Toward a Model of Collaborative Information Behavior in Organizations

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There is increasing interest in topics at the nexus of collaboration and information behavior. A variety of studies conducted in organizational settings have provided us with key insights about the collaborative aspects of seeking, retrieving, and using information. Researchers have used a range of terms, including collaborative information seeking (CIS), collaborative information retrieval (CIR), collaborative search, collaborative sensemaking, and others to describe various pertinent activities. Consequently, we lack conceptual clarity concerning these activities, leading to a tendency to use terms interchangeably when in fact they may be referring to different issues. Here, we offer *collaborative information behavior* (CIB) as an umbrella term to connote the collaborative aspects of information seeking, retrieval, and use. We provide the contours of a model of CIB synthesized from findings of past studies conducted by our research team as well as other researchers. By reanalyzing and synthesizing the data from those studies, we conceptualize CIB as comprised of a set of constitutive activities, organized into three broad phases—*problem formulation, collaborative information seeking*, and *information use*. Some of the activities are specific to a particular phase, whereas others are common to all phases. We explain how those constitutive activities are related to one another. Finally, we discuss the limitations of our model as well as its potential usefulness in advancing CIB research.

Introduction

Modern organizational settings are characterized by an increasing interdependence among actors, artifacts, and activities (Karsten, 1999). Work is rarely completed by individual actors working in isolation; instead, work is becoming more collaborative (Gorman et al., 2000; Reddy & Jansen, 2008). Furthermore, organizations have become information-intensive, but information is also fragmented across multiple actors, artifacts, and systems (Hansen & Järvelin, 2000, 2005). Therefore, collaboratively seeking, retrieving, and using work-related information have become common practices within organizations (Reddy & Dourish, 2002).

Until recently the collaborative nature of information seeking, retrieval, and use had not been a research focus, for a variety of reasons (Fidel et al., 2000; Foster, 2006; Hyldegård, 2009). First, various aspects of the phenomena were studied within different disciplinary silos. On the one hand, much of the research related to information seeking, retrieval, and use was conducted within the information science discipline. On the other, a significant portion of conceptual as well as technical studies of collaboration were carried out within the computer supported cooperative work (CSCW) and organizational studies disciplines. Because there has not been much cross-pollination among these different disciplines, the collaborative nature of information seeking—although very relevant to practice—was largely understudied. Second, researchers have often viewed information seeking from an individual user's perspective (Leckie, Pettigrew, & Sylvain, 1996) and have conceptualized it as an inherently individual activity (Ellis, 1989, 1993; Kuhlthau, 1991; Leckie et al., 1996; Wilson, 1981, 1999). For example, Wilson (1981) viewed information seeking as "the purposive seeking for information which arises as a consequence of the recognition of some *need* perceived by the *user*" (p. 4; emphasis added). Similarly, Kuhlthau's (1988) and Ellis's (1993) models also conceptualize information seeking as an individual activity. Such a

conceptualization not only has an underlying bias toward traditional interaction patterns between an individual user and a technology but also implicitly views organizational work as a series of individual activities (Reddy & Jansen, 2008). Therefore, our conceptual and technical approaches related to the collaborative dimensions of information seeking and retrieval are relatively underdeveloped. The underlying conceptualizations of information behavior within many information retrieval (IR) systems are still viewed primarily from an individual user's perspective. Consequently, these systems could not support the collaborative activities that are intrinsic to many information seeking and retrieval activities in organizational settings (Foster, 2006; Gorman et al., 2000; Reddy & Dourish, 2002; Sonnenwald & Pierce, 2000).

However, recently researchers have focused on how the concepts of collaboration and information seeking are interrelated (Gorman et al., 2000; Poltrock et al., 2003; Reddy & Jansen, 2008). There is growing interest in topics related to the collaborative nature of information seeking and retrieval, partly reflected in the increasing number of research studies published and workshops conducted in this research area (Fidel et al., 2000; Gorman et al., 2000; Hansen & Järvelin, 2005; Hertzum, 2008; Hyldegård, 2009; Karamuftuoglu, 1998; Morris & Horvitz, 2007; Paul & Reddy, 2010; Poltrock et al., 2003; Reddy & Dourish, 2002; Reddy & Jansen, 2008; Reddy, Paul, Jansen, Foster, & Twidale, 2009; Reddy & Spence, 2008; Shah, 2010a; Twidale & Nichols, 1998). In doing so, researchers have become cognizant of the difficulty of understanding one without understanding the other. They have also become aware that organizational work cannot be reduced to a series of individual activities and have recognized the need to move beyond traditional interaction patterns between an individual user and a technology (Golovchinsky, Morris, & Pickens, 2010; Golovchinsky, Qvarfordt, & Pickens, 2009; Morris & Horvitz, 2007; Shah, 2010a; Twidale & Nichols, 1998).

Despite the burgeoning interest, this is still a relatively young research area. Hence, researchers have used a wide variety of terms, such as collaborative information seeking (CIS), collaborative information retrieval (CIR), collaborative search, and collaborative sensemaking to describe the various activities and concepts. However, there have been very few attempts to synthesize these disparate, yet related, concepts and their associated research findings. The lack of any overarching framework or model that ties all of these activities together has led to a tendency to use these terms interchangeably (Fidel et al., 2000; Foster, 2006; Hansen & Järvelin, 2005; Shah, 2010b). As a consequence, researchers could miss the broader picture of how these sets of activities are related to each other. Because there is no consensus on what these activities are in the first place and how they relate to one another, findings from one set of studies on a particular activity might not be able to inform another set of studies centered on a different activity. These hinder efforts toward cumulative theory building. Moreover, as Shah (2010b) notes, "there is need to develop models that extend or augment single-person information-seeking systems and information-seeking behaviors into collaborative environments" (p. 27).

For all these reasons, we need to synthesize past theory and research pertaining to this research area. As a first step toward this synthesis, we propose using *collaborative information behavior* (CIB) as an umbrella term to connote the collaborative aspects of information seeking, retrieval, and use. We define CIB as the totality of behavior exhibited when people work together to (a) understand and formulate an information need through the help of shared representations; (b) seek the needed information through a cyclical process of searching, retrieving, and sharing; and (c) put the found information to use. As Olson and Olson (1997) stated, a common vocabulary is essential for cumulative theory building, which would in turn not only help us enhance our understanding of the research phenomena but also enable us to better translate research findings into workable design recommendations and sociotechnical solutions. Next, we develop the contours of a model of CIB by synthesizing the findings from past studies conducted by both our research team as well as other researchers. We conceptualize CIB to be comprised of a set of constitutive activities that are organized into three broad phases—problem formulation, collaborative information seeking, and information use. Some of the activities are specific to a particular phase, whereas others cut across all phases. We explain how those constitutive activities relate to one another. Later, we discuss the potential usefulness of our model in advancing CIB research. Therefore, we have two major goals:

1. To present an early model of CIB by reflecting on our research as well as that of others, highlighting the collaborative aspects of information seeking, retrieval, and use.
2. To suggest future directions for CIB research by identifying problem areas and unanswered questions within the extant literature and to develop suitable recommendations.

