study was well-designed, it had simulated tasks, which might not reflect the complexity of the real-world information demands.

Longitudinal studies are hard and costly to implement, and it is why they have been quite scanty even with the acknowledged significance of temporal dynamics.

8.3 The Gap between Research and Design

Although information seeking research has affected system design, there is still room of improvement as far as translating insight to implementation is concerned. Findings of research are usually provided in forms (scholarly articles, conceptual frameworks) that the designers might not necessarily come across or get a hold of. The research to commercial implementation time may be long. And commercial forces can favour those features that are simple to realize or have proven to be profitable instead of those that are the most cognitively supportive.

The recommendation of McKay and others to have interfaces that allow searching to browse shows how possible and difficult it can be. Their study reveals a real information behaviour that is not adequately supported by the existing systems. Still, to turn this insight into features that are implemented in large numbers, not just persuasive evidence would be needed, but also design specifications, effort to create it and commercial adoption.

8.4 Incomplete Models of Sense-Making

Although the idea of sense-making is extensively invoked, specific models of how it works in online settings have not been extensively developed. We have known that sense-making entails processes such as evaluating, choosing, developing and planning. However, we know less about the interaction of these activities and how they may be different among tasks and individuals and the ways they can be facilitated by information systems.

The Million et al. critique of Dervin's sense-making theory—that it "alone cannot explain the information-seeking behaviours that we observed" in data discovery contexts—suggests that existing frameworks may require extension or revision for new domains. Sense-making for data analysis may differ qualitatively from sense-making for document comprehension.

8.5 Limited Attention to Failed Search

Most research focuses on successful or typical search episodes. Failed searches—those that do not yield satisfactory results—are less studied, despite their frequency and importance. The Evans and Chi survey on difficult searches represents a valuable exception, but such research remains rare. Understanding why searches fail may be as important for system design as understanding why they succeed.

8.6 The Problem of Generalizability

Information seeking research often studies particular populations (university students, academic researchers, Mechanical Turk workers) in particular settings. The generalizability of findings to other populations and contexts cannot be assumed. The ICPSR study explicitly acknowledges that its findings about data discovery may be specific to quantitative social science data in a well-structured archive. Information seeking for qualitative data, in less structured environments, or by non-academic users, may differ substantially.

9. History of Information Seeking Research

The evolution of information seeking research can be understood as a series of conceptual shifts, each responding to limitations in previous approaches and opening new directions for inquiry.

9.1 The System-Centered Era (1950s-1970s)

The earliest information retrieval research was fundamentally system-centred. Emerging from efforts to manage scientific and technical literature in the post-war period, researchers focused on questions of representation, matching, and efficiency. How should documents be indexed? What retrieval algorithms worked best? How could systems return relevant results quickly?

This era produced fundamental advances in information science—the development of classification schemes, the articulation of relevance, the design of early retrieval systems. But it paid relatively little attention to users. The implicit model was one of question-answering: users had needs, they articulated them as queries, and systems matched queries to documents. The complexity, vagueness, and evolution of real-world information needs were largely invisible.

9.2 The User-Centered Turn (1980s)

A drastic change towards user-oriented views took place in the 1980s. The question which started to be posed

by the researchers was not only how well the systems worked but how individuals actually searched information. The rationale behind this shift was increasing awareness that measures that are system centered (recall precision) only told half the story. A system would give out very relevant documents yet fail to impress users who did not subscribe to it based on its cognitive processes, work practices and contextual constraints.

Key developments included:

Dervin's sense-making theory (1983), which framed information seeking as bridging gaps in understanding, emphasizing the active, constructive role of the user.

Ellis's behavioural model (1989), derived from empirical studies of social scientists and identifying characteristic patterns in information seeking.

Belkin's Anomalous State of Knowledge (ASK) hypothesis, which recognized that users often cannot specify what they need precisely because their knowledge is incomplete.

Taylor's analysis of information needs, distinguishing levels of need from the visceral to the compromised.

