Collaboration in Search Processes and Results Sharing

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ABSTRACT
We present results from a survey of real-world collaborative information seeking situations. Specifically, we investigate how computers were used and shared as part of the search process, and how displays were used and shared to communicate results that were found from the searches. We present analysis of our survey responses, and give illustrative examples of five combinations of behaviors observed in the data. These results provide examples of real-world collaborative searches from a range of users and help inform the design of collaborative search systems.

Keywords
Information seeking, collaborative search.

1. INTRODUCTION
In this short paper, we examine and characterize situations of real-world collaborative information seeking described by respondents to an on-line survey. Prior investigations of collaborative information seeking have often sought to understand aspects of how collaboration takes place across dimensions of time (synchronous vs. asynchronous), location (co-located vs. remote), and the methods of communication used (e.g., face-to-face, phone, email, etc.). We examine our data from these perspectives, but also focus on how physical computers and displays were used as part of the overall collaborative processes. Specifically, we investigate two aspects: 1) how physical computers were shared while conducting searches, and 2) how displays were shared to communicate information found from the searches.

Implicit in our analysis is the assumption that collaborative search involves at least two components: 1) a *search* component in which collaborators work either individually or jointly to conduct searches to look for information, and 2) an *information sharing* component in which collaborators communicate their findings to their collaborators. Depending on the circumstances, these components may occur concurrently or sequentially, and they may also be iterated. In this paper, for the information sharing component, we focus on cases where a visual display (e.g. computer monitor, projected display) was used to share results with other collaborators. Using these dimensions, we sought to identify patterns of collaborative searching and information sharing across time, location and sessions.

2. RELATED WORK
Prior work on group work, collaboration, and collaborative search has investigated aspects of how people work together to conduct searches for information and share the results. Poltrock et al. [7] note that "information retrieval involves identifying an information need, formulating a query, retrieving information, evaluating it, and applying it," and that collaboration adds activities to "communicate about the information need, share the retrieved information... and coordinate the constituent information retrieval activities across multiple participants" (p. 239). In studies of two design teams, Poltrock et al. [7] observed that face-to-face meetings were commonly used to identify information retrieval tasks and to share retrieved information.

Evans and Chi [5] studied the social aspects of searching, and found that people engaged in social interactions about a search before, during, and after their searches. Capra at al. [2] investigated how people share information after searches and found that many users rely on simple tools such as email to communicate search results.

Twidale et al. [10] investigated collaborative search in terms of time and location, and also distinguished collaboration on the search process and on the search product. In a survey of workers at a technology company, Morris [6] also used this distinction of collaboration on the search *process* versus collaboration on search *products*. In the analyses we present here, we use a similar distinction to investigate how collaborators share computers when conducting searches and how they share displays to communicate results. In Morris' study, she found that 87% of the respondents had "watched over someone's shoulder as he/she searched the Web, and suggested alternate query terms", and that 85% had "Showed a personal display to other people to share results of a Web search." Amershi and Morris [1] present "shared-computer searches" and "parallel-computer searches" as two scenarios commonly reported from a diary study they conducted. Shah and González-Ibáñez [9] investigated the differences among several search scenarios including individual users and users collaborating while: co-located and using the same computer, co-located using their own computers, and remotely located. They reported that remotely located collaborators worked more independently than those who were co-located, and found benefits of working collaboratively versus individually.

3. METHOD
We conducted an on-line survey that asked participants to provide information about their experiences collaborating on searches and sharing search results. We have reported results from this survey previously [3][4], and additional details about the method and data collection methods are given in [4]. Here, we report on an aspect of the data that has not been previously examined: how computers and displays were used in the collaborative search process and how they were used to support information sharing[1].

Participants were recruited using the Amazon Mechanical Turk. A total of 452 people started the survey, and 307 gave usable responses for the analyses presented here. Participants ranged in age from 18 to 68 years, 64% were female, 32% were students, and 59% were employed at least part-time. Participants had a wide variety of backgrounds including: delivery man, operations specialist, automotive assembler, and police officer.