This article is organized as follows: In the following section we provide an overview of past research related to information seeking, sharing, and use. We also provide some background about individual and collaborative information behavior and draw a distinction between them. Next, we discuss the method that underlies our synthesis and model development. Then we present our three-phase model of CIB. We discuss the various activities that constitute CIB and explain how these activities interrelate with one another. We then identify research issues and open questions, problem areas and provide suitable recommendations for future research. Next, we describe some of the limitations of our model. We conclude by summarizing the key findings.

Collaborative Information Behavior

As noted by Vakkari (1997), one of the striking features about the research area of "information behavior" is its use
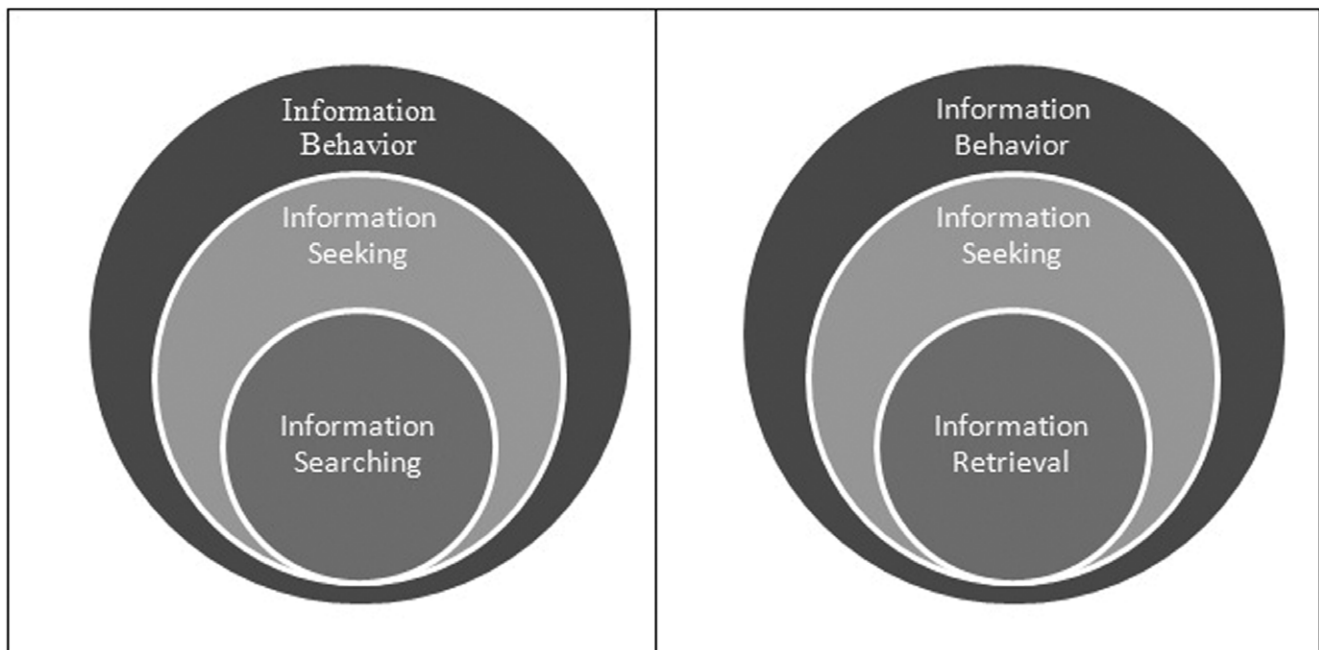
FIG. 1. The nested model of information behavior—Wilson's (1999) model (left) and Ingwersen and Järvelin's (2005) model (right).

of core concepts without concrete definitions. It is indeed difficult to define many of the core concepts such as "information" (Poteri, 2007). However, it would be helpful to provide a brief background about them because it will provide the reader with a frame of reference. So we start with the question, "What exactly is collaborative information behavior?" and attempt to trace its conceptual lineage.

Information Behavior

Wilson (1981) defined information behavior as the "totality of human behavior in relation to sources and channels of information" (p. 49). This includes both active as well as passive information seeking and information use. In general, information behavior involves the generation, acquisition, use, and communication of information. In that regard, Wilson viewed information searching, information seeking, and information behavior as hierarchical (Figure 1), placing information behavior at the highest level. "Information seeking" was viewed as the purposive seeking of information that arises as a consequence of some need to satisfy a goal (Wilson, 2000, p. 49). "Information searching" was considered to be the "micro-level" of behavior that emerges due to the interactions among various information systems (Wilson, 2000, p. 49).

However, Wilson (1999) did not incorporate "information retrieval" within his model because he argued that information retrieval occurs only within the larger information seeking-related processes. Ingwersen and Järvelin (2005) adapted Wilson's model (1999) to include information retrieval. Through this revised model, they established the

relationship between information behavior, information seeking, and information retrieval (Figure 1).

Other models of information behavior were also developed. These include Kuhlthau's (1991) six-stage Information Search Process (ISP) model, Ellis's (1989, 1993) eight-featured model of information-seeking behavior, Dervin's (1998) theory of sense-making, Leckie et al.'s (1996) model of professional information seeking, and many more. Table 1 provides a summary of some of these models.

IIB and CIB: Differences and Transition Points

The models listed in Table 1 viewed information seeking, searching, and retrieval as an intrinsically individual activity (Leckie et al., 1996) and, therefore, conceptualized information behavior at the individual level. For instance, Wilson (1981) conceptualized information seeking as an individual activity, which gets triggered when the individual user recognizes some information need.

We refer to such models as models of "individual information behavior" (IIB) because they have an underlying conceptualization that views information behavior primarily from an individual user's perspective (Wilson, 1981) and as an intrinsically individual activity (Leckie et al., 1996), largely ignoring the collaborative aspects of work and organizing. Reddy and Jansen (2008) state the following reasons for the dominance of IIB models: (a) a bias towards traditional interaction patterns between a single user and technology and (b) organizational work viewed as a set (or series) of individual activities; lesser emphasis was placed on the collaborative aspects of work.

TABLE 1. Dominant models of information behavior (adapted from Srivatsan, 2008).

Model	Description
Wilson's Model (Wilson, 1981)	Information need as a trigger for the overall information seeking behavior Information need is not a basic need, but part of process to satisfy three basic needs, namely *physiological, cognitive* & *affective*
Sense-making model (Dervin, 1998)	Information seeking is a sense-making process used by an individual actor to construct a bridge between a context and a desired situation
Professional information seeking model (Leckie et al., 1996)	Specific to a particular professional practice Roles and related tasks carried out by professionals lead to information needs, leading to information seeking. Importance given to intervening factors
Integrated model (Sonnenwald & Iivonen, 1999)	Outlines five facets that shape information behavior, namely—personality, matter, energy, space, and time
Process-oriented model (Ellis, 1989)	Multistage model - starting, chaining, browsing, differentiating, monitoring, extracting, verifying, and ending
Information Search Process (ISP) Model (Kuhlthau, 1991)	Process of construction that involves the experience of the person, feelings as well as thoughts and actions Activities include - initiation, selection, exploration, formulation, collection, and presentation
Information Retrieval (IR) model (Ingwersen, 1996; Saracevic, 1996; Spink, 1997) Task-oriented information seeking (Hansen, 2005)	Addresses the interaction between users and information retrieval systems that serve to satisfy human information needs *Work task* triggering the information needs; *information* seeking tasks embedded in the work task

However, there is now a growing number of studies that have looked at collaborative aspects of information seeking, searching, retrieval, and use (Attfield, Blandford, & Makri, 2010; Bruce et al., 2003; Fidel et al., 2000; Fidel, Pejtersen, Cleal, & Bruce, 2004; Foley & Smeaton, 2010; Hansen & Järvelin, 2005; Hertzum, 2008, 2010; Hyldegård, 2006, 2009; Karamuftuoglu, 1998; Prekop, 2002; Reddy & Jansen, 2008; Reddy & Spence, 2008; Sonnenwald & Pierce, 2000). One of the first definitions of the collaborative aspects of information (specifically, collaborative information retrieval) was proposed by a team of researchers from the University of Washington. They defined collaborative information retrieval as "activities that a group or team of people undertakes to identify and resolve a shared information need" (Poltrock et al., 2003, p. 239). Reddy and Jansen (2008) observed that there are two central concepts in this definition: (a) collaboration (i.e., two or more people working together to seek information) and (b) resolving an information need.

