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An elaborated model of social search

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ABSTRACT

Search engine researchers typically depict search as the solitary activity of an individual searcher. In contrast, results from our critical-incident survey of 150 users on Amazon's Mechanical Turk service suggest that social interactions play an important role throughout the search process. A second survey of also 150 users, focused instead on difficulties encountered during searches, suggests similar conclusions. These social interactions range from highly coordinated collaborations with shared goals to loosely coordinated collaborations in which only advice is sought. Our main contribution is that we have integrated models from previous work in sensemaking and information-seeking behavior to present a canonical social model of user activities before, during, and after a search episode, suggesting where in the search process both explicitly and implicitly shared information may be valuable to individual searchers.

We seek to situate collaboration in these search episodes in the context of our developed model for social search. We discuss factors that influence social interactions and content sharing during search activities. We also explore the relationship between social interactions, motivations, and query needs. Finally, we introduce preliminary findings from the second survey on difficult and failed search efforts, discussing how query needs and social interactions may differ in cases of search failures.

1. Introduction

Web search has changed dramatically how we interact with the knowledge of the world. Its success in impacting our everyday lives in the last two decades is perhaps unparalleled. Surprisingly, however, researchers have mostly thought about navigating and browsing for information as a solitary user activity, focusing on eliciting a user's information needs and improving the relevance of search results.

This view is somewhat in conflict with prior research by library scientists looking at users' information-seeking habits (Fox et al., 1993; Kuhlthau, 1991; Shepherd, 1983; Twidale, Nichols, & Paice, 1997; Wilson, 1981). These studies were done by scientists before the wide availability of web search engines, but demonstrated that other individuals may be valuable information resources during searches.

More recently, researchers have observed direct user cooperation during web-based information seeking. Morris (2008) conducted a survey of 209 enterprise users, revealing that nearly half engaged in explicit collaboration on joint search tasks on the web. Collaboration is defined to be the "act of working jointly" (WordNet. Definition of "collaboration", 2009). So by extension, collaborative search is the act of working jointly on a search problem. Certainly, active collaboration by multiple parties does occur under some circumstance (e.g., enterprise settings); at other times, and perhaps for a greater majority of searches, users may interact with others remotely, asynchronously (Rodden, 1991), and even involuntarily and implicitly.

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As we shall see, it is clear that a wide range of collaboration happens in search episodes, including individual searchers who momentarily make use of peers, colleagues, and social resources as part of their otherwise personal search goals. Such episodes represent momentary collaborations in the scope of a larger search task. We are interested in this entire range of collaboration, from loosely coordinated searches, where perhaps only the search result is distributed to others, to highly coordinated searches, where people interact before, during, and after the search episode.

We refer to any search that contains social interactions to be "social search." The general term "social search" has been applied widely in the field of Web 2.0 to describe searches that:

- utilize social and expertise networks;
- are done in shared social workspaces;
- or involve social data mining or collective intelligence processes to improve the search process.

Our definition of "social search" is intended to be broad, to include a range of possible social interactions and collaborations that may facilitate information seeking and sensemaking tasks:

> *"Social search" is an umbrella term used to describe search acts that make use of social interactions with others. These interactions may be explicit or implicit, co-located or remote, synchronous or asynchronous.*

Our focus, therefore, is to bring some clarity to how *social search* occurs in the real world. We analyzed the self-reported search experiences of 150 users from Amazon's Mechanical Turk, and mapped their complex social activities onto a single, canonical model of the extended search process. As we present this integrated model of social search, we note specifically where social interactions occurred before, during, and after a search event. We support the model with observations from our data by describing: (1) users' search motivations; (2) their pre-search preparation process (seeking guidance, advice, and clarifications on the information need); (3) how they conducted searches according to those information needs (*transactional*, *navigational*, *informational*); (4) how they shared end results after the search.

We also discuss factors that influence social interactions and content sharing during search activities, and explore the relationship between social interactions, motivations, and query needs. Finally, we introduce preliminary findings from the second survey on difficult and failed search efforts, discussing how query needs and social interactions may differ in cases of search failures.

We present our results in four parts:

- Part 1: characterization of social search.
- Part 2: factors of social interaction and content sharing.
- Part 3: patterns between pre-search and post-search social interactions.
- Part 4: preliminary results of failed and difficult search data.