[1] Since we developed new codes and analyses for this paper, the number of usable cases included in the results presented here differ slightly from our previously reported analyses in [4].

We gave participants the prompt: "Think about a situation in which you have done a Web search in cooperation with another person (or several people)" and then asked a series of questions about the situation. We asked free-response questions to describe the overall situation, the search topic, the coordination of the searchers, and the computers/displays that were used. We also asked fixed-choice questions about synchronicity, location, and what communication methods were used. Each of these is described in more detail below.

Synchronicity – For this question, we asked, "Did people work on the search at the same time, or on their own time?" We included three choices: 1) Mostly people worked at the same time, 2) Mostly people worked on their own time, and 3) A mix of both – some at the same time, some on their own time.

Location – This question asked, "Where were the people working on the search located?" with three choices: 1) Everyone was in the same room, 2) Everyone was in different locations, and 3) A mix of both – some in the same room, some at different locations.

Communication – We asked, "How did you communicate with the other people to cooperate on the search?" and allowed people to choose all that applied from these choices: face-to-face, phone, email, instant message, text message on cell phone, social network service, blog post, other (describe).

4. Analysis

The results presented here extend our previous analyses of this data by looking at how computers and displays were used in the overall collaboration. Specifically, we look at: 1) how computers were shared (or not) in search process, and 2) how displays were shared (or not) to support sharing of information found while searching. We manually coded the data for both these dimensions as described below.

For each survey response, we coded a variable called *search_computers_used* as one of the following:

Individual computers – each participant used their own computer to conduct the search(es).

Shared computer – all searchers were using the same computer to conduct the search(es), maybe at the same time or at different times.

Mixed computers – either: a) some participants used their own computer and others used a shared computer, or b) participants used their own computer for part of the search and a shared computer for part of the search.

For each survey response, we coded a dichotomous variable called *shared_information_display* based on the data. We coded a response as using a shared display if the respondent specifically mentioned looking at the same screen face-to-face or using a screen-sharing tool. Any searches that were conducted using a shared computer at the same time were also coded as having a shared display. For other cases, we assumed that no shared display was used. We note that this is a conservative assumption – respondents may have used a shared display but failed to mention it in their response.

5. RESULTS

In this section, we describe results from our analysis. First, we examine our data in terms of the dimensions of time and locations. Next, we consider the variables *search_computers_used* and *shared_information_display* individually. Finally, we investigate combinations of *search_computers_used* and *shared_information_display* and present examples to illustrate interesting cases reported in our data.

5.1 Time and Location

To get an initial understanding of our data, we examined it in terms of the dimensions of time and location. Table 1 shows a cross-tabulation of the frequency counts for our data.

Table 1: Time by Space Cross-Tabulated Frequencies

		Location			
		Co-located	Remote	Mix	Total
Time	Sync	32% (98)	15% (46)	2% (5)	49% (150)
	Async	1% (3)	15% (45)	2% (5)	17% (53)
	Mix	6% (19)	11% (35)	16% (51)	34% (104)
	Total	39% (120)	41% (126)	20% (61)	100% (307)

As shown in Table 1 (and also discussed in [4]), our respondents reported collaborative searches across all combinations of time and location. Prior work in collaborative search has often considered time and location as dichotomous dimensions (i.e., either synchronous or asynchronous), whereas we included an option for respondents to indicate if there was "a mix of both". In our data, 20% were cases that involved a mix of locations, and 34% had a mix of both synchronous and asynchronous searching. These results suggest that real-life collaborative search involves many complex situations. Studying such mixed time and location situations can be challenging and few experimental studies have tried to do so ([8] and [9] are notable exceptions). We see this as an important area for future research that should draw upon research methods from both information science and CSCW.