Reddy and Jansen's (2008) empirical study of two healthcare teams provided insights about the nature of CIB. In particular, findings from this study helped demarcate CIB from IIB. The first key distinction between IIB and CIB is the differing role that communication plays in each case. In IIB, communication between people plays an important but a limited role. It is primarily focused on asking questions and getting answers. However, in CIB communication plays a more central role that extends beyond just a "question and answer" exchange. It focuses "not only on questions and answers but also on tying together different pieces of information to find the answers" (Reddy & Jansen, 2008, p. 263), that is, involves ongoing information sharing and turn-taking among the collaborating actors.

The second distinction is the difference in the nature of triggers. Triggers are "an external event within the environment that initiates collaborative information behavior amongst a formal or informal group of people" (Reddy & Spence, 2008, p. 249). IIB has various triggers. For instance, Dervin (1998) offers suggestive evidence as to how the individual's need to bridge the gap between a context and a desired situation triggers the information-seeking process. CIB, on the other hand, has different types of triggers that arise due to the complexity of the "information" itself (Reddy & Spence, 2008) or due to the fragmented nature of the sought information (Reddy & Jansen, 2008). They could also occur due to a lack of domain expertise or lack of immediately accessible information (Reddy & Spence, 2008). Indeed, it is these triggers that initiate the transition from IIB to CIB. These insights on triggers are consistent with the findings offered by other researchers who have explored similar issues in various domains, such as physical and digital libraries, web search, patent processing, and so on (e.g., Hansen & Jarvelin, 2005; Morris, 2008; Twidale, Nichols, & Paice, 1997; for a review of these findings, please refer to Shah [2010b]).

Finally, the third major distinction between IIB and CIB is the role played by "information retrieval" (IR) technologies. In IIB, IR technologies act as an important—if not a primary—tool available for people to look for information. In the case of CIB, IR technologies again play an important, but only a supporting role. Using IR technologies is only a first step in a range of activities that follows to collaboratively find the needed information. These technologies act as mechanisms for coordination and collaboration that helps two or more individuals weave and make sense of the fragmented information. This, however, does not mean that people use IR technologies less during CIB activities. On the contrary, they may end up using IR technologies more often. But these technologies are only one "resource" among many others that actors use to collaboratively seek, share, and use information (see Table 2 for a summary of these differences).

Building on these findings and others, Reddy and Jansen (2008) developed their initial model for understanding CIB in

TABLE 2. Differences between IIB and CIB across different items (adapted from Reddy & Jansen, 2008).

Items	IIB	CIB
Communication	Limited to Questions & Answers	Plays a more central role
Triggers	Gap between current situation and future task demands Lack of information	Complexity of information need; Fragmented information resources; Lack of domain expertise; Lack of immediately accessible information
IR Technology	Primary medium to search for information	Plays a supporting role, Supports coordination/collaboration among information seekers

context (Figure 2). They conceptualized the information environment along two axes, a behavior axis, which moves on a spectrum starting from information searching (lowest level) to information seeking (highest level), and a context axis, which moves on a spectrum from IIB to CIB. Through this model they described the interaction between the two axes unfolding at the level of individuals and groups. These interactions are further influenced by other intervening factors such as the mode of interaction, agents, and domain.

This model helps describe the key distinction between IIB and CIB across different activities (information seeking, searching, and behavior) and identify various transition points in the form of trigger occurrences within each of these activities.

A summary of the differences between IIB and CIB are depicted in Table 3. In the next section we describe the research method that underlies our CIB model development.

Research Approach and Methods

We engaged in "scholarship of integration" (Boyer, 1997) via inductive top-down theorizing (Shepherd & Sutcliffe, 2011). That is, instead of building new theories, models, and frameworks in a bottom-up fashion through conducting grounded field studies, we attempted to integrate extant theories, models, and frameworks in a top-down fashion by looking across a set of studies. In other words, our model is "top-down" because it is informed by the literature, but is "inductive" because it begins with "data." These data include raw field data that we collected over the years as well as other materials that represent the "collective knowledge of the intellectual community" (Shepherd & Sutcliffe, 2011, p. 362), including research papers, conference proceedings, workshop notes, books, and presentations. Inductive top-down theorizing, thus, "relies on the data themselves to speak to the theorist" (Shepherd & Sutcliffe, 2011, p. 362). The role of the theorist then is to focus the attention on the recurrent themes and patterns, conflicts and

contradictions that arise across a span of studies through a process of gist formation (Shepherd & Sutcliffe, 2011) and constant comparison (Glaser, 1965), aimed at answering a set of questions. (See the Data Sources and Analysis subsection for more details.)

Therefore, in this article we use "top-down inductive theorizing" to develop the contours of a model of CIB. Accordingly, we have scoped the article in the several ways. First, although we describe IIB models, that is not the primary focus of this article (for excellent reviews of research on individual information behavior, please refer to Case [2006]; and Wilson [1999]). We acknowledge and have benefited from the longstanding stream of research on individual information needs, seeking, and use (INSU). We have incorporated the insights that emerged from this research into our model, wherever appropriate. However, because the focus of this article is on the collaborative aspects of information seeking, retrieval, and use, we do not do an in-depth review and synthesis of this research (for excellent reviews and synthesis, please refer to Bates [2002], Case [2006], Cornelius [2002], Courtright [2007], and Lievrouw and Farb [2003]).

Second, although we present some of the key studies related to specific CIB activities, we do not review each of the activities in detail. Rather, we look at how they constitute the broader concept of CIB (for a comprehensive review of collaborative information seeking and retrieval, please refer to Foster [2006] and Shah [2010b]).

Finally, this article primarily focuses on CIB within the context of organizations. Although CIB is an important aspect of other contexts, such as web search (Morris & Horvitz, 2007; Morris, Teevan, & Bush, 2008) and browsing (Twidale et al., 1997), we concentrate on CIB in organizations because that has been the primary focus of our empirical research as well as that of many other researchers. However, we do include important studies conducted in other contexts that we believe are relevant to organizational work.

Data Sources and Analysis

Our theoretical model is predominantly grounded within two bodies of literature: information science and CSCW. Specifically, our model attempts to synthesize and weave together the series of conversations that happened within the information science and CSCW literature from January 1998 to the present. We chose 1998 as the starting point because during that year Karamuftuoglu (1998) proposed a framework that was one of the first attempts to understand the collaborative nature of information retrieval.