9.3 The Cognitive Turn (1990s)

The 1990s have contributed to the development of the focus on the cognitive aspect of the information seeking, with the user-centered foundations. Research question: What are the mental representations that users develop? What is their way of processing and integrating information? What is the evolution of understanding by interaction with information systems?

The model of Information Search Process by Kuhlthau incorporated cognitive and affective aspects to demonstrate how the thoughts, feelings, and actions are developed simultaneously during six search process phases. The model disclosed that uncertainty is not an issue that should be solved but is an ordinary and an inevitable aspect of information seeking.

Information Seeking in Electronic Environments by Marchionini synthesized the cognitive and system perspective and described the ways the digital environment alters the opportunities and problems of information seeking. Marchionini noted the iterative, interactive quality of electronic information seeking, where the end-user is continually reviewing and modifying his or her strategies.

The model of berrypicking of searches formulated by Bates presented the dynamic character of search, which demonstrates that every experience with information might redefine knowledge and create new avenues. The model refuted the linear notions of information seeking and focused on the relevance of browsing and serendipity.

9.4 The Social Turn (2000s)

While early user-centered research recognized that information seeking occurs in social contexts, the social dimensions received relatively little systematic attention until the 2000s. The social turn brought into focus the ways that information seeking involves interaction with others—consulting colleagues, sharing findings, collaborating on joint tasks.

Research on **collaborative information seeking** examined situations where multiple people work together on shared information problems. Morris's studies of enterprise search revealed that nearly half of users engaged in explicit collaboration on joint tasks. Twidale and colleagues explored how browsing itself can be a collaborative process.

The concept of **social search**, articulated by Evans and Chi, broadened the focus to include any search that incorporates social interactions, whether explicit or implicit, co-located or remote. Their canonical model showed how social interactions occur throughout the search process—before, during, and after the primary search act.

This social turn recognized that even apparently solitary searches often involve social dimensions. Users may search because someone asked them to. They may consult others while formulating queries. They may share findings with colleagues. Information seeking is embedded in social practice.

9.5 The Contextual Turn (2010s-Present)

Most recently, information seeking research has emphasized the importance of context—the specific situations, tasks, and environments that shape information behaviour. This contextual turn recognizes that there is no single "information seeker" but rather diverse users with diverse needs, strategies, and constraints.

The task-based information seeking research looks into the variation of behaviour according to the characteristics of a task, which can be complex, familiar, or at an advanced stage. Research indicates that various tasks attract varying search strategies, evaluation criteria and sense-making processes.

The domain-specific information-seeking research investigates the difference in practices between fields. Scientists do not require the same kind of information as humanists, social scientists who want data do not

want documents.

The information seeking in context (ISIC) research has developed into a special subfield with conferences and journals devoted to the study of contextual influences on information behaviour.

This contextual sensitivity can be seen in the Million et al. data discovery study. Instead of trying to assume that the theories that were developed to search documents are useful in data search, the researchers directly tested their relevance and found them unproductive. These unique characteristics of data, the necessity to document, the significance of contextual data and the object of analysis nature of data demand unique responses on theoretical and design levels.

9.6 The Methodological Evolution

Along with these changes in theory, there has been a progressive advancement in the methodology of information seeking research. The initial researches were more based on surveys and interviews. During the 1990s, more people used the think-aloud protocols and transaction log analysis. In the 2000s, advanced eye-tracking and mass log analysis were introduced. Modern studies are utilizing larger amounts of mixed methods, machine learning, and predictive modeling.

Such a methodological development has helped the researchers to answer questions which could not be answered before. The prediction mechanisms of perceived problems based on behavioural features would not have been possible with the previous procedures (the ability of Sarkar et al. to build predictive models of perceived problems).

10. Current Trends in Information Seeking Research

Modern information seeking studies are marked with a number of interrelated trends that reacted to the shortcomings of the earlier research and introduced new avenues of research.