5.2 Shared Computers and Displays

5.2.1 Search Computers Used

To understand how computers were being shared when conducting collaborative searches, we tabulated the codes for the *search_computers_used* variable. In our data, there were cases where each collaborator used their own computer (77%), a shared computer (16%) or a mixture where some collaborators used their own computers and others used a shared computer (6%). Illustrating the mixed situation, one respondent described a search for family history information search with 6 participants using mixed computers:

"We used 3 different computers, in 3 different locations, but multiple family members were together."

5.2.2 Shared Information Display

Out of our 307 responses, we identified 75 (24%) in which there was a clear description of a collaborator viewing another collaborator's display for the purposes of sharing results that were found from the search. For example:

"one was searching, the other was looking at the screen and providing search suggestions"

"Everyone looked at and shared the same computer."

We note that in the 232 cases where no shared display was specifically mentioned, other methods were frequently used to share results. Across all the responses, the other reported methods

included face-to-face (67%), email (40%), phone (33%), instant message (22%), and text messages (17%).

5.2.3 Search and Sharing Combinations

To get a better understanding of how computers and displays are shared in real-world collaborative search situations, we re-examined our data by looking at all combinations of the *search_computers_used* and *shared_information_display* variables. Table 2 shows the frequency counts and percentages.

Table 2: Displays by Computers Used

		Search Activities			
		Own Computer	Shared Computer	Mix	Total
Information Sharing	Shared Display	3% (10)	15% (46)	7% (22)	25% (78)
	No Shared Display	74% (227)	1% (2)	0% (0)	75% (229)
	Total	77% (237)	16% (48)	7% (23)	100% (307)

Our respondents reported examples of five of the six possible patterns as shown in Table 2:

- search using individual computers and information sharing using a shared display when interesting results were found (3%, n=10).
- search using a shared computer and information sharing using a shared display (15%, n=46).
- search using a mix of individual and shared computers and information sharing with a shared display (7%, n=22).
- search using individual computers and information sharing without a shared display (74%, n=227). We note that in these cases, information was shared using other methods (e.g. phone, email).
- search taking turns using a shared computer and information sharing without a shared display (1%, n=2).

We did not find any examples in our data that involved search using a mix of individual and shared computers without a shared display being used for information sharing.

In the subsections that follow, we explore each of five patterns we observed in more detail and give examples to illustrate each case.

5.2.4 Shared search + shared info display

In our data, 15% of the searches involved collaborators searching together on shared computers using a shared display. In these searches, the collaborators were co-located (n=45, 14%) or had mixed locations (n=1, <1%) and searched synchronously (n=41, 13%) or with mixed time (n=5, 2%). Below are two examples from our study:

> *"I had to work cooperatively to find answers about special needs children. One person read the question while one searched. We all read the search results and agreed on which one to click. We read the information and all agreed on the answer after discussing it."*

> *"We were brainstorming together about what keywords we could use to locate the book…we each stated search terms as they came to us to try. We shared the screen, and skimmed Google entries looking for a relevant link."*

In searches that took place with mixed time, one searcher did most of the searching and shared the results on the same display:

> *"I mostly did the searching. I turned pages… I was interested in into shortcuts. Then, I showed my husband each page. We picked one out together. We looked at my computer monitor display together."*

The above example illustrates a situation in which the primary search was done individually, but the results examination was a collaborative effort.

5.2.5 Individual search + shared info display

In 3% of the cases (n=10), searchers used their own computers to search for information and used a shared display to share information. In each of these cases, the searches were at least partially synchronous and the searchers were co-located except for one case that was conducted over a web meeting.