Our primary data come from a series of studies that our research team conducted during the past 10 years (Karunakaran & Reddy, 2012; Paul & Reddy, 2010; Reddy & Dourish, 2002; Reddy & Jansen, 2008; Reddy & Spence, 2006, 2008; Spence & Reddy, 2007, 2012; Spence, Reddy, & Hall, 2005). We reanalyzed the data from each of the individual cases using the constant comparative method
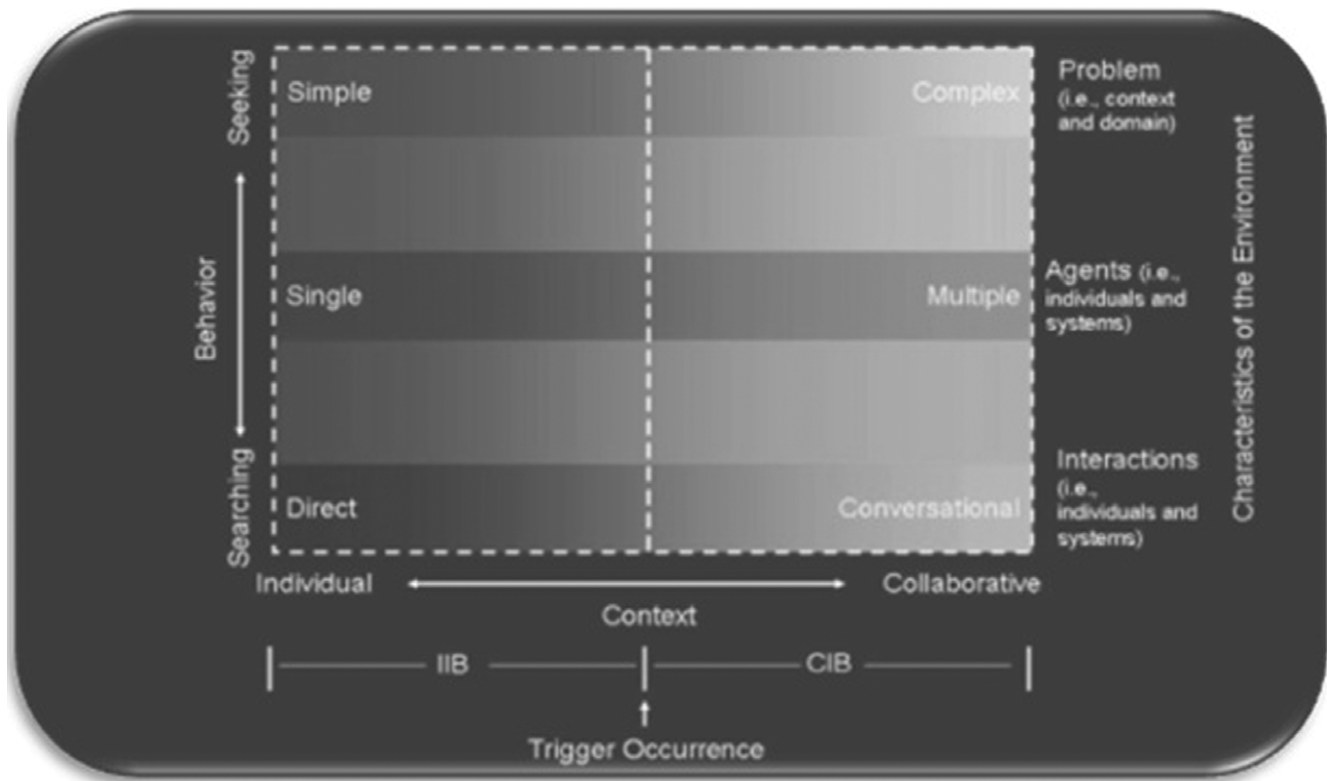
FIG. 2. Individual vs. collaborative information behavior.

TABLE 3. Differences between IIB and CIB across different levels (adapted from Reddy & Jansen, 2008).

Level	IIB	CIB
Information behavior	Simple information problems, direction interaction with a single system	Complex information Problems, importance of communication, interaction with multiple systems
Information seeking	Use of a single system. Relatively little interaction with other people or systems	Use of multiple agents (people and system). Significant interaction with other people and systems
Information searching	Direct (Q&A) Interaction Mode	Conversational interaction to address exploratory search, problem resolving, decision making

(Glaser, 1965). We also analyzed the findings from other research studies in this area (Fidel et al., 2000; Gorman et al., 2000; Hansen & Järvelin, 2005; Hertzum, 2008; Hyldegård, 2009; Karamuftuoglu, 1998; Morris & Horvitz, 2007; Poltrock et al., 2003; Sonnenwald & Pierce, 2000). We compared and contrasted the codes, concepts, and categories across these studies to understand and identify the emergent themes. In the process, we were able to specify a set of activities that constitutes CIB and the interrelationships between those activities. This, in turn, formed the basis of our model development.

As mentioned previously, in addition to relying on our own data, we also examined current research within this space. We followed a three-level search strategy to collect these data. First, we began by manually scanning and reviewing some of the key recent articles published within the CIB research to understand the current issues. We then systematically examined leading journals within the research fields of information sciences and CSCW (*Information Processing & Management, Journal of the American Society for Information Science and Technology, Computer Supported Cooperative Work*), conference proceedings (ASIS&T, JCDL, CHI, CSCW, ECSCW, GROUP) and other important outlets, such as the *Annual Review of Information Science and Technology, New Directions in Human Information Behavior*, and *The New Review of Information Behavior Research.* We used a combination of these keywords such as "collaboration," "collaborative," "information behavior," "information sharing," "information seeking," "information searching," "information retrieval," and "information use" to gather our articles from these individual outlets.

Second, we used the same set of keywords and searched in databases, including ABI-Inform, Science Direct (Elsevier), Library and Information Sciences Abstract, and EBSCO Business Source Premier, to identify any articles we may have missed. Finally, we examined the references and bibliography sections in recent CIB-related articles (e.g., Hertzum, 2010; Prekop, 2002; Shah & Marchionini, 2010; Shah, Pickens, & Golovchinsky, 2010) to ensure that we did
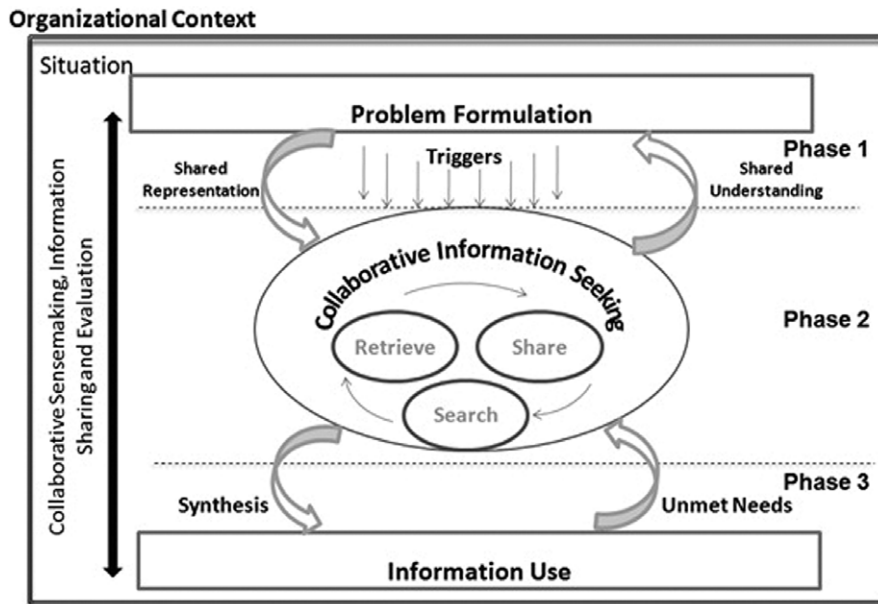
FIG. 3. A model of collaborative information behavior in organizations.

not overlook any other relevant research. In addition to collecting published research articles, we also collected work-in-progress papers, in the form of workshop papers, position papers, workshop discussion notes, conference presentations, and the like.

