Understanding and Supporting Sensemaking in Collaborative Web Search

Sharoda A. Paul
College of Information Sciences and Technology
Penn State University, University Park, PA
spaul@ist.psu.edu

Meredith Ringel Morris
Microsoft Research
Redmond, WA, USA
merrie@microsoft.com

ABSTRACT
While there has been some research on sensemaking in individual information seeking, there is little understanding of sensemaking in collaborative information seeking tasks, such as collaborative Web search. We conducted a study of users' sensemaking in collaborative Web search tasks performed using SearchTogether. Based on findings of this study, we designed, implemented, and evaluated a tool, CoSense, to enhance sensemaking for collaborative search tasks. The results of our evaluation of CoSense provide insight into how people collaboratively make sense of information and what design features can help them.

Keywords
Collaborative sensemaking, collaborative Web search, SearchTogether, CoSense.

INTRODUCTION
While there has been research on sensemaking in various domains [3, 13], designing interfaces to support users' sensemaking of information remains an important and challenging problem in HCI [14]. Sensemaking has been broadly defined as the cognitive act of understanding information. Most of the current sensemaking research has been focused on helping individual users make sense of large amounts of information.

The goal of our research is to understand sensemaking in collaborative work, specifically in collaborative information seeking. In this paper we report on a study of sensemaking in collaborative Web search tasks. We conducted a formative study of sensemaking in collaborative Web search using SearchTogether [8]. Based on findings of this study, we designed a tool CoSense to enhance sensemaking in collaborative Web search. Here we report on the results of our formative study, the resulting CoSense tool, and findings from an evaluation of CoSense. We also discuss the implications of our findings for understanding the nature of collaborative sensemaking and design features that can aid sensemaking for collaborative information seeking.

RELATED WORK
In HCI, sensemaking has been viewed as a cyclic process of finding information based on an initial framework; organizing information into categories or representations; refining the search criteria or representations used based on new information found; and changing representations or frameworks in use to fit new information [6, 11]. While sensemaking has been modeled as an important aspect of information seeking activities, discussions of sensemaking have been in the context of *individual* information seeking. Hence, most tools designed to support sensemaking focus on enabling individual users to annotate, categorize, structure, and visualize task-related information [2, 9]. Few researchers have studied how sensemaking takes place in *collaborative* information seeking, or designed tools to support the same.

Prior research has shown that people regularly collaborate in information seeking activities, both in their personal and professional lives. Twidale et al. [12] found that searching for information is often a collaborative activity in which group members share both the products and process of their search. Reddy et al. [10] found that in organizations (such as hospitals) people frequently collaborate to find and share information to achieve shared goals. Morris [7] found that people collaboratively search the Web for travel planning, shopping, or finding medical and technical information. Amershi et al. [1] found that in resource-constrained environments people often collaborate around a single computer to search the Web [1]. To support such collaborative information seeking, researchers have recently developed collaborative Web search tools (see [1, 4, 5, 8]) which help users to jointly search for information and share search results. However, since the role of sensemaking in collaborative information seeking has not been explored much, it is not know whether these tools adequately support groups' sensemaking.

FORMATIVE STUDY
In order to understand how sensemaking takes place in collaborative information seeking tasks, we conducted a formative study using SearchTogether[1], a collaborative Web search tool available as a free browser plug-in from http://research.microsoft.com/searchtogether. The goal of our study was to examine how SearchTogether currently supports sensemaking during collaborative Web search tasks and what features can be added to enhance support for

[1] For details on SearchTogether features, please refer to [8].

sensemaking. 18 Microsoft employees were recruited to participate in our study. They were assigned to six, 3-person teams such that members of each team knew each other (i.e. they were friends or acquaintances) and were familiar with basic Web search. The task given to each team was to plan a weekend of activities to explore the local metropolitan area. Each team member was provided a computer with SearchTogether and other standard tools like Microsoft Office. The task was conducted in two phases; in phase 1 two group members were online synchronously but in separate physical locations and searched together. In phase 2, the third group member logged into the search session created by her group members in phase 1, and continued the task. The two-phase design of the task enabled us to study sensemaking challenges associated with handoff of the search task.

Participants were told to "think aloud" and an observer took notes of their usage of SearchTogether. We also audio- and video-recorded participants and their interactions with the tool were logged automatically. After the task was completed, we conducted semi-structured interviews with each participant.