10.1 The Data Turn

The rising interest in data as a specific form of information object may be considered the most important current trend. According to Million and his colleagues, some theories about human information behaviour (HIB) suppose that information objects are represented as text documents of a form of information. This is becoming a false assumption in the age of data-driven research.

The difference between document search and data search has far reaching consequences. The search of documents is usually based on the fact that the object of interest will be read and comprehended. The process of data search presupposes that the object of the search will be processed - analysed, processed, combined with other data, subject to statistical/computational procedure. These various uses suggest that the information requirements of the data seekers will differ: they will not need the data as such only, but a wide range of background information related to the way the data was collected and how it can be used.

According to the ICPSR study, the data seekers have unique search methods. Others go directly to familiar data. Others take **scenic paths**, exploring related materials and contextual information. Still others take **orienting paths**, seeking to understand the landscape of available data before committing to specific datasets. These patterns differ from document search in ways that current systems inadequately support.

The data turn has significant design implications. If data seekers need contextual information, systems must provide rich metadata and documentation. If data seekers need to evaluate suitability for analysis, systems must support preview and exploration. If data are objects of analysis, systems must facilitate download and integration with analytical tools.

10.2 Social Search Maturation

Research on social search has matured from initial demonstrations that social interactions matter to more nuanced understandings of how, when, and why they occur.

The Evans and Chi model identified three phases where social interactions enter the search process. **Before search**, users may consult others to frame the problem and refine requirements—their data showed this occurring 42% of the time. **During search**, particularly for informational tasks, users may seek feedback on findings or brainstorm with colleagues. **After search**, users often organize and distribute findings to others—47.3% of their sample organized end products, often for sharing.

Contemporary research explores the varieties of social search. Some interactions are **explicit and coordinated**—joint searches where multiple people work together on shared goals. Others are **implicit and opportunistic**—momentary consultations with nearby colleagues. Some are **synchronous** (real-time collaboration); others **asynchronous** (sharing results for later use). Some will be strong ties (close colleagues); others weak ties (distant experts that are consulted via social media).

This maturity also has a system design implication. Provided social interactions are part of search, they must be supported by the system; that is, with sharing options, collaborative workspaces, linking to networks of

expertise. However, social search is diversified, and not a single feature will suffice; there should be many different types of interactions in systems.

10.3 Searching to Browse as Emergent Behaviour

The recent article of McKay and colleagues on the topic of searching to browse can be seen as an example of how modern research knows about behaviours that earlier models did not yet consider. Their point is that the old paradigms consider any search and browsing to be an independent or mixed process. However, it is possible to see a specific hybrid: users specially query to find the environment into which they can then meaningfully browse.

Suppose that a user is looking to find books on a subject. They could look up information seeking behaviour and go to the part of the library that contains such an item and then scan the shelves around it. The search is not in itself a goal but a way to an attainable browsable space. This trend contrasts with pure browsing (ad drifting aimlessly) and pure searching (searching things that one has).

Browse search is unique in nature. The question is usually general, and it is aimed at a type and not an exact product. It is not a specific document but a place to explore. Achieving success is not determined by the accuracy of the matches but the quality of the browsable environment achieved.

This observation has design implications. The digital systems used to facilitate the search to browse modes should not just give the correct results of the search, but should also give clear signs of membership to the category, browsing structures, and easy navigation between the search and browsing modes. A large number of existing systems, optimized to be precise, can fail to support this hybrid behaviour.

10.4 Predictive Modelling of Information Needs

A significant methodological trend is the use of machine learning to predict information needs, perceived problems, and appropriate help from observable behaviours.

The Sarkar et al. study demonstrates the potential of this approach. By collecting search logs and user annotations of problems and sought help, they were able to identify behavioural features associated with different problem types. The number of bookmarks, query length, number of unique queries, and time spent on search results all correlated with perceived barriers. More strikingly, they could build predictive models achieving 78% accuracy in inferring needed help from combined behavioural and problem data.