Overall, we collected a total of ~2,500 articles. We eliminated articles published before 1998. We also eliminated articles that we felt were not directly relevant to CIB (e.g., articles on "inter-organizational collaboration," articles that focused only on "collaboration" or "information," and articles on "cognitive information processing"). Through this elimination process, we arrived at a list of 182 articles. We then used a subset of those articles that seemed most relevant to the development of our model.

In the next section, we present our model of CIB by talking about each of its constitutive activities and how these interrelate.

Toward a Model of CIB in Organizations

Our goal is to conceptualize the broad set of activities that constitute CIB. Ours is a situated model embedded within the organizational context and has three phases: problem formulation, collaborative information seeking, and information use. Each phase is made up of certain concrete activities. However, there are also activities that cut across all the phases. Through this model we plan to illustrate and explain how these sets of activities relate to one another (Figure 3). In doing so, we provide a more integrative picture of collaborative information behavior in organizations.

Phase 1: Problem Formulation

Phase 1 begins with problem formulation. Understanding and formulating a problem is a precursor to any subsequent information searching, retrieving, and sharing activities that unfold in later phases. An individual becomes aware of the problem usually during the process of enacting his or her work activities (Weick, 1995). This occurs when he or she experiences some sort of a gap that prevents him or her from completing the task. This phase thus starts at the individual level—where actors become aware of and try to speculate about what the problem is—and transitions to the collaborative level, where actors collaboratively sense-make and agree on a way of seeing and articulating the problem. This transition from the individual to the collaborative level happens because of a set of triggers. In other words, triggers are critical transition points from IIB to CIB.

Unlike IIB, where information-seeking activities get triggered due to a gap between the current context and a desired situation (Dervin, 1983), CIB has slightly different, if not more complex, triggers (Table 2). This complexity arises due to the nature of the formulated problem. For instance, there is either a lack of immediately accessible information or a lack of domain expertise that could resolve the problem-at-hand. Furthermore, the information that is being sought is fragmented across multiple actors, artifacts, and systems (Reddy & Jansen, 2008; Reddy & Spence, 2008). All of these, in turn, trigger actors to collaborate.

For example, consider the vignette below from our field study of a multidisciplinary patient care team in an emergency department (Reddy & Spence, 2008, p. 247).

An ambulance brings a trauma patient who was involved in a car accident to the unit. Individual members of the patient-care team are not sure about the patient's condition. Each person in the team has different roles, responsibilities, and expertise in stabilizing the patient's condition. Each of them begins to speculate on what the problem could be, yet none of

these individuals alone have the expertise or the complete information to nail it down completely. Therefore, they begin to collaborate with the intent of eliminating as many problems as possible. The physician assisted by the nurse and the paramedic start working their way through possible problems. The patient is awake and responsive. The team is quickly able to eliminate injury to the neck and spine. They continue this process until the physician determines that the patient is not in any immediate danger. He orders some more x-rays, prescribes some medication and moves on to the next patient. (Vignette 1)

In this vignette, we observe that the individual actors become aware of and try to speculate about the patient's condition. However, a set of triggers—in this case a lack of expertise, a lack of immediately accessible information, and complexity of information need—led people to collaborate. Specifically, collaboration happened when information was not available at the right time and the right place.

Shared representations played a crucial role in orchestrating this collaboration. In particular, narrowing down the problem (concerning the patient's condition) happened via an iterative process through which actors create a representation of the problem to arrive at an understanding of the situation. This shared representation could include conversations, verbal communication, and representations via artifacts (Russell, Stefik, Pirolli, & Card, 1993). It informs and refines the formulated problem which in turn elaborates and fine-tunes the representation (Qu, 2003; Qu & Hansen, 2008). In the above case, the shared representation took shape via a mixture of verbal communication and external artifacts (e.g., X-ray), which led the actors to come up with a shared understanding of the patient's condition.

In addition to this iterative process, problem formulation also gets refined and shaped during the subsequent phase of CIS. Articulation of the type and complexity of the problem triggers and directs the actors' CIS, and the process of CIS enriches their shared understanding, making the formulated problem clearer.

Phase 2: Collaborative Information Seeking

The triggers that we discussed in the previous section lead to phase 2—CIS. CIS could be defined as an activity in which two or more individuals work together to seek needed information in order to satisfy a goal.

We conceptualize CIS to be comprised of three micro-level activities—namely, searching, retrieving, and sharing—that unfold in a cyclical fashion. That is, after being triggered to collaborate, actors search for information from a variety of sources they are aware of, retrieve information, share it with each other, and continue searching for information until they feel that the time is right for evaluating and using the found information. These "micro-level" behaviors are exhibited when actors interact with one another and/or with systems of all kinds (Bruce et al., 2003; Fidel et al., 2000; Gorman et al., 2000; Hertzum, Pejtersen, Cleal, & Albrechtsen, 2002; Hyldegård, 2006, 2009; Poltrock et al., 2003; Reddy & Dourish, 2002; Reddy & Spence, 2006). This interaction could unfold either in a co-located, face-to-face context or in a distributed context, mediated by information systems and technologies. Moreover, the actors who interact could be from the same (formal) team or from different teams who, during the moment of collaboration, form ad-hoc teams to try and solve the problem-at-hand.

Consider the following vignette from our field study of a multidisciplinary patient care team in an emergency department (Reddy & Spence, 2008, p. 249).

The ED physician, PK, is waiting for lab results for a patient in room 5. Normally, upon completion of the lab work, the results print directly to the unit secretary DF's printer and are placed on the patient chart or in the appropriate slot in the rack on her desk. However, the needed results are not in either location. PK asks DF about the labs, but DF has not seen the results either. Therefore, DF checks the status of the results in the patient record system, while PK calls the lab directly to check on the results. The patient record system shows the lab results as status of 'pending,' while the lab tells PK that it will be at least 15 minutes before the results are ready. PK and DF share the information that they each collected. PK decides to wait until the results are finalized in the system before implementing a plan of care. (Vignette 2)

In this vignette, the lab result information needed by PK was not available where he thought it would be available (i.e., in the rack at the unit secretary's desk). This in turn initiated a process of search. This search process unfolded not in an individual but in a collaborative manner, wherein the physician, PK, and the unit secretary, DF, divided their search task, since each of them knew different ways to access the information (i.e., the physician calling the lab directly and the unit secretary using the information system). Through this process, they find the appropriate information source that has the potential to resolve the information need. At this stage, information is retrieved. Then it gets shared across the actors. If the need is resolved, then the CIS phase is completed. The sought information is now synthesized, evaluated, and put to use. If the need is not resolved, then it leads to another cycle of searching, retrieving, and sharing information. Consider another set of vignettes from the same field study (Reddy & Spence, 2008, p. 250).