Findings

Participants felt that collaborative Web search necessitated support for sensemaking, beyond what was offered by SearchTogether. There were three main findings of our formative study.

First, the temporality of the search process was important for group members' sensemaking. Many participants said that they wanted to see chronological orderings of heterogeneous content (such as comments and ratings associated with web pages, query terms, links followed, etc.). Persistence of the process of collaborators' sensemaking was important. Group members wanted to be able to view the path that others had followed during the search and felt that currently they "didn't have an idea of what route they [group members] were taking." Persistence of the products of sensemaking was also important. SearchTogether allows group members to comment on Web pages, but participants said that they wanted to be able to note meta-comments and decisions that were not associated with particular Web pages, but rather with the task itself. They also wanted to be able to edit these meta-comments as the group's sense evolved over time.

Second, awareness played a key role in group members' sensemaking. Participants wanted awareness of others' actions. They wanted notifications when another group member looked at a web page they added to the summary or typed a chat message. They also wanted awareness of the context surrounding the Web pages, queries, and chat messages.

Third, it was found that sensemaking was specifically difficult for phase 2 participants who were handed off the search task. These participants were overwhelmed with all the information in the search session and felt that there was no quick way to get an overview of "what others were thinking." They found it difficult to correlate the different kinds of information (web pages, comments, ratings, chat) and determine what decisions had been made by others. They also found it hard to distinguish "old information" from "new information."

Thus, our formative study showed that there was a need to enhance sensemaking in SearchTogether. Based on our findings, we designed a new tool, CoSense.

COSENSE

CoSense uses data from a user's SearchTogether session and provides alternate views of this data to enhance sensemaking. Users log into CoSense along with SearchTogether. When a user logs into CoSense, the tool reads that users' SearchTogether search session data from a database and displays this data in four views – the search strategies view, the timeline view, the workspace view, and the chat-centric view. Data added via CoSense are reflected in SearchTogether and vice versa. CoSense updates its views in real-time in response to new data from any instances of SearchTogether and/or CoSense (that is, changes made by any group member are reflected in CoSense in real-time). The different views of information in CoSense were designed to make explicit the temporal nature of the search, provide action and context awareness, and support sensemaking during handoffs.

Search strategies view

The search strategies view (Figure 1) visualizes the query and browsing history of both individual group members and the group as a whole. There are graphs showing, for each group member in a search session, the total number of URLs visited, the total number of queries issued, the advanced operators used in queries, and the average time between queries. There are tag clouds of the websites visited by the group, as well as by individual group members. There are also tag clouds of the query keywords of individual group members and the group. The tag clouds are interactive in that hovering over a website name in the website tag cloud shows all the URLs associated with that website. Clicking on the website name in the tag cloud opens up all the URLs in tabs of the current browser window. Similarly clicking on keywords in the keyword tag clouds re-issues all the queries containing that keyword and shows the results of these queries in separate browser tabs.

Timeline view

This view (Figure 2) shows chronologically all the actions performed by group members during a search session in the form of an integrated timeline. The timeline contains queries issued, web pages visited, comments and ratings associated with web pages, and chat messages. Content is color-coded by group members. This timeline is interactive in that clicking on a website in the timeline opens it in the browser window. Also, a "preview" of the webpage appears

in the right side of the timeline tab. This preview shows a thumbnail of the web page, group members who visited that page, chat messages exchanged when that page was being viewed, and any comments and ratings associated with that web page. The timeline can be interactively filtered by group member or action type.

Workspace view

The workspace (Figure 3) is designed to support categorization of search results and storing of the products of sensemaking, such as meta-comments associated with the search session and files or other electronic artifacts group members might create. The left side of the workspace contains summaries of web pages group members have commented on. The summary for each web page contains a link to the webpage, comments and ratings associated with that web page, and a list of group members who visited that web page. Group members can tag summary items and then filter the workspace by tags. The right side of the workspace contains areas for free-form note-taking (allowing group members to note to-do items or decisions reached). It also allows uploading of digital artifacts like text files, spreadsheets, photos, or email that group members might have created during their search. The notes and artifacts in the workspace are accessible to all group members.