In the rest of this paper, we briefly review past research works in this area, describe our survey and data collection procedure, and present the canonical model, both as a diagram and with quantitative support and anecdotal case studies of actual behavior. We conclude with design implications, limitations, and some general remarks.

2. Related work

Until quite recently, researchers have mostly thought about navigating and browsing for information as a single user activity (Catledge & Pitkow, 1995; Cockburn & Jones, 1996), even among those who developed behavioral models of information seeking (Bates, 2002; Choo, Detlor, & Turnbull, 1999; Ellis, 1989; Marchionini, 1995). Ellis' early work in understanding the behavioral patterns of users as they search for information led to a basic model of information-seeking characterized by six general categories: starting, chaining, browsing, differentiating, monitoring, and extracting (Ellis, 1989). Marchionini expanded this model to describe how the user acknowledges and defines the information need, formulates the query, executes the search, and examines and internalizes the results (Marchionini, 1995). Choo et al. (1999) and Bates (2002) have subsequently presented more integrated models of search on the web. However, the "modes of information seeking" that they discuss focus more on categories of search behaviors and motivations, than on how people actually accomplish search. Like much of the information-seeking literature, this work overlooks the role of other individuals in search, instead focusing on the search act from a single user's perspective.

It is interesting, therefore, that library scientists have recognized for some time that other individuals may be valuable information resources during the search process (Wilson, 1981). Even prior to the search, "the inquirer decides whether to discuss his problem with a colleague or go to whatever literature or information center may be available" (Taylor, 1968). Later, users refine their topic selection in preparation for the search by consulting friends and colleagues who serve as sounding boards for ideas (Kuhlthau, 1991) and who provide pointers to key references in the literature (Fox et al., 1993; Shepherd, 1983). More recently, Twidale et al. (1997) have highlighted the prevalence and benefits of collaborative searching. By studying the behavior of library users at computer terminals and throughout the library, they observed that co-located, synchronous collaboration occurs both during the search *process* and after obtaining the *end product* (e.g., query

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results). These findings, in particular, suggest that we should expand our investigation of "search" to include the periods of time surrounding the user's interaction with a search engine.

Most of the library scientists explored the explicitly collaborative social interactions that occurred around searches; yet other researchers have focused on implicit sharing mechanisms as a means for better personalizing web search (Glance, 2001; Goldberg, Nichols, Oki, & Terry, 1992; Hofgesang, 2007; Konstan et al., 1997; Smyth, 2007). Social recommendation systems, for example, use techniques like collaborative filtering to provide recommended items to information seekers (Glance, 2001; Goldberg et al., 1992; Konstan et al., 1997; Smyth, 2007), based on the opinions or activities of other people. These approaches are arguably also "social search" systems since they make use of latent community behavior, even though they typically do not exploit users' social networks to personalize search. Chi (2009) provides a distinction by referring to such approaches as *social feedback* and *social answering* systems, respectively. The goal of social recommendations is to provide implicit *social feedback* to individual searchers; *social answering* makes explicit use of social networks.

Considering the related work in the library sciences and recommender research communities, a reasonable hypothesis is that a significant portion of web search involves social acts, and that social interactions can improve the search process. Indeed, an increasing number of Web 2.0 sites provide various types of social inputs, which could be used to augment search. Tagging services allow users to socially annotate web links for personal (del.icio.us (Lee, 2006), diigo), academic (CiteULike, Connotea), and enterprise use (Dogear (Millen, Feinberg, & Kerr, 2006), ConnectBeam). Many of these tagging systems are in fact used as collaborative tools by groups of users who designate each other as peers. Networking sites allow users to maintain social connections with peers (MySpace, Facebook) and business partners (LinkedIn). Even search engines are beginning to apply a "social" lens on search result listings—for example, through votes of link relevance (Google's SearchWiki) or human-written entries (Mahalo). Yet despite the potential of these sites, only a few researchers have explored how such "social web services" might improve the search process (Heymann, Koutrika, & Garcia-Molina, 2008; Yanbe, Jatowt, Nakamura, & Tanaka, 2007).