The ED physician, PK, is reviewing x-rays of a patient and sees some irregularities that he does not recognize. He contacts a radiologist, BM, for his expertise. PK shows BM the x-rays and tells him that he is not sure if the fracture in the shoulder is old or new. BM asks PK a series of questions about the patient's age and presenting condition. While BM reviews the x-rays, PK returns to the emergency department to ask the patient about possible past shoulder injuries. After reviewing the x-ray, BM tells PK that the fracture looks old because the edges of the bone are rounded, not sharp. PK is able to support the diagnosis with the information gathered from the patient — he had hurt his

shoulder about 11 months earlier. PK and BM discuss the issue further and decide to have the patient see an orthopedic physician. (Vignette 3)

A patient's pain is severe enough that the nurse, AM, starts a treatment protocol. However, she does not believe that the suggested medication is strong enough for the patient. Before deciding on a pain medication, the physician, PK, wants to know the patient's weight, current pain level rating, symptoms and pain location. Although AM has some of this information documented, the pain level rating is not up-to-date. Therefore, another nurse, SP, volunteers to talk with the patient about the pain rating, while AM reviews the Emergency Department Flowsheet. Once the needed information is found by AM and SP, they share it with each other and PK. The gathered information is then used by the team to determine that Demerol should be administered for the pain. (Vignette 4)

In vignette 3, the physician, PK, lacked the expertise needed in radiology to make a proper diagnosis. This in turn triggered him to search for a specific expert. Through the help of that expert (i.e., a radiologist), the needed information was retrieved and shared among the collaborators. The entire process was orchestrated via constant verbal communication and facilitated through external artifacts. All of these helped the physician to seek and find the needed information and make a confident diagnosis.

In vignette 4, the physician PK initiated this collaboration because the information he needed had many subcomponents, such as weight, pain rating, symptoms, and pain location, which he could not easily find by himself. So, PK, along with nurses AM and SP, were drawn into a search process. Each of them started looking for different pieces of information by exploring different information sources (such as asking the patient or checking the flow sheet). Then they retrieved those different components and shared the information with each other in order to make a diagnosis about the patient. In both vignettes 3 and 4, CIS unfolds in a cyclical "search-retrieve-share" fashion.

The above examples illustrate how CIS takes place via a set of micro-level activities—namely, searching, retrieving, and sharing—that unfold in a cyclical fashion. We refer to micro-level activities as tactical maneuvering—behavior exhibited when two or more individuals interact with each other and with systems to retrieve the needed information. Cyclical interactions between these micro-level activities give rise to the macro-level activity of collaborative information seeking, which we refer to as strategic maneuvering.

Phase 3: Information Use

Finally, once the needed information is sought it will be evaluated and synthesized by the information seekers during the process of using that information. We call this phase "information use." This also forms the final phase within our model.

Information use involves the physical, mental, and communicative acts involved in evaluating, synthesizing and incorporating the information (Spence & Reddy, 2012)

found during the previous CIS phase. That is, the output from the previous phase is collaboratively evaluated and synthesized, and if actionable, put to use. Although the use of the information might be at the individual level, the evaluation and synthesis of information happens at the collaborative level. Information needs are said to be met when the synthesized information resolves the problem-at-hand. If it does not, we then return to phase 2 for further CIS activities. For instance, consider the following vignette from our field study of an IT support team within a hospital (Spence & Reddy, 2012, p. 299).

Jim, a CSC representative, cannot resolve a client issue in the time allotted; therefore, he creates a HEAT ticket and assigns it to Richard on the Clinical Software Services team. Richard is able to determine the cause of the problem immediately (the user has access rights to the scanning folders on the network that are beyond his job need); however, Richard does not have the knowledge to determine exactly how to resolve the issue. Therefore, Richard pulls together an ad-hoc team of experts to tackle the problem. Richard calls a meeting to discuss the problem. The meeting participants include Chip, a systems programmer, Chris, a network technician, and Matt, a project manager. The meeting takes place in Richard's office so that everyone in attendance can discuss the issue while having access to the system and network in question.

On his computer, Richard shows the team the current permissions settings for the scan folders. They talk through what permissions should and should not be given to users based on a previous system configuration. The team discusses if the scanning groups should be broken down more granularly. After the team members share their particular knowledge on the subject, Matt says, "Why don't we take the global group and give them read/write/modify? I could have sworn modify allows for deleting of files." Richard suggests that they test Matt's hypothesis. Richard edits the share permissions and then suggests that they do a preliminary test where Chris attempts to get access to the scan folder now that the Everyone group has been removed from share permissions. Richard and Matt walk over to Chris's desk to have him test his access. Chris's access to the scan folder is denied. This proves that removing the Everyone group from the share permissions seems to have worked. The meeting is adjourned. At this point, the issue is considered resolved. (Vignette 5)

In vignette 5, team members were seeking information regarding folder permissions. The information-seeking activities involved an exchange between experts combined with the use of information found in an existing system. Next, they evaluated the usefulness of the information to solve the current problem by testing the potential solution generated through information exchange. Once the potential solution proved useful, then the information was found to be appropriate and used to solve the problem. As one could notice, each of the collaborative information seekers had partial information on how to resolve the issue. And it is through the collective evaluation and synthesis of the information that they determine whether the information is actionable. For instance, Richard was able to quickly

identify the problem while Jim was not. But Richard was not able to find a "fix" for the problem, and so, he pulls together an ad-hoc team. Each of the individual team members contributes some information, which then is evaluated and synthesized "on-the-fly" through the process of using that information. In the process, the collectively sought information is put to use to solve the problem-at-hand.

Activities Common to All Phases

Besides activities that are specific to certain phases, there are also activities that are common to all the phases. These include information sharing and evaluation and collaborative sensemaking.

Information sharing and evaluation. Throughout the entire process, from formulating and refining a problem to collaboratively seeking the information to using the found information, there is continuous sharing and evaluation of information. Information sharing and evaluation occur both within each phase as well as across the phases. For example, in phase 1 actors collaboratively share and refine the problem-at-hand (in the form of external representations), and then evaluate their understanding of the problem before moving on to the next phase. Similarly, within the CIS phase actors continually evaluate the retrieved information before they synthesize and use it.

Consider this vignette from another field study conducted within an emergency department (ED) and surgical intensive care unit (SICU) of a hospital (Reddy & Jansen, 2008, p. 263).

> The team members are talking about a patient during morning rounds. They are concerned about the spike in the patient's temperature and are not sure what is causing it. Because there are many different aspects of the problem they want to look at, the team splits up the tasks. Susan, the pharmacist, prints out a medication list to check what the patient is on. John, a resident, checks the culture book to see if the patient has any infections that might be causing this. Gina, a fellow, is checking the patient record system for information and Vasanth, another fellow, is checking the patient to try to get more information. After bringing all the different pieces of information together, the team decides to change patient's medications. (Vignette 6)

In vignette 6, although the information need of identifying the source of a patient's temperature spike looked simple in the beginning, it became much more complex in practice. As team members were not sure of where to start or which place to begin (phase 1: problem formulation), they began to collaboratively accumulate as much information as possible by dividing their search tasks (phase 2: collaborative information seeking). For example, the pharmacist checked her medication lists, while one of the physicians checked the paper records, and another physician checked with the patient. It was only through this process of bringing together all these different fragments of information that they were able to put the found information into use, and solve the problem (phase 3: information use). Throughout the entire process, information was continually shared and evaluated.

