

Research Statement

Sharoda A. Paul
College of Information Sciences and Technology
Pennsylvania State University
spaul@ist.psu.edu
March 2009

My research spans the fields of computer-supported cooperative work, human-computer interaction, and healthcare informatics. My primary research interest is to understand and support collaborative information behavior. I have examined the question “How do people collaboratively find, retrieve, understand, and use information?” in two domains – healthcare and Web search. Traditionally, studies of human information behavior have focused on *individuals* interacting with complex information spaces; however, recent research has found that people frequently collaborate and communicate when they retrieve and use information. For instance, physicians may collaboratively search hospital information systems to find and share information to treat a patient. Similarly, a family planning a vacation might collaboratively search the Web to create their vacation itinerary.

In spite of the mounting evidence of how important collaboration is during information retrieval, researchers lack a conceptual understanding of how people find and use information together. Consequently there is a lack of models of collaborative information behavior; such models can be the basis for designing effective collaborative information retrieval tools. My research addresses these gaps by examining collaborative information behavior in two contexts – healthcare and Web search – using different methodologies. Through field studies of healthcare providers working in emergency care, I have examined how groups collaboratively find, understand, and use information “in the wild”. Through lab studies and prototype development, I’ve studied how users find and understand information together during collaborative Web search tasks.

Collaborative information seeking and sensemaking in healthcare

In my dissertation, I explored collaborative information seeking and sensemaking in emergency care. I conducted a two-year ethnographic study of healthcare providers in the Emergency Department (ED) of the Penn State Hershey Medical Center, a 500-bed teaching hospital with 50,000 ED visits a year. The ED is a dynamic and information-intensive environment where a challenging aspect of the work of healthcare providers is to collaboratively find and make sense of a wide variety of information using several electronic and non-electronic information sources (Figure 1).

In the Hershey ED, I examined the information sources and information seeking strategies ED care providers use to collaboratively find and understand information. I specifically focused on collaborative sensemaking during information seeking and found three important characteristics of collaborative sensemaking among healthcare providers [1]. First, sensemaking in collaborative work is strongly temporal and persistence of the products of sensemaking is important, not only across time but across multiple sensemakers. Second, activity awareness, that is awareness about long term endeavors (like taking care of a patient from the time he is admitted to the ED to the time he is discharged) is more important for collaborative sensemaking than mere action awareness (like information about drug administration or ordering of x-rays). Third, the creation and manipulation of shared representations of information (such as those provided by whiteboards, digital displays, and the electronic medical record, see Figure 2) helps care providers create a shared understanding of information [6]. Based on my findings, I present three design principles for collaborative information retrieval tools. The first is that the process and products of sensemaking should be made explicit via *sensemaking trajectories*. The second is that the notification-based system of providing action awareness should be enhanced by providing

awareness information about activities using *activity timelines*. Finally, collaborative information retrieval tools should provide group representations of information that allow *role-based information encoding*.

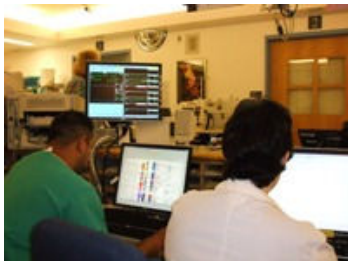


Figure 1. Healthcare providers collaborate to find and understand information for treating a patient at the Hershey ED.

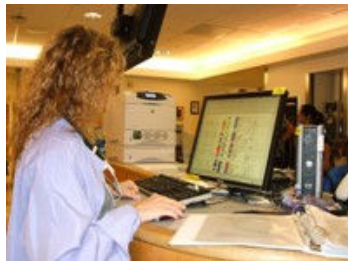


Figure 2. The electronic medical record (left) and the whiteboard (right) serve as shared representations of information. While the medical record is used to store and access patient information, the whiteboard is used to assign patients to nurses.



I have drawn on the results of my study in the emergency care domain to provide insight into how interfaces can be designed to support sensemaking in collaborative Web search. I applied the design principles mentioned above to enhance sensemaking in SearchTogether, a collaborative Web search tool.