More importantly, we still do not fully understand users' social and collaborative information seeking and sensemaking needs. How and where in the search process do users interact with others? How can social networks help? What benefit do social interactions and collaborations have on the quality or efficiency of the search process? Morris (2008) recently looked at collaboration surrounding web search activities and found that office workers often coordinated with others during joint search efforts. To support these types of activities, a number of tools have been built for explicit collaboration among small groups of people for shared web search tasks: SearchTogether (Morris & Horvitz, 2007), CoSearch (Amershi & Morris, 2008), and Cerchiamo (Pickens, Golovchinsky, Shah, Qvarfordt, & Back, 2008).

Past research builds a solid foundation for future social and collaborative technologies. We hope that our work further illuminates the broad social and collaborative needs of users throughout the search process to help inform these tools. We believe that the benefits of social search will include but also extend beyond joint collaborative (synchronous and co-located) search to more implicit, asynchronous, and remote interactions. Our focus in this paper is to begin to explore a model of social search that may offer suggestions for supporting momentary collaboration and other social interactions in the extended process of online information seeking.

3. Procedure

In this paper, we report on two critical-incident style surveys that we posted on Amazon's Mechanical Turk. Here, we first describe the methods for the primary survey—a collection of everyday searches. In Part 4, we describe the methods for the secondary survey—a collection of failed and difficult searches.

Mechanical Turk is a type of micro-task market, which can engage a large number of users to perform evaluation tasks both at low cost and relatively quickly (Kittur, Chi, & Suh, 2008). Although it is a relatively new tool for academic research, its utility has been demonstrated in a number of research domains (Kittur et al., 2008; Sheng, Provost, & Ipeirotis, 2008; Snow, O'Connor, Jurafsky, & Ng, 2008).

Following Kittur et al. (2008), we took special care in both surveys to formulate our tasks to probe for specific information, minimize generalities, and reduce invalid responses. Our results reflected our careful consideration of the survey design: nearly all replies were complete, coherent, focused, revealing, and purposeful. Table A presents a sample of the raw data that we obtained. We have made the complete set of raw data from the first survey publicly available for detailed examination; it can be downloaded from: <http://asc.parc.googlepages.com/2009-08-social-search-survey-data.xlsx>.

3.1. The survey

The survey in both studies was designed to collect self-reports of "critical" incidents, in which users describe events of a certain class or quality that were out of the ordinary or otherwise noteworthy (Castillo, Hartson, & Hix, 1998; Flanagan, 1954).

Originally critical-incident questioning occurred face-to-face and probed for the details and context of just a single event in order to avoid generalizations from similar incidents. This style of questioning—around only one noteworthy incident—has been employed more recently in the form of a questionnaire (Brookfield, 1995). Therefore, we designed a modified *critical-incident style* survey that probed for a search events that occurred *most recently*.

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For the primary survey on everyday searches, we recruited users with a specific statement of our purpose:

We are interested in how you search for digital information on your computer. Please answer the following questions about your most recent search experience.

The survey prompted users for details surrounding the selected incident, presented as yes/no, multiple choice, or free-form responses. We collected information related to the search *context* and *purpose*, additionally asking how (or if) users interacted with other individuals prior to and following the primary search act. For example, users were shown the following series of search-related questions. Table A shows selected responses to questions 6, 7, and 8 below.

1. When was the last time you searched for information?
   [ ] today, recently
   [ ] today, earlier in the day
   [ ] yesterday
   [ ] 2 days ago
   [ ] more than 2 days ago
2. What kind of information was it? [free-form answer]
3. What were you doing just before you searched? [free-form answer]
4. Did you talk with anyone (face-to-face, email, phone, etc.) before you searched? Why or why not? [free-form answer]
5. If yes, was your conversation related to your current search? [free-form answer]
6. What prompted you to perform the search? [free-form answer]
7. What steps did you take to find this information? [free-form answer]
8. What did you do just after you searched? [free-form answer]
9. If other people were nearby, were you interacting with them or were they influencing your search process?
   [ ] There were no others in the room.
   [ ] There were others, but I was not interacting with them.
   [ ] There were others, and my interaction with them was related to my search.
10. 10. If other people were nearby, please explain your interaction with them. [free-form answer]
11. After you found the information, did you share it with anyone?
    [ ] yes
    [ ] no
12. Why or why not? [free-form answer]
13. If yes, how did you share the information? [free-form answer]

Finally, users provided background information on their job roles, professional sector, and job expertise. They commented on how the reported incident was similar to and different from related search experiences, when the search occurred, and how long it took to complete.