Similar insights concerning the central role of information sharing and evaluation in CIB were also illustrated by other researchers. For example, Gorman et al. (2000), in their field study of how team members in an intensive care unit worked together to seek and share the needed information, found the importance of sharing and binding different sources of information together in order to address a specific problem. Similarly, in a field study of two design teams, Poltrock et al. (2003) highlighted the criticality of continually sharing the retrieved information between the team members in accomplishing the design work. They found that teams used a strategy of continually proposing ideas and requesting feedback, as opposed to asking directly for recommendations. These studies highlight the importance of information sharing and evaluation within CIB.

By acknowledging information sharing and evaluation as activities that are common to all the CIB phases, we also address Hertzum's (2008) criticism of extant research for placing information sharing at the periphery of CIB, and for separating the acquisition of information from the process of being informed by it.

Collaborative sensemaking. In addition to sharing and evaluating information, "collaborative sensemaking" plays an important role in CIB. Although "sensemaking" is a widely researched area that spans several disciplines, most of the research has focused on sensemaking at the individual level (Qu, 2003). For example, Dervin's (1983) "sense-making" theory describes sensemaking as a process used by an individual actor to construct a bridge between a context and a desired situation. Weick (1995) discusses "sensemaking" (no hyphen) within the context of organizations, and explores the idea of how people organize their world to make sense of equivocal situations, and how they use this organization to create a sense of order and routine (Weick, 1993, 1995).

In our model, we conceptualize sensemaking at the collaborative level. We posit collaborative sensemaking to occur when multiple actors, with different perspectives about a situation, engage in the process of making sense of "messy" information (Ntuen, Munya, Trevino, Leedom, & Schmeisser, 2006; Paul & Reddy, 2010). Consider the following vignette from a different field study conducted within an emergency department of a large teaching hospital (Paul & Reddy, 2010, pp. 7–8).

> 1:40pm: Registration associate RA2 tells me that she feels sorry for the patient in room 20 who is 8-weeks pregnant and was hit by a car. The next shift's charge nurse, CN3, arrives and the current charge nurse, CN2, tells CN3 information about each patient by going through FirstNet.
>
> CN2 tells CN3 that the patient in room 20 was hit by a car and is 8-months pregnant. CN2 remembers the case of a former patient who was 7 months pregnant when brought to the ED and the baby had been lost because no one realized that the patient

was pregnant.

5:00pm: CN3 is talking to the attending (physician) AP about her patients. She specifically tells AP that she is worried that the patient in room 20 who is 8 months pregnant.

AP (surprised): "How pregnant?"

CN3: "8 months. I've been told baby is ok."

AP is still concerned so he and CN3 pull up the patient's record in FirstNet and discuss various aspects of her case. They don't verify the pregnancy information. They miss that the record says 8-weeks pregnant. They discuss how the patient should be treated given the advanced (i.e., 8 months) stage of pregnancy. (Vignette 7)

In vignette 7, when a charge nurse "remembers the case of a former patient who was 7 months pregnant when brought to the ED and the baby had been lost because no one realized that the patient was pregnant," she is not just simply providing an answer. She is evoking memories of the past and recontextualizing them to apply to the problem-at-hand, so that both the charge nurse and the attending physician are able to share their frames and understand the seriousness of the current situation. Thus, collaborative sensemaking occurs when actors interactively make sense of the sought information that is fragmented and messy. Although some wrong information was passed in the process as they miss out noticing some details (i.e., 8 months instead of 8 weeks pregnant), this is not merely "a case of miscommunication of information" (Paul & Reddy, 2010, p. 328). Instead, it is about what that "information meant for the patient" (i.e., death of the baby, criticality of the patient, need to take quick action, etc.). These sensemaking processes thus give facts and experiences meaning, making the underlying information more sticky and salient—which could lead to both generative as well as negative outcomes. Collaborative sensemaking infuses facts with meaning by contextualizing and recontextualizing the information in order to address the problem-at-hand (Lutters & Ackerman, 2002).

We believe that our model of CIB is useful to not only delineate the various activities that unfold at the nexus between "collaboration" and "information behavior," but also in understanding the relative importance and sequence of these activities in facilitating collaborative work within organizations.

Problem Areas and Recommendations for Future Research

In this section, we turn our attention to discussing some important challenges in pushing this research forward and making recommendations on how these challenges may be addressed. These ideas also highlight potential opportunities for future research.

Problem Area 1: Scale and Scope of CIB models

Although we have defined CIB and specified the activities that constitute it, the scale and scope of CIB is still unclear. Because groups and teams are at different sizes and configurations and exhibit different types of behavior, it would be hard to generalize findings from studies conducted within a specific team configuration to other configurations. Furthermore, the term *collaborative* could mean anything from collaboration between 2 people to collaboration among 200,000 people. In addition, as Golovchinsky, Adcock, Pickens, Qvarfordt, and Back (2008) proposed, the intent of collaboration (implicit or explicit) could vary from setting to setting, and from system to system. Explicit small group collaboration is indeed different from implicit (or indirect) large-scale collaborations (e.g., Amazon recommender systems).

Recommendation 1. To address these issues a distinction needs to be drawn between "deliberate" and "nondeliberate" collaborative information behavior. Through this distinction, purposeful and explicit collaborations (such as the collaborations happening within organizations) could be distinguished from indirect and implicit large-scale collaborations (such as the ones facilitated through algorithms in recommendation engines). This in turn would help us to scope the CIB models correctly.

Problem Area 2: Mismatch in Priorities Between the Social and the Technical Perspectives of CIB

Although both the social and technical perspectives have provided significant insights into CIB, there are some differences that persist. The motivation behind the social perspective is to come up with a better understanding of the context within which CIB happens, with the intention of improving organizational work practices. Studies conducted in this arena have provided us with a set of insights about the differences between IIB and CIB, what triggers CIB, what hinders CIB, and so on. On the other hand, the technical perspective is driven by the desire to develop prototypes and tools to support and improve collaborative work. This difference in motivation in turn affects priorities, leading to different conceptualizations of CIB. For example, this difference is visibly manifested in the proposed taxonomies and typologies of collaboration put forth by researchers. Although the typology proposed by Hansen and Järvelin (2005) and Hara, Solomon, Kim, and Sonnenwald (2003) had collaborative "tasks" and "activities" as the basic unit, the taxonomy proposed by Golovchinsky et al. (2008)—which has a "technical-orientation"—differed significantly. In the latter taxonomy, "intent" of collaboration (explicit or implicit) is considered to be the most important among all the dimensions, whereas "location" (co-located or distributed) is considered to be the least important. From a technical standpoint, this makes sense because collaborative search systems, collaborative querying and filtering systems, and recommender systems could leverage on the "intent" dimension to come up with more sophisticated query clustering, search result clustering algorithms, and item-to-item recommendation engines. Also, the dimension "location,"

that is, whether the collaborating actors are co-located or distributed, is of least importance to them because this does not influence the technical functionalities or the algorithms in any major ways. However, from an organizational standpoint, "location" plays a very significant role in collaboration, if not the most significant role among all the listed dimensions. Thus, this difference in conceptualization at a very fundamental level leads to differing outcomes.