Collaborative Web search

With the recent explosion of Web 2.0 technologies, there has been a lot of interest in collaborative Web search tools. Such tools support both implicit collaboration (where the system returns search results based on data obtained from other users, e.g. recommender systems) and explicit collaboration (where people explicitly come together to find information for a joint task). These tools also differ in the level of mediation provided; some tools mediate only on the UI level while others mediate algorithmically (e.g. by combining relevance feedback from multiple people to rank documents). Drawing on the results of my field studies of collaborative information seeking in organizational settings, I am interested in designing both UI-level and algorithmic mediations of search results in collaborative and social search tools.

At the UI-level, I studied users' collaborative search and sensemaking behavior using the tool SearchTogether developed at Microsoft Research, with Merrie Morris. I conducted formative studies of users' sensemaking in SearchTogether and, based on the results of these studies, designed a tool CoSense to enhance sensemaking in SearchTogether [4].

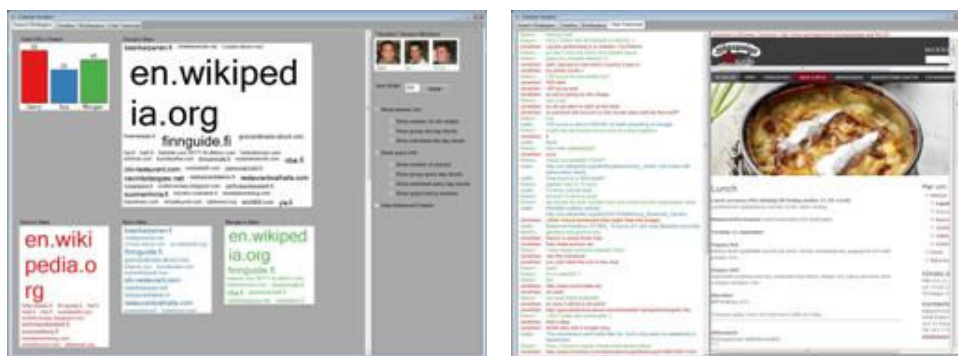


Figure 3: CoSense provides different views to enhance sensemaking in collaborative Web search tasks. The *search strategies* view (left) shows the query keywords and websites used by group members and hence makes explicit the roles and skills of group members. The *timeline view* (right) contextualizes the chat messages with the webpages viewed.

I conducted evaluation studies in which groups of participants searched the Web, both synchronously and asynchronously, using SearchTogether and CoSense and participants' actions in both tools were logged.

On examining the logs for patterns of users' search and sensemaking behavior, I found that users had two strategies during collaborative search, *search-lead* and *sensemaking-lead* [2]. Also, the "sense" made during a collaborative search task was stored in the form of various "products" of sensemaking (such as ratings and comments on web pages and chat messages). During handoff of the collaborative search task to group members who searched asynchronously, transferring the products of sensemaking was challenging. CoSense helped support different search and sensemaking strategies and also enabled easier handoff of sensemaking products [4].

Supporting inter-group information sharing, coordination, and decision-making.

One of my research interests is to support collaboration and coordination between multiple groups engaged in information-intensive work. I conducted field studies with healthcare professionals in the ED and emergency medical services to understand information flows and coordination challenges during emergency crisis response [3]. We found that due to the ineffectiveness of current information and communication tools (ICTs), care provider preferred paper artifacts to ICTs for transferring information during crisis scenarios [5]. Also, mismatch between different ICTs used by the different groups engaged in crisis response led to breakdowns in information flows. Our findings have important implications for the design of ICTs that can support coordination between different healthcare agencies during a crisis. We also studied decision-making between multiple teams engaged in crisis response and found that two kinds of dependencies between these teams posed as a challenge to effective inter-team decision-making – *information dependencies* and *decision dependencies* [7]. We designed a collaborative intelligent-agent architecture, R-CAST-MED to support inter-team decision-making. R-CAST-MED is based on the Recognition Primed Decision-making model and contains intelligent agents who seek, filter, and share information to provide *decision recommendations* to human agents involved in crisis response [7].

Future research vision

In future work, I am interested in extending my current research in both healthcare and collaborative search. As the United States grapples with providing affordable and accessible healthcare for all, technology that helps improve communication and collaboration between healthcare providers, health agencies, and patients can contribute greatly by reducing costs and increasing efficiency of the healthcare system. Increasingly, the Web is becoming one of the driving technologies behind healthcare information sharing and dissemination. I want to design Web-based tools that help healthcare providers and patients find and share information and expertise.