We received a total of 164 replies to this survey. Of these, seven were immediately rejected for being incomplete (95.7% of replies were initially acceptable and complete); we later discarded an additional seven for having indecipherable responses (4.5% dismissal rate). The resulting data set includes 150 complete and thorough responses. We paid $0.28 for each good reply, with a total data collection cost of $42.00.

Table A
Three selected replies to our critical-incident questionnaire. Responses are shown to Questions #6, 7, and 8.

6. What prompted you to perform the search?	7. What steps did you take to find this information?	8. What did you do just after the search?
I was between projects, sitting at my computer with nothing to do; I remembered the handheld vac, which was in a box in my closet. I had been meaning to look up a replacement filter for it for some time and figured that was as good a time as any	I went to ebay, typed in the model of the vac and filter and it came right up	Modified the search, leaving in only single words from the make of the vac, to see if I could get more hits and compare prices
I needed to locate information regarding where the GED tests were given so I could inform my client who did not have access to a computer	I solely used the Google search function and put in multiple queries, such as "GED locations in Winston Salem", "Winston Salem GED" among others	I contacted the location to determine the answers to the remainder of my questions
I found that some important information was missing from a client's application	I used internet explorer to pull up Google (which I also have set to search my desktop,) and I typed in the name of the credit card company and the work "contact" and found the page I needed near the top of the search results	Completed processing the client

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Table B
The most frequently occurring professional sectors and job roles reported by users in our sample.

Professional sector	Users %	Job role	Users %
Education	9.3	Manager	19.3
Financial	8.7	Assistant	18.7
Healthcare	6.7	CEO/director	8.0
Government agency	6.0	Customer support	7.3
Retail	6.0	Teacher	6.0
Software	6.0	Programmer	6.0
Research	5.3	Analyst	4.0

Table C
Information reported about duration of the search act and level of job experience.

Search duration	Users %	Job expertise	Users %
<5 min	44.7	5	33.3
5–10 min	23.3	4	35.3
10–20 min	10.7	3	20.7
20–30 min	13.3	2	7.3
>30 min	8.0	1	3.3

3.2. Sample data

Our initial survey resulted in 150 complete reports of everyday searches from anonymous workers on Mechanical Turk. Since critical-incident self-reports are most accurate in recounting recent experiences (Flanagan, 1954), we elicited user responses about their latest search acts. Consequently, about 2/3 of search acts occurred on the same day that users filled out our survey (48.7% occurred "recently" and 14.7% occurred "earlier in the day"). 19.3% of searches occurred the day before, and 17.3% occurred more than 2 days ago.

Search acts were relatively brief, nearly half requiring fewer than 5 min to complete. Respondents came from a range of professional sectors, job roles (Table B), and levels of job experience, as rated on a 5-point Likert scale (Table C).

A majority of our users only searched for information on the Internet (111/150, 74.0%). The remainder used tools that were internal to their professional organizations (e.g., Outlook, software programs, company Intranet). Only two users reported using both Internet and internal tools over the course of their search act.

Finally, we categorized each reported incident using Broder's (2002) taxonomy of web queries according to information needs. Other taxonomies could be used to classify information-seeking patterns (e.g., Jansen, Booth, & Spink, 2008; Kellar, Watters, & Shepherd, 2007; Shen, Sun, Yang, & Chen, 2006). Kellar et al. (2007), for example, focuses on task-based needs and information seeking and gathering activities broadly. We wanted a simple framework for classifying search needs in particular, and therefore selected Broder's basic taxonomy for "needs behind the query," which we call "query needs" in the rest of the paper:

transactional performing a transaction and extracting information after a source or website is located;
navigational following a series of steps to identify a known fact or website;
informational searching for information assumed to be present, but otherwise unknown.

There is a rough correspondence between the taxonomy from Kellar et al. and the one we've borrowed from Broder. Kellar et al. also have a *transactional* category. Broder's *informational* query needs may fall under the category of "Information Gathering" because of its exploratory nature where "you do not always know when you have completed the task, and there is no one specific answer" (Kellar et al., 2007, p. 1005). *Navigational* query needs also corresponds roughly to the "Fact Finding" category when the necessary navigational steps are already known to the user.