Recommendation 2. Although this diversity in perspectives provides some benefits, it also poses problems with respect to theory development as well as in providing design recommendations. This is especially critical for a relatively young research area such as CIB because neither detailed analytical models nor technical tools and prototypes alone are enough to facilitate, support, and improve collaborative work in organizations. Therefore, the intellectual challenge should be articulated along the lines of better understanding the gap between the social requirements and technical feasibilities (of what Ackerman [2000] refers to as the socio-technical gap), in order to come up with better organizational practices and collaborative tools. Also, positioning CIB research within other alternate research paradigms, such as action science (Argyris, 1995), would help us to bridge the disconnect between the two perspectives and enable a better integration of "the activities directed at understanding with those directed at design" (Carroll, Singley, & Rosson, 1992, p. 181).

Problem Area 3: Lack of a Clear Demarcation Between IIB and CIB

Although some initial analytical distinctions are identified to demarcate IIB from CIB, there are still a number of unanswered questions. For example, it has been claimed that when the "information problem" becomes more complex and intricate, the need to collaborate increases and this in turn acts as the take-off point toward moving from IIB to CIB (Reddy & Jansen, 2008). However, the term *complex* is ambiguous and "what is simple, and what is complex" is currently a matter of debate (Reddy & Jansen, 2008, p. 266).

Recommendation 3. It is indeed difficult to analytically differentiate between "simple" and "complex" when it comes to information needs because these are extremely subjective constructs and are contingent on the work context. Although ethnographic field studies could provide us with rich contextual insights about how information needs are perceived, formulated, and sought, it is difficult to tease out the differences about what constitutes simple and complex information by just observing collaborative activities "in the wild." Experimental methods might prove to be helpful in informing and complementing field work (Convertino, Neale, Hobby, Carroll, & Rosson, 2004), particularly in refining our understanding about what constitutes "complex" information needs, what are the analytical differences between the triggers for IIB and CIB, and so on.

Therefore, it becomes important to conduct experimental work alongside fieldwork to come up with a more nuanced understanding of CIB.

Problem Area 4: Mechanisms That Underscore CIB-Related Activities

Researchers have tried to differentiate between the concepts of IIB and CIB. In doing so, they have argued that CIB is not just about two (or more) people posing questions and answers to each other in their attempt to look for specific information (e.g., Reddy & Jansen, 2008; Sonnenwald & Pierce, 2000). They have argued that CIB is much more complex, and goes beyond simple "question and answer" exchange. Consequently, what are the underlying mechanisms and practices that underscore CIB-related activities? These questions have not been sufficiently addressed.

Recommendation 4. We propose that one way to demarcate and specify the mechanisms and practices that underlie CIB is to think of it as constituted through and orchestrated via "narratives" (Bartel & Garud, 2003; Pentland & Feldman, 2007). Narratives could be thought of as the underlying platform through which CIB is enacted in practice. Research within sociology and organizational studies suggests that most of our social realities are transmitted via narratives (Bartel & Garud, 2003; Weick, 1995). This line of research has shown suggestive evidence as to how narratives provide a pathway for organizational actors to share information with one another and create a common ground to facilitate coordinated action. Moreover, when actors evoke a narrative, it automatically and simultaneously implicates "the physical artifacts (e.g., equipment, databases and documents), work processes (e.g., analytic techniques and standard operating procedures), and people (e.g., expertise, power and political clout)" (Garud, Dunbar, & Bartel, 2011, p. 588) that are involved in a situation. Since tools, technologies, and artifacts are part and parcel of CIB, these narratives could be potentially very useful for actors on the field to address the information needs of the specific situation.

Understanding how these narratives are created, shared, and put to use in "real time" would, in turn, help us uncover the fundamental mechanisms that underlie CIB.

Limitations

Our proposed model is not without limitations. First and foremost, the collaborative activities that we highlight in our vignettes are limited to shorter timeframes that are completed within a span of few minutes or, at best, a few hours. We do agree that there are collaborative activities that could span longer timeframes, such as student teams collaborating for a semester on a class project or software engineering teams collaborating to deliver a product to a client. Our current model does not adequately capture the longitudinal dynamics that unfold during such longer timeframes of

collaboration, where factors such as group membership and socialization, member turnover, and shared identity all become important.

Second, even though we reviewed and analyzed CIB-related studies conducted in various organizational contexts (such as universities, libraries, patent processing, military, and software design), most of the work on CIB is conducted within healthcare settings. Indeed, the majority of our field-work that we synthesized in this article was conducted within hospitals. One could argue that hospitals, similar to most other contemporary organizations, are becoming more "collaborative" and "information-intensive" and thereby the findings related to CIB from these field studies are transfer-rable to other nonhospital settings. However, it is also impor-tant to note that hospitals and healthcare organizations are different from other organizations in a number of ways (e.g., the level and intensity of activity, patient privacy, related institutional regulations, etc.). Therefore, it is important to note that there could be limits and boundary conditions with regard to the transferability of our findings to other settings. At the same time, we would also like to note that our intent was not to develop a canonical model of CIB that is highly generalizable and could cut across multiple settings. On the contrary, our intent was to provide a common vocabulary and the contours of an early model of CIB that researchers could use as a "resource" to inform their future studies and the findings from their research could in turn be fed back to make cumulative refinements and improvements to the CIB model.

Third, even though we tried to define and analytically demarcate between the various activities that constitute CIB, we do agree that these are far from complete. Further empirical studies in the form of ethnographic fieldwork and fine-grained lab experiments could be employed to under-stand how these constitutive activities play out in different settings and what could be the possible markers (e.g., level of information complexity and fragmentation, distribution of expertise, etc.) that distinguish them from one another.

Conclusion

Traditionally, information behavior has been considered an individual activity because of the dominant view of a single user interacting with a search tool. Furthermore, orga-nizational work has been viewed as a series of individual activities with lesser emphasis placed on collaborative work. Hence, we see an array of simplistic organizational policies and information systems that support IIB but are unable to handle the complex and intricate nature of CIB. As Shah (2010b) posits, "a holistic approach is needed, along with models that can measure and evaluate collaborative information systems and environments which [goes] beyond traditional single-user IR paradigms" (p. 26).

CIB research offers us some rich possibilities addressing this issue. However, the research area is relatively young and at a pre-paradigmatic stage. Consequently, there are many divergent perspectives with different priorities and vocabu-laries, leading to fragmented research findings. In this article, we attempted to synthesize our research as well as that of others to capture the various activities that constitute CIB. We do not think that this model captures every facet of CIB activities; however, we believe it provides a starting point to understand collaborative information behavior in organizational settings.

Organizations with information-intensive environments are complex systems with many visible and invisible inter-dependencies. To effectively support collaborative work in such environments, we need to consider the complex ensemble of individuals, groups, artifacts, work practices, information technologies, and its overall interaction pat-terns. Research on CIB offers us an interesting space to explore this ensemble further.

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