Chat-centric view

The chat-centric view (Figure 4) shows a color-coded transcript of the chat conducted during the search session. Clicking on a chat message in this transcript shows the web page that was open in the browser of the person who authored that chat message, at the time that chat message was typed.

EVALUATION

We conducted a study to evaluate whether CoSense enhanced group members' sensemaking when searching collaboratively. We were specifically interested in evaluating whether CoSense helped sensemaking handoff for group members who searched asynchronously, since this was the most challenging aspect found by our formative study.. Finally, we were interested in how CoSense could be improved to better support sensemaking.

Thus, for our evaluation of CoSense, we chose an information retrieval task which was designed to require handover. We recruited 18 participants from Microsoft. As in the formative study, our evaluation task had two phases. In phase 1, two groups of 3 participants each searched the Web synchronously in order to plan a vacation in Europe. In phase 2, each of the remaining 12 participants were asked to continue the search session of either group from phase 1 and come up with a final itinerary of their vacation. Observers took notes during the search task and participants' interactions with CoSense and SearchTogether were logged automatically. After completing the task, participants were administered an online questionnaire containing questions that probed the extent of their sensemaking. The questionnaire recorded participants' answers and the time taken to answer each question. Finally, we conducted semi-structured interviews with phase 2 participants after they completed the task.

FINDINGS

CoSense feature use

We examined which features of CoSense were used most during phase 1 (synchronous search), phase 2 (asynchronous search) and in answering the post-test questionnaire. We found that in phase 1, the most frequently used view was the **search strategies** view, followed by the **chat-centric** view. In the search strategies view, participants viewed tag clouds and clicked on tag cloud items (query keywords and websites). In the chat-centric view, participants often clicked on chat messages to open web pages associated with chat items. In phase 2, the most frequently used views were the **workspace view**, followed by the **timeline view**. In the workspace view, participants edited the "scratchpad" and "to-do" (free-from text entry areas) and also opened the web pages associated with summary items. In the timeline view, participants most often clicked on web pages in the timeline to re-open them in their browser.

Different views were used to answer different questions in the questionnaire. The search strategies view was used to answer questions related to skills and strategies of group members. The timeline view was used to understand relationships between different kinds of content, as well as the relative importance of different content. Participants used this view to answer questions about which pages generated the most discussion, and which queries were the most successful. The workspace view was useful in helping participants understand group members' contributions and roles with respect to the task, as well as decisions reached. The chat-centric view was also important to understand which group member contributed most to the task and what decisions were reached.

We found that when the task was handed off, phase 2 participants used the CoSense views, rather than those provided by SearchTogether, for their sensemaking. To get an initial understanding of what phase 1 participants had found, phase 2 participants used the search strategies view to get an overview of the queries issued and the websites visited by other group members. They further found the timeline view useful for digging into the details of the search process followed by others.

Measuring sensemaking

In analyzing the results of the questionnaire, we examined the average amount of time participants took to answer each question and the quality of their answers. In phase 1, participants took the longest times to answer questions related to group members' contributions and skills with respect to the search task. They took the longest time to

answer the question about which group member contributed most to the task; 50% of participants said they didn't know or that it was hard to tell. Participants also took a long time to answer the question about which group member was the most skilled searcher. Here again, 50% of participants said that it was hard to know or that they couldn't tell. In phase 2, participants again found it difficult to answer questions about contributions and roles of group members. Also, participants in both phases found it hard to answer the question about which websites generated a lot of discussion and which queries were the most successful. Phase 1 participants mostly said that they didn't know the answer to these questions, while phase 2 participants answered the questions but their answers were all different for a given phase 1 session. Participants in both phases took the same amount of time to answer the question about what decisions the group had reached.

DISCUSSION AND CONCLUSION

The evaluation showed that CoSense addressed many of the sensemaking challenges faced by participants in our formative study. The different views used in CoSense helped participants' sensemaking during synchronous and asynchronous search. During synchronous search group members' wanted to make sense of the search process in terms of how group members were searching (the websites found and queries issued) and their reasons behind finding and recommending content. For this, they viewed the tag clouds in the search strategies view and clicked on chat messages in the chat-centric view to see what web pages were being discussed and why. In asynchronous search, group members were more interested in the products of the search and used the workspace to look at the list of important web pages that others had commented on. They also drilled down into the details of the search to understand how sense had evolved during the search session. In this way, CoSense was useful in the handoff of the task. It especially helped phase 2 group members to make sense of the decisions made by group 1 members.