4. Results

Our main contribution is that we have integrated our findings with models of sensemaking and information seeking from the literature, and we present a canonical model of user activities throughout the search process (Fig. 2, below). We present our results in several parts:

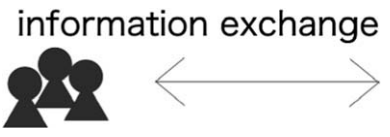

Fig. 1. Users exchanged information with others through social interactions in a number of places throughout the search process.

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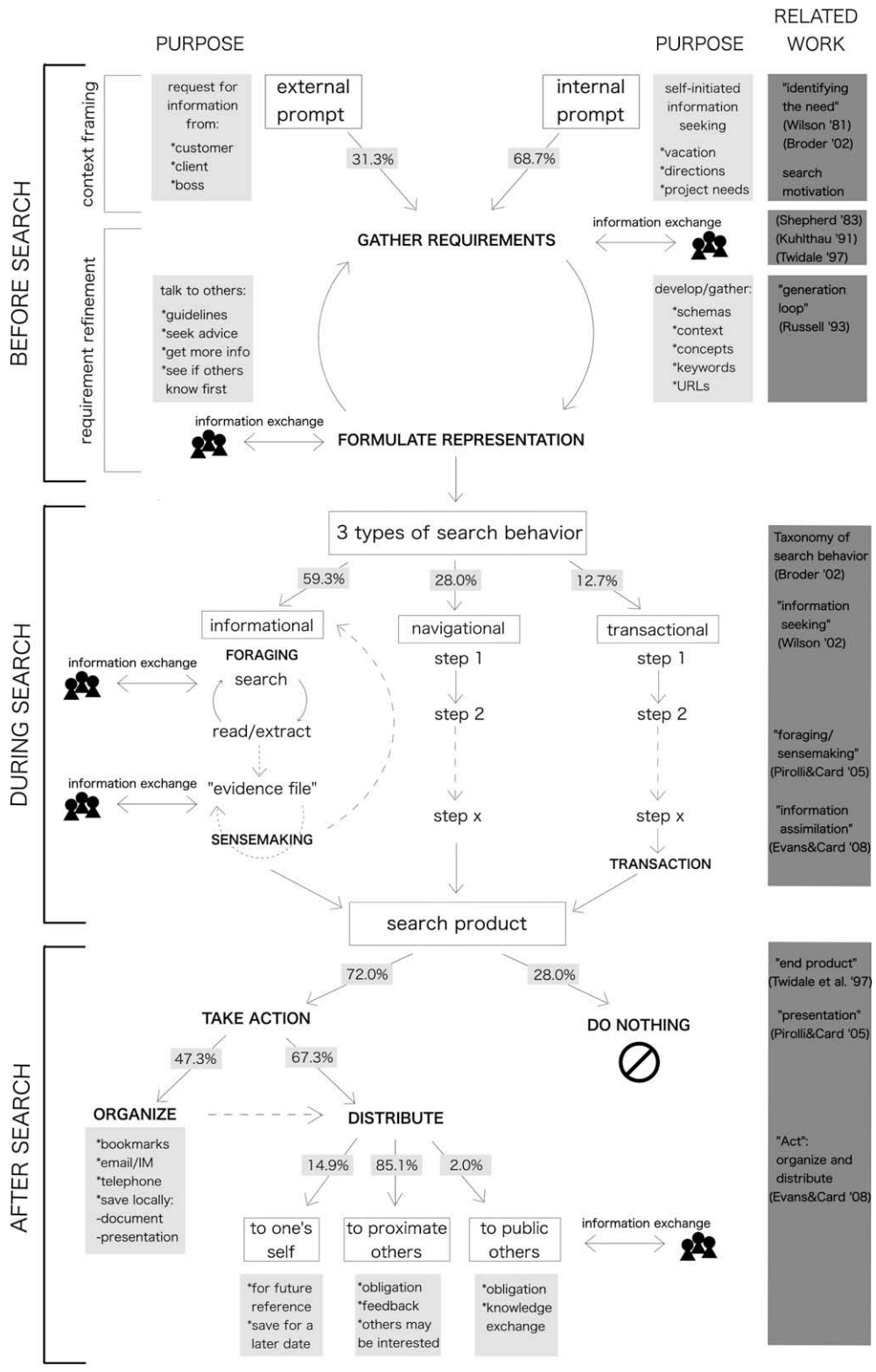

Fig. 2. Canonical social model of user activities before, during, and after a search act, including citations from related work in information seeking and sensemaking behavior.