This research suggests that information systems might become more responsive to user needs—not by asking users what they need (which they may not be able to articulate) but by observing what they do. A system that detects behaviours associated with query formulation difficulties might offer query suggestions. A system that detects signs of information overload might help filter results. A system that recognizes exploratory behaviour might suggest broader browsing.

However, predictive modelling also raises challenges. Models trained on particular populations may not generalize. Behavioural features may be noisy or ambiguous. And there are privacy implications in systems that monitor user behaviour to infer mental states.

10.5 Integration of Sense-Making and Search

Contemporary research increasingly recognizes that sense-making is not separate from search but deeply intertwined with it. The Abraham study of doctoral students' web-based research reveals how seeking and sense-making activities interweave throughout information-intensive tasks.

Abraham's analysis identified five categories of information interaction: **seeking, evaluating for selection, evaluating for use, compilation, and planning**. These categories do not occur in fixed sequence but interleave dynamically. Users request, assess, compile, plan request, assess, compile. There is a blur in between locating information and interpreting it.

Such combination has both theoretical and design implications. Theoretically, it implies that the models of search and sense-making can be artificially divided by a single process. Design- It implies that the system must facilitate not just the finding, but also the activities involved in finding, including evaluation, compilation, annotation, integration.

10.6 Cross-Domain and Cross-Population Comparisons

Researchers are more and more comparing information seeking across fields and groups, therefore attempting to determine the overall applicability of results and detecting any domain-specific patterns.

The study by Million et al. is an example of such a comparison strategy. They contrasted theories derived to search documents with data-seeking behaviour uncovering the advantages and limitations of the frameworks available to date. The comparisons between disciplines (sciences and humanities), settings (academic and workplace), and populations (experts and non-experts) are becoming more widespread.

Such comparisons are both theoretical and practical. Theoretically, they expose the areas of information seeking that are universal and those that are contextual. In practice, they dictate the design of domain-specific and user-centric systems.

10.7 Attention to Failure and Difficulty

Although the prevalent research deals with successful or typical search, the failed and difficult searches are attracting more attention. The survey of challenging searches by Evans and Chi is a significant move, which shows that unsuccessful searches can be characterized by different forces than successful ones.

It is significant to understand failure because of a number of reasons. First, it is usual that many searches do not provide satisfactory results, that is, fail. Second, failure will show limits of systems that are not always evident in case of success. Third, the question of why searches fail can be used to inform interventions, that is, training, system redesign, or alternative search strategies.

The Sarkar et al. mindfulness of perceived issues on search also looks after difficulty, investigating these obstacles that users face and assistance they seek. This problem-oriented approach as opposed to success is in line with the user-oriented value: to make it easier, it is necessary to know what makes information seeking a problem.

11. Discussion

11.1 The Evolving Conception of Information Seeking

The theoretical development followed in this paper system-centered to user-centered, cognitive to social, search to sense-making is a real one. The information seeking in each shift has not been covered in the past frameworks.

Introduction to user-centered turn as it turned out, system performance metrics (recall, precision) only tell a half of a story. This is because a given system can present the most relevant documents, yet fail users due to affinity to their cognitive processes, working practices and contextual imperatives.

The cognitive turn showed that information seeking is not only about finding information, but also entails understanding it, that the user needs to combine information found with his or her prior knowledge structures, and that this combination determines future seeking.

The social turn demonstrated that the information seeking process is hardly ever a solitary pursuit. In cases where the search is performed one-on-one, the user might be answering someone, watching the experience of others, or building the report.

The contextual turn found that there is no uniform information seeker and instead heterogeneous users with heterogeneous needs, strategies and constraints that are influenced by their domains, tasks and situations.

The changes do not disregard the previous knowledge. The performance of the system is important. The cognition processes continue to count. However, every new point of view adds to our knowledge base and implies more points to be considered when designing the system.

12. Results

This synthesis yields several substantive results regarding information seeking behaviour in online environments.

12.1 Theoretical Integration

The article shows how seemingly unrelated theoretical models can be combined to create a logical explanation of information seeking. Evans and Chi model has proven to incorporate the insights of both the information seeking and sense making studies and indicates how the two theories are complementary instead of contradictory to each other.