Our results show that there is scope for improving CoSense. Though helped by the views we provided, group members still found it hard to keep track of others' contributions and skills with respect to the search task (as evidenced by their difficulty in answering questions related to this in the questionnaire). They also found it hard to tell which queries or websites found by others had been useful or significant to the search session. Participants mentioned that they would like support for better prioritization of information (e.g. finer-grained ranking of summary items in the workspace) and better support for noting the products of sensemaking so that these can be easily passed along to group members.

We designed features to enhance sensemaking in collaborative search and found that different kinds of features support sensemaking at different stages of a collaborative search task. We hope to discuss the implications of our findings with the CHI '09 Sensemaking workshop participants and gain feedback for improving CoSense.

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REFERENCES

1. Amershi, S. and Morris, M.R. CoSearch: A system for co-located collaborative Web search. In *Proc. CHI 2008*, ACM Press (2008), 1647-1656.
2. Billman, D. and Bier, E.A. Medical Sensemaking with Entity Workspace. In *Proc. CHI 2007*, ACM Press (2007), 229-232.
3. Dervin, B. From the mind's eye of the user: The Sense-Making qualitative-quantitative methodology. In *Sense-Making methodology reader: Selected writings of Brenda Dervin*. Hampton Press Inc, Cresskill, NJ, USA, 2003.
4. Freyne, J. and Smyth, B. Cooperating search communities. In *Proc. Adaptive Hypermedia and Adaptive Web-based Systems 2006*. ACM Press (2006), 1-10.
5. Golovchinsky, G., Pickens, J., and Back, M. A taxonomy of collaboration in online information seeking. In *JCDL Workshop on Collaborative Information Retrieval*. 2008, Pittsburgh, PA, 1-3.
6. Klein, G., B. Moon, and R.R. Hoffman. Making sense of sensemaking 2: A Macro-cognitive Model. *IEEE Intelligent Systems*, 21, 5 (2006), 88-92
7. Morris, M.R., A survey of collaborative Web search practices, In *Proc. CHI 2008*, ACM Press (2008), 1657-1660.
8. Morris, M.R. and Horvitz. E. SearchTogether: An interface for collaborative Web search. In *Proc. UIST 2008*, ACM Press (2008), 3-12.
9. Qu, Y. A Sensemaking Supporting Information Gathering System. In *Ext. Abstracts CHI 2003*.ACM Press (2003), 906-907.
10. Reddy, M. and Jansen, B.J. A model for understanding collaborative information behavior in context: A study of two healthcare teams. *Information Processing and Management* 44 (2008), 256-273.
11. Russell, D.M., Stefik, M.J., Pirolli, P., Card, S.K. The cost structure of sensemaking. In *Proc CHI 1993*. ACM Press (1993), 269-276.
12. Twidale, M., Nichols, D., and Paice, C. Browsing is a collaborative process. *Information Processing and Management* 33, 6 (1997), 761-783.
13. Weick, K.E., *Sensemaking in Organizations*. Sage Publications Inc, Thousand Oaks, CA, USA, 1995.
14. Whittaker, S., Making sense of sensemaking, in *HCI remixed: Reflections on works that have influenced the HCI community*, MIT Press, Boston, MA, USA, 2008.