I am also interested in extending my research on collaborative Web search. With the rising popularity of social media sites like [Twitter](#), [Facebook](#), [Digg](#), and [Delicious](#), search is no longer a solitary activity; *social search* will be the new paradigm of search. I envision social search to move in two directions – one in which searchers ask experts or people with similar information needs to rank search results returned by search engines like Google. The other direction in which I see social search growing is users directing their search queries to their social networks (e.g. [Peerspective](#)) or to experts (e.g. [Aardvark](#)). In the latter model of social search, services will be able to mine social queries to find trends in users' search needs (e.g. Twitter search shows the 'trending topics' based on users' Tweets) and target those search needs with products or information. I would like to draw on my current research on search and sensemaking patterns, to develop models of users social search behavior and design search tools based on these models. I also want to study how trends revealed by social search queries can be targeted effectively in real-time.

Finally, I am interested in combining my research on health information seeking and collaborative Web search to design Web-based tools that enable healthcare providers, patients, health agencies, and auxiliary health services (like pharmacists) to share information. For instance, sites like [Sermo](#) are providing forums for physicians to discuss their experience, insight, and medical knowledge in an "information arbitrage" model. In this model, financial services and health agencies can view physicians' discussions

(about drugs they are prescribing or difficult medical cases they are treating) to help forecast potential problems with certain drugs, gain insight into outbreaks and changes in disease states, and survey physicians for their medical opinion. Through such models, I see great potential in combining my healthcare and collaborative information seeking research to build forums to empower healthcare professionals and agencies, and patients.

Related publications

[1] Paul, S.A. and Reddy, M. (In preparation). Understanding together: Collaborative sensemaking in the emergency department. To be submitted to *Information Processing and Management*. [Impact factor 1.5]

[2] **Paul, S.A.** and Morris, M.R. (Submitted). Sensemaking in Collaborative Web Search. Submitted to *Human Computer Interaction special issue on Sensemaking*. Special Issue Eds. Daniel Russell and Peter Pirolli. (Impact factor 2.4)

[3] Reddy, M., **Paul, S.A.**, Abraham, J., McNeese, M.D., deFlicht, C.J., and Yen, J. (In press). Challenges to Effective Crisis Management: Using Information and Communication Tools to Coordinate Emergency Medical Services and Emergency Department Teams. To appear in *the International Journal of Medical Informatics (IJMI)*. [Impact factor 1.5] ([PDF](#))

[4] **Paul, S.A.**, and Morris, M.R. (2009). CoSense: Enhancing Sensemaking for Collaborative Web Search. To appear in *Proceedings of the Conference on Human Factors in Computing Systems (CHI '09)*, Boston, MA. (**Best paper nominee**). [Acceptance rate 24.5%] ([PDF](#))

[5] **Paul, S.A.**, Reddy, M. Abraham, J., and deFlicht, C.J. (2008). The Usefulness of Information and Communication Tools in Crisis Response. *Proceedings of the Fall Symposium of the American Medical Informatics Association (AMIA '08)*, Washington, D.C. [Acceptance rate 20%] ([PDF](#))

[6] **Paul, S.A.**, Reddy, M., and deFlicht, C.J. (2008). Information and Communication Tools as Aids to Collaborative Sensemaking. In *Extended Abstracts of the ACM SIGCHI Conference on Human Factors in Computing Systems (CHI '08)*. [Acceptance rate 38%] ([PDF](#))

[7] Zhu, S., Abraham, J., **Paul, S.A.**, Reddy, M., Yen, J., Pfaff, M., and deFlicht, C.J. (2007). RCAST-MED: Applying Intelligent Agents to Support Emergency Medical Decision Making Teams. *Proceedings of the 11th Artificial Intelligence in Medicine Conference (AIME '07)*, Amsterdam, the Netherlands. [Acceptance rate 20%] ([PDF](#))