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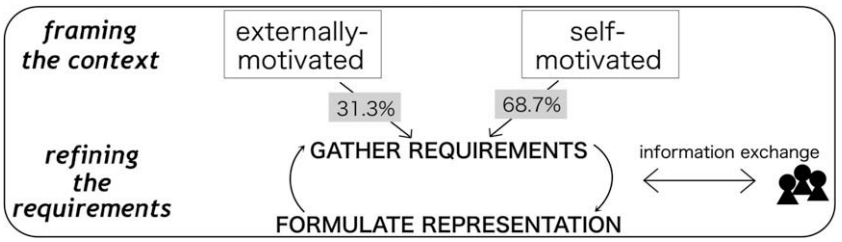

Fig. 3. The Before search phase of our model. Important search preparations take place even before users turn to information databases and search engines. Social interactions serve to help clarify search needs here.

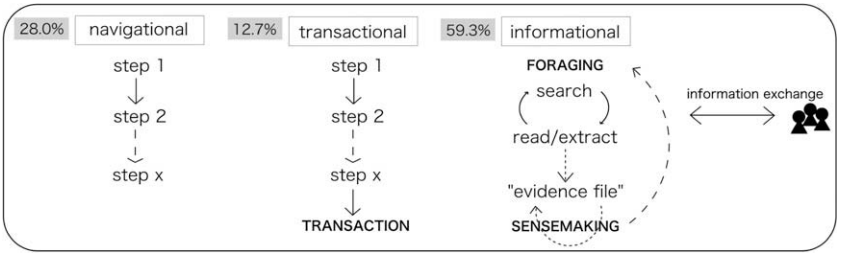

Fig. 4. The During search phase of our model. We describe three types of searches based on Broder's (2002) information needs (navigational, transactional, and informational).

1. First, our characterization of social search discusses our model in three phases: before, during, and after a search act. We illustrate each phase with quantitative data and anecdotal case studies of actual, reported user behavior.
2. Second, we elaborate on the factors that influence social interactions and content sharing. For example, what class of users is likely to engage in social interactions during search tasks?
3. Third, we explore the relationship between social interactions, motivations, and query needs. This section focuses on patterns within the data around social engagement.
4. Finally, we introduce preliminary findings from a new study on search failures. We briefly discuss the differences between successful and unsuccessful searching, and how social activities were part of these processes.

4.1. Part 1: characterization of social search

Using data from our original search survey, we discuss our canonical model of social search (Fig. 2) in three phases: before, during, and after search. Although search is a fluid, dynamic process making it somewhat inappropriate to draw boundaries between different phases of "search," we want to examine behaviors that occur before and after interacting with a search engine. Thus, we intend to document user interactions from in the entire, extended search process, even when those behaviors occur "offline." We highlight the places where information exchanges occurred through social interactions by the illustration in Fig. 1. The nature and consequence of these social interactions is elaborated on in Part 2.

4.1.1. Before search

Important search preparations take place even before users turn to information databases and search engines. (For the sake of discussion, we refer to the activities occurring before interaction with a search engine as *before search*.) Some people only briefly reflect on their goals; others gather preliminary evidence on their own; and still others reach out to peers and colleagues to think through and clarify their search needs (Fig. 3).

4.1.1.1. Context framing. Information-seeking behavior is rooted in a "need" to find information (Broder, 2002; Wilson, 1981) or a motivation that drives the search process. This may be thought of as the context framing stage of search, where user motives and information needs are defined. Requests for information may come from an external source (e.g., specific request from a boss, customer, or client) or may be self-initiated (e.g., finding information related to personal or work endeavors).

External requests (47/150 users, 31.3%): About 1/3 of the searches were motivated by external sources. For instance, a Dell customer support representative was searching for information related to a promotion advertised on another website—a search prompted by a specific customer request. The service representative was tasked with finding this information and consequently reporting back relevant information to the customer on the phone.

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Self-initiated search (103/150 users, 68.7%): Over two-thirds of searches were self-motivated prompts to find information related to personal or work endeavors. As an example, while creating a spreadsheet of songs to teach to students, a piano teacher was searching for JPG files of sheet music that highlighted certain musical concepts. Since this teacher always works alone, she is constantly "seeking new resources to keep piano students interested, and to teach them concepts through enjoyable songs and activities." Therefore, this search behavior is a career-related, self-motivated process for continually finding new and better material.