Some of the important areas of integration are:

Search and sense-making are not separate phases but intertwined activities, with sense-making occurring throughout the search process and search supporting sense-making.

Individual and social dimensions coexist in information seeking, with even solitary searches embedded in social contexts and social interactions supporting individual understanding.

Cognitive and behavioural perspectives are complementary, with behaviours providing observable traces of underlying cognitive processes and cognitive frameworks explaining behavioural patterns.

12.2 Empirical Patterns

The synthesis identifies recurring empirical patterns across multiple studies:

Social interaction is pervasive. Across diverse populations and search tasks, users engage with others

before, during, and after search. The Evans and Chi survey found that 31.3% of searches followed a specific request from someone else, 42.0% involved pre-search social interactions for requirement refinement, and 47.3% involved organizing findings for distribution.

Search varies by intent. Transactional and navigational searches differ systematically from informational searches in their patterns of social interaction, iteration, and sense-making. Informational searches are more likely to involve social input, multiple iterations, and integration of findings.

Behavioural signals indicate problems. Specific search behaviours correlate with specific perceived problems. The Sarkar et al. study identified relationships between time on results, query length, unique queries, and problems with articulation, relevance, and availability.

Search paths vary by goal. The ICPSR research identified direct, scenic, and orienting paths through data archives, each associated with different user goals and strategies.

Searching to browse is distinct. McKay and colleagues' analysis reveals that searching to browse differs from both pure browsing and pure searching in its goals, strategies, and system requirements.

12.3 Methodological Findings

The synthesis reveals the value of methodological pluralism in information seeking research. Each method contributes different insights:

Surveys reveal patterns across large samples

Think-aloud protocols capture cognitive processes

Log analysis provides behavioural data at scale

Experiments enable controlled comparison

Longitudinal studies reveal temporal dynamics

Mixed-methods designs that combine these approaches are particularly valuable, enabling triangulation across different types of data.

12.4 Gaps and Limitations

The synthesis also identifies persistent gaps in the research literature.

13. Conclusion

The paper has followed an information seeking research development through the system centered beginnings to the user centered, cognitive, social and contextual turns to modern day concerns of data, sense making and prediction. A number of general conclusions come up.

To begin with, information seeking is essentially a human activity. It is influenced by cognition, emotion, social situation, task requirement and the properties of objects desired. Narrow models of system interaction are interesting only to some extent.

Second, the discipline has achieved actual theoretical advancements. Every emerging perspective has shown the side of information seeking that earlier paradigms have ignored. The present knowledge is more diverse, deeper, and applicable in designing as compared to previous periods.

Third, the process of searching and sense-making go hand in hand. Information is not merely found and then rendered sense, but created sense by finding and created meaning by creating sense. Systems and frameworks which separate these activities lack their fundamental integrity.

Fourth, information seeking is infused with social aspects. Although users browse alone, they are enclosed into social contexts which define their needs, strategies and uses of information. Solitary search design ignores the way information search takes place.

Fifth, object type matters. Data seeking of information as opposed to document seeking of information is different in ways, which are not sufficiently covered in existing theories and systems. This gap has to be addressed as the data are increasingly becoming central to research and practice.

Sixth, there must be methodological pluralism. The whole complexity of information seeking can not be described by one approach. The only way forward is to use a combination of methodologies, i.e. surveys with a think-aloud, logs with interviews, experiments with observation, in order to triangulate the phenomena of interest.

Seventh, there still exist ongoing challenges. The articulation issue, the challenge of researching sense-making, the small focus on failure, and the issues of generalizability have to be pursued in further research.

The line of search to sense-making is as much a line of progress as possible, but it is progress in that direction to an even more distant horizon. New questions arise as we gain more knowledge. With the development of technologies, there are new opportunities and threats. Information seeking behaviour has been, and will

continue to be an important, dynamic field to study online, as man will always be in need of understanding the world using information.