Sample Publications

1. Sensemaking in Collaborative Web search

Sharoda A. Paul and Meredith Ringel Morris

ABSTRACT: Sensemaking is an important aspect of information seeking tasks but has mostly been studied at the individual level. We conducted a study of sensemaking in collaborative Web search using SearchTogether and found that collaborators face several challenges in making sense of information during collaborative search tasks. We built and evaluated a new tool, CoSense, which enhanced sensemaking in SearchTogether. In this paper we discuss findings about how sensemaking occurs in synchronous and asynchronous collaboration, and the challenges participants face in handling handoffs. We found that participants had two different strategies of handling handoffs – search-lead and sensemaking-lead, and that participants with these two strategies exhibited different procedural knowledge of sensemaking. We also discuss how complex and varied the products of sensemaking are during a collaborative search task. Finally, we provide a taxonomy of sensemaking in collaborative information seeking tasks that can be used by researchers to study and design tools for sensemaking in such tasks. (**Paper under review**)

2. Challenges to Effective Crisis Management: Using Information and Communication Tools to Coordinate Emergency Medical Services and Emergency Department Teams.

Madhu Reddy, **Sharoda A. Paul**, Joanna Abraham, Michael D. McNeese, Christopher deFlicht, and John Yen.

ABSTRACT: *Objective:* The purpose of this study is to identify the major challenges to coordination between emergency department (ED) teams and emergency medical services (EMS) teams. *Design:* We conducted a series of focus groups involving both ED and EMS team members using a crisis scenario as the basis of the focus group discussion. We also collected organizational workflow data. *Results:* We identified three major challenges to coordination between ED and EMS teams including ineffectiveness of current information and communication technologies, lack of common ground, and breakdowns in information flow. *Discussion:* The three challenges highlight the importance of designing systems from sociotechnical perspective. In particular, these inter-team coordination systems must support socio-technical issues such as awareness, context, and workflow between the two teams. [Download PDF](#)

3. Enhancing Sensemaking for Collaborative Web Search.

Sharoda A. Paul and Meredith Ringel Morris

ABSTRACT: Making sense of the information found during an investigational Web search task can be daunting. With the recent emergence of tools to support collaborative Web search, the associated sensemaking task has become even more complex, requiring sense to be made not only of the *products* of a search (*i.e.*, results found) but of the *process*, as well (*i.e.*, group division of labor and decision-making). We present the findings of a formative study illustrating the sensemaking challenges posed by collaborative search tools. Based on these findings, we created CoSense, a system that supports sensemaking for collaborative Web search tasks by providing several rich, interactive views of a group's search activities. We describe an evaluation of CoSense, reflecting on how its features supported different aspects of sensemaking, and how future collaborative search systems can benefit from these findings. [Download PDF](#)

4. The Usefulness of Information and Communication Tools in Crisis Response.

Sharoda A. Paul, Madhu Reddy, Joanna Abraham, Christopher deFlicht

ABSTRACT: Information and communication technologies (ICTs) play a vital role in coordinating crisis response between pre-hospital services and emergency departments of hospitals. In spite of the advances in these technologies, there remain a variety of challenges to their usage during a crisis. To identify these challenges, we conducted focus group interviews with emergency department (ED) and emergency medical services (EMS) personnel. We found that ED and EMS personnel have widely varying perceptions about the usefulness and ease-of-use of information tools and communication tools used in crisis management. We discuss the importance of bringing together communication and information tools into integrated networks of ICTs for effective crisis response. We also highlight design features of ICTs which can support seamless and effective communication and coordination between ED and EMS teams. [Download PDF](#)

5. Applying Intelligent Agents to Support Emergency Medical Decision Making Teams.

Shizhuo Zhu, Joanna Abraham, **Sharoda A. Paul**, Madhu Reddy, John Yen, Mark Pfaff, and Christopher deFlicht

ABSTRACT: Decision-making is a crucial aspect of emergency response during mass casualty incidents (MCIs). MCIs require rapid decisions to be taken by geographically-dispersed teams in an environment characterized by insufficient information, ineffective collaboration and inadequate resources. Despite the increasing adoption of decision support systems in healthcare, there is limited evidence of their value in large-scale disasters. We conducted focus groups with emergency medical services and emergency department personnel who revealed that one of the main challenges in emergency response during MCIs is information management. Therefore, to alleviate the issues arising from ineffective information management, we propose R-CAST-MED, an intelligent agent architecture built on Recognition-Primed Decision-making (RPD) and Shared Mental Models (SMMs). A simulation of R-CAST-MED showed that this tool enabled efficient information management by identifying relevant information, inferring missing information and sharing information with other agents, which led to effective collaboration and coordination of tasks across teams. [Download PDF](#)