4.1.1.2. Requirement refinement. After information needs and motives are established, search requirements are refined. Previously described as a generation loop (Russell, Stefik, Pirolli, & Card, 1993), this phase involves gathering requirements and formulating relevant search schemas. As an example, an operations technician at Lexus–Nexus needed to collect certain information in order to prepare a new client file. Prior to the search, a meeting was called with several other colleagues to discuss what type of information should be included in the file. This served to establish the necessary guidelines, after which the technician was able to find the agreed-upon information by searching in an internal program. In this account, social inputs were integral to formulating the requirements for the technician's subsequent search. Other pre-search accounts demonstrate that this phase is marked by social interactions 42.7% of the time (64/150 users) both to "influence the information need" (Twidale et al., 1997) and refine the task guidelines.

4.1.2. During search

Although search can be a cyclical process, the *during search* stage in our model represents the active instantiation of representations or "encodons," as part of a "data coverage" loop (Russell et al., 1993). In other words, this is the stage where users engage in traditional information seeking (Wilson, 1981) and foraging activities (Pirolli & Card, 1999, 2005)—typically by interacting with a search engine. We detail the three types of searches that we observed in this phase, based on Broder's (2002) query needs: *transactional*, *navigational*, and *informational* (Fig. 4).

4.1.2.1. Transactional search. With a *transactional* search, users locate a source where they can subsequently perform a transaction or other "web-mediated activity" (Broder, 2002). In our sample, this typically involved navigating to a website through a series of routine steps and requesting specific information such as driving directions, weather at a destination, movie listings, or data from a customer's account. As an example, an ambulance chief was required to include in a patient's file the distance from the patient's home to the hospital. To perform this routine and transactional search, the chief navigated to MapQuest.com, entered the start and end locations, and retrieved the mileage information.

Although *transactional* searches (19/150 users, 12.7%) were less common in our sample than *navigational* or *informational* ones, over a third did involve pre-search social interactions (8 of the 19 users, or 42.1%). However, users did not engage in social or collaborative activities in the midst of (*during*) these types of searches.

4.1.2.2. Navigational search. During a *navigational* search, users perform a series of actions to identify content from a particular, often familiar, location. The content is typically known in advance or will be easily recognized once it is (re)discovered. For example, a hospital nurse found a drug listed in a patient's medical chart, but was unfamiliar with how it was used. Before blindly administering it, the nurse decided to look up the drug on the NIH website, a familiar source often used to recover this type of information. As a result, the search act was *navigational*: the nurse went to Google, looked up the NIH's web address, and then searched for the drug on the NIH website. The nurse reports: "I knew exactly where [the information] would be—just couldn't recall what the answer was."

Navigational searches were performed by 42/150 users (28.0%), and of these, nearly half involved pre-search interactions with others (20/42 users, or 47.6%). This class of search did not involve social or collaborative activities during the main search itself either.

4.1.2.4. Informational search. In comparison to *navigational* and *transactional* searches, social search may greatly improve tasks involving *informational* search, which is typically an exploratory process of searching for information that may or may not be familiar to the user.

Over half of the reported search experiences (89/150 users, 59.3%) were *informational* in nature, involving clear foraging and sensemaking processes (Pirolli & Card, 1999, 2005); 40.4% (36 of the 89 users) engaged in social interactions prior to their primary search act. Surprisingly, only two users (2/89 users, 2.2%) sought social inputs *during* their computer-related search activities. Another five (5/89 users, 5.6%) made use of passive interactions by searching previously-recorded social data on Wikipedia, technical forums, or discussion boards.

Foraging. The basic "information assimilation" process described by Evans and Card (2008) illustrates this early foraging phase where users search for information within a specific patch, followed by skimming, reading, and extracting information from source files. Throughout this process, users may update and shift their search representations (Shepherd, 1983) as they discover new items.

For example, an environmental engineer began searching online for a digital schematic of a storm-water pump while simultaneously browsing through printed materials to get "a better idea of what the tool is called." This search was

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iteratively refined as the engineer encountered new information, first on metacrawler.com and then on Google, that allowed him to update his representation of the search space, or what might be called a "search schema." He finally discovered a keyword combination that provided the desired results.

During this foraging and reformulation process, users may seek input from others for feedback and further refinement of their search (Twidale et al