Although this represents a small percentage of searches, we believe that this configuration is an important area for collaborative search research. We provide several examples to illustrate these situations. The first example involves a reluctant participant in a web meeting:

> *"Ugh-- I hate it. Last time, we were one web meeting and people had a question about something and they said, hit Google. So, I had to. Then, it was like herding cats. People wanted us to look for x or y or z … We were all looking at a single web meeting screen… It's annoying, because there is only one "driver" of the meeting and everyone has a different way of looking at the internet"*

Three of these types of searches involved searching for videos to watch together:

> *"My friends and I were each on our separate laptops and we searched for stand-up comedy online to show each other. Sometimes we would use our own computers and sometimes we would watch... on one person's screen."*

Another example involved two searchers who searched on their own computers during a conversation and shared the results using both a shared display and email:

> *"…we start having a conversation about something and both [tried] to find a link to what we are talking about, we do it quite a bit with recipes and movie trailers coming out and then both watch them together. We both just searched at the same time and the one who found it 1st e-mailed the other... We each had a computer, once the item was found we looked at a single computer."*

The above examples illustrate situations in which improved collaboration technologies could benefit users. These scenarios each involve users who appreciate having individual control, but the ability to quickly and fluidly move the group focus from one display to another as the searchers individually find interesting information.

5.2.6 Mixed search computers + shared info display

In 6% of the cases (n=22), searchers used some combination of their own computers and a shared computer (i.e., "mixed" search) and at some point they shared results using a shared display. The majority of these cases (n=19, 5%) were conducted over multiple

sessions with some sessions involving searching on individual computers and other sessions using a shared computer.

> *"…sometimes we'd be together talking about it and a computer would be nearby, so we'd do a quick serch [sic]. Other times, the searches were done seperately [sic] at our houses or at our desks.... occasionally we all looked at one display whenever we all happened to be in the same room."*

> *"Some used their own computer others shared, but the majority of the time everyone had their own computer."*

In one search, searchers began their search together and then switched to using separate computers in the same location:

> *"…my husband and I were watching a TV show and we wanted to know the ages of the individuals representing this... panel. My husband was looking up each panel member's age and at first I was observing until we wanted more detailed information and then he continued to look up ages and I looked up more details."*

This scenario is similar to the previous scenario in that in each search took place partly co-located (7 co-located only and 15 mixed locations) and partly synchronously (4 synchronous and 15 mixed times).

5.2.7 Individual search + no shared display

In the majority of cases (n=227, 74%), searches involved each searcher using their own computer to search and there was no mention of sharing information using a shared display. These cases were presented in our data across time and location conditions with sync and co-located (16%), sync and remote (14%), async and remote (15%) and mixed time and mixed location (10%) most frequently. We note again that our coding of shared display use was conservative – respondents may have used shared displays but not mentioned them.

Respondents described searching individually and comparing notes or discussing findings using a number of communication methods without shared displays.

> *"Me and my best friend were looking for great destinations to have a wedding. We were in different locations and searching at different times... I did searches until I felt I had enough information and she did the same. After a few days we shared our information over the phone."*

By separating the search experience into the search process and information sharing when possible, we were able to identify instances in which respondents indicated they searched remotely and asynchronously yet used face-to-face communication for information sharing.

> *"In researching [medical condition] my family and I all searched for information and shared it with each other via email and telephone. Each person researched on their own for anything they found intriguing, and then everyone compared notes."*

Two respondents described group projects with a remote search and face-to-face information sharing, with one indicating a preference for using a shared display for information sharing:

> *"What we usually did was divide the topics of research into sub-groups, and then each individual went home and did individual research. Then we met and discussed the findings...Everyone had a computer at home. Then we printed or wrote a summary of what was more useful and discussed everything face-to-face... So many times I wished I was looking directly at a screen rather than just hearing about the research"*

6. CONCLUSION

In this paper we presented results from a survey of real-world collaborative information seeking situations. We investigated how computers were used during the search process, and how displays were used to share information found during the searches. We characterized five combinations of these dimensions and presented illustrative examples from our data. These results can help inform the design of collaborative search systems and give insights into real-world search scenarios.

7. ACKNOWLEDGMENTS

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