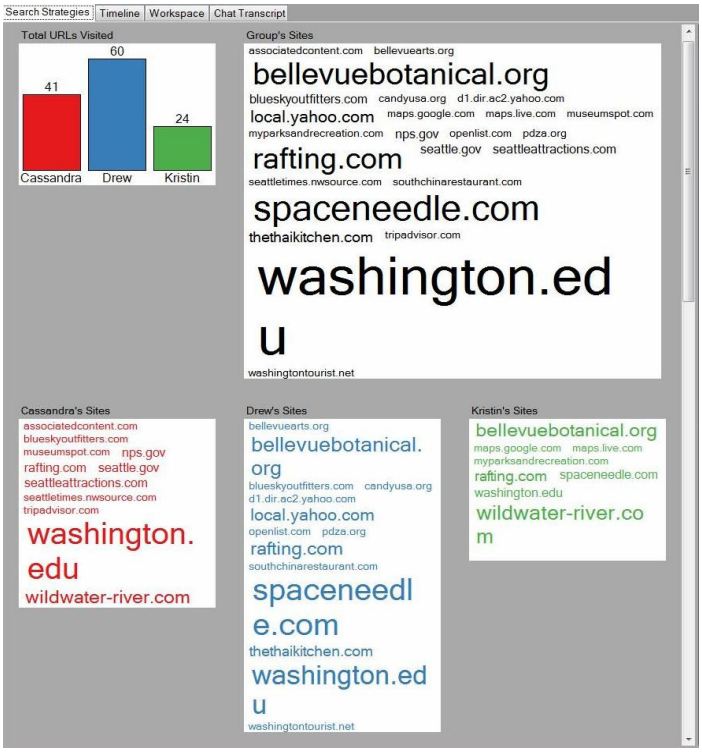

Figure 1. The search strategies view provides information about group members' roles, skills and expertise. It shows how many queries each group member executed as well as tag clouds of the websites visited by each group member and the group as a whole.

Figure 2. The timeline view provides a history of the entire search. It shows a unified chronological representation of the queries issued, web pages visited, comments and ratings on web pages, and chat messages. Content can be filtered by user.

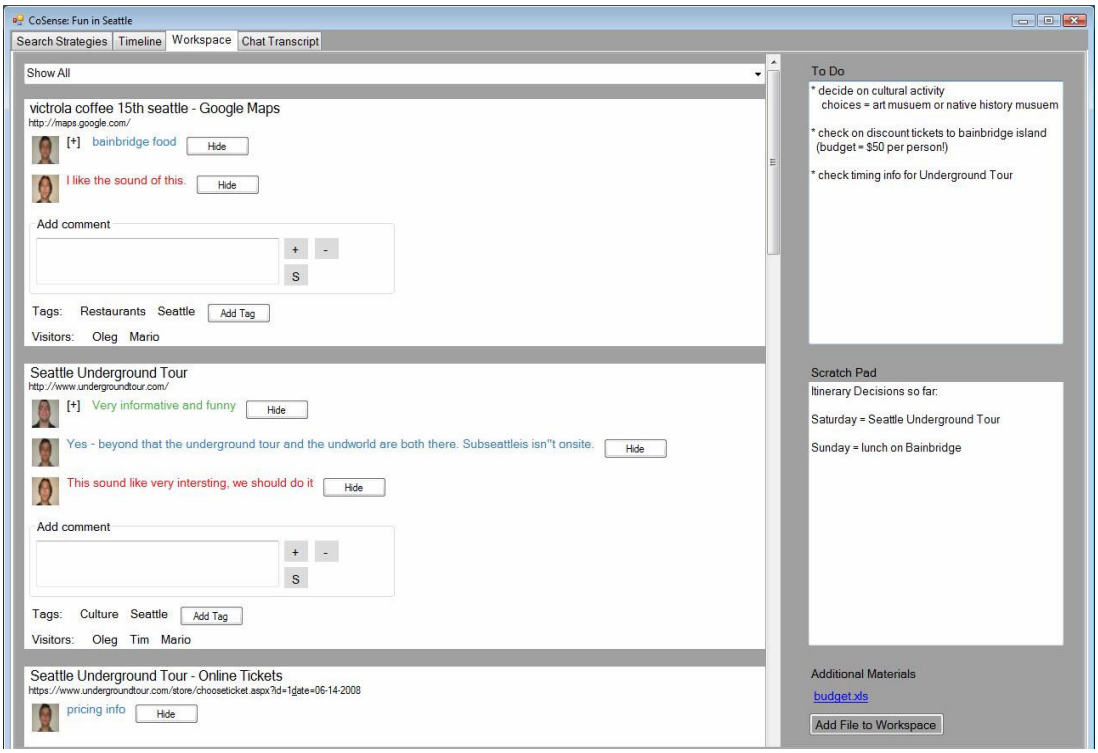

Figure 3. The workspace provides a place to store the products of the sensemaking process The left-side contains a list of "summary items", *i.e.*, web pages that have been commented on by group members. The right-side provides "to do" and "scratchpad" areas, as well as links to external documents associated with the task.

Figure 4. The chat-centric view shows the group's color-coded chat conversation (left). Clicking any chat message shows the webpage that message's author was viewing at the time that message was sent (right).