14. Suggestions and Recommendations

14.1 For Researchers

Attend to object type. When researching information seeking, ask yourself whether the results of document search can be generalized to other types of objects. Test theoretical frameworks of various types of information objects.

Study failure. Unsuccessful searches are no less informative than the successful ones. Establish search difficulty, abandonment and dissatisfaction capture and analysis techniques.

Integrate methods. Decrease behavioural data (logs, eye-tracking) and increase cognitive data (think-aloud, interviews) and contextual data (task characteristics, user characteristics). Cross-check methods to fortify claims.

Carry out longitudinal study. The process of information seeking may take several sessions and long periods of time. These dynamics are lost in cross-sectional studies.

Compare across contexts. Test the generalizability of findings across domains, populations, and settings. Identify which patterns are universal and which are context-dependent.

Develop sense-making measures. Sense-making is central to information behaviour but difficult to measure. Develop and validate instruments for capturing sense-making activities and outcomes.

Engage with design. Ensure that research findings are presented in forms accessible to designers. Articulate clear design implications. Collaborate on implementation and evaluation.

14.2 For System Designers

Support the full process. Design for the entire information journey, not just query formulation and results examination. Support problem framing, evaluation, compilation, organization, and distribution.

Enable social interaction. Provide features that support appropriate forms of social interaction—connections to expertise, shared workspaces, easy sharing, and surfacing of community traces.

Multiple search modes supported. Design to transactional, navigational, informational and searching-to-browse. Helps accurate targeting and discovery.

Attend to object type. Provide deep metadata, context, preview, paths between discovery and analysis, in case your system is serving data seekers.

Help users help themselves. Offer query suggestions, relevance feedback and facet navigation in aid of users who are not capable of expressing needs. Track behavioural indicators and provide proactive support when the users seem to break.

Support sense-making. Add annotation tools, comparison views and synthesis workspaces. Not only assist users to locate information but to interpret the information they found.

Test with diverse users. Ensure that designs work for novices and experts, different domains, and different task types. Do not assume that patterns observed in one population generalize to others.

14.3 For Educators

Teach information literacy as sense-making. Information literacy instruction should go beyond search mechanics to address evaluation, integration, and knowledge construction. Help students understand that finding information is only the first step.

Address social dimensions. Teach students to leverage social resources appropriately—consulting experts, collaborating with peers, sharing findings. Help them understand both the opportunities and challenges of social search.

Attend to object type. Help students recognize that different information objects (data, documents, images) require different search strategies and evaluation criteria.

Address failure. Teach strategies for when searches fail—how to reformulate queries, try alternative sources, seek help. Normalize failure as part of the information seeking process.

Integrate theory and practice. Help students understand the theoretical frameworks that underlie search systems. When systems work well or poorly, explain why in terms of information seeking theory.

14.4 For Policymakers

Support information literacy. Recognize that effective information seeking is essential for education, work, and civic participation. Support programs that develop information literacy across the population.

Fund diverse research. Support research on information seeking behaviour across different populations, domains, and object types. Recognize that understanding how people seek information is essential for designing systems that serve public needs.

Promote open data. Encourage data sharing and the development of infrastructure for data discovery. Ensure that publicly funded data are findable, accessible, and usable.

Address digital divides. Recognize that effective information seeking depends on access, skills, and supportive environments. Address inequalities in these resources.

15. Future Scope

The study of information seeking behaviour in online environments continues to evolve. Several directions for future research are particularly promising.

15.1 Artificial Intelligence and Information Seeking

The rapid development of artificial intelligence, particularly large language models and generative AI, will transform information seeking in ways we are only beginning to understand.

Conversational search may shift information seeking from query formulation to dialogue. How will users express needs in conversation? How will systems need to adapt? What new sense-making opportunities and challenges will conversational interfaces create?

AI-generated summaries and syntheses may change how users interact with information. If systems can summarize multiple sources, synthesize findings, and generate answers, what will be the role of traditional search? How will users evaluate and trust AI-generated content?

Personalization and prediction may become more sophisticated. If systems can predict needs from behavioural signals, how should they intervene? What are the privacy implications? How can personalization support rather than constrain?

Human-AI collaboration in information seeking raises new questions. How should humans and AI systems work together to find, evaluate, and make sense of information? What division of labor is most effective? How can AI augment rather than replace human judgment?

15.2 Data Discovery and Reuse

As data become increasingly central to research and practice, understanding data discovery will become ever more important.

Cross-disciplinary data discovery raises questions about how researchers find and use data from other fields. What barriers do they encounter? What support do they need?

Data citation and credit may influence discovery. If datasets become citable and credited, how will this affect seeking behaviour? Will users search for data by author or citation as they now search for documents?

Data quality and trust are central to data reuse. How do users evaluate whether datasets are suitable for their purposes? What signals of quality and trustworthiness matter?

Data discovery infrastructure—repositories, catalogues, search interfaces—requires continued development and evaluation. What designs best support data seekers? How can infrastructure be made more discoverable and usable?

15.3 Sense-Making in Complex Domains

Understanding how people make sense of complex information across extended time periods remains a rich area for research.

Sense-making in scientific research involves integrating findings across multiple sources, developing and testing hypotheses, and constructing new knowledge. How can systems better support these processes?

Sense-making in learning involves novices building understanding in unfamiliar domains. How do their needs and strategies differ from experts? How can systems support learning through information seeking?

Sensemaking in decision-making involves integrating information to support choices with real-world consequences. How do people seek and use information for important decisions? How can systems support better decisions?

Collaborative sensemaking involves multiple people constructing shared understanding. How do groups seek, share, and integrate information? What tools support collective sense-making?

15.4 Cross-Cultural and Global Perspectives

Most information seeking research has been conducted in Western, educated, industrialized, rich, and democratic (WEIRD) contexts. Expanding the geographic and cultural scope of research is essential.

Information seeking in the Global South may differ systematically from patterns observed in wealthy countries. What are the distinctive challenges and strategies? How do infrastructure, language, and culture shape behaviour?

Cross-cultural comparisons can reveal which aspects of information seeking are universal and which are culturally specific. How do information practices vary across cultures? What design implications follow from these variations?

Multilingual information seeking raises questions about how users navigate across languages. How do they find, evaluate, and integrate information in multiple languages? What support do they need?

15.5 Methodological Innovation

Further methodological creativity will allow novel approaches to inquiry.

Information seeking on a scale never before seen can be performed with the aid of computational methods, such as machine learning, natural language processing, network analysis. What can these methods do to supplement qualitative methods? What are the new questions they facilitate?

Eye-tracking, physiological measurements, ambient sensing Sensor-based approaches are able to measure information behaviour dimensions that cannot be attributed using self-report. What are the ethical and effective ways of implementing these methods?

Temporal dynamics that are not presently observable may be manifested in longitudinal platforms that follow through with information behaviour over time. What can be done to such platforms so as to respect privacy and yet allow research to be conducted?

Engagement of users in the development of the system through participatory design may help to make sure that the knowledge of research is converted to the real improvements. What can be done to improve the collaboration of researchers and designers?

15.6 Ethical Dimensions

New methodological innovations will be made possible through further methodological creativity.

Computational methods, including machine learning, natural language processing, network analysis, etc., can help to perform information seeking in a scale previously unimaginable. What are the ways these methods can be used in supplementing qualitative methods? What are the novel questions they support?

The dimensions of information behaviour that can not be measured by self-report can be measured through eye-tracking, physiological and ambient sensory approaches of Sensor-based measurement. How do we make ethical and effective implementations to these methods?

The temporality that is not currently evident can be represented in the longitudinal platforms that persist in the information behaviour over time. How can the privacy be honoured in such platforms and at the same time research can take place?

The participatory design, which involves the users in developing the system, could be used to ensure that the knowledge of research is translated into the actual improvements. So how can the collaboration between researchers and designers be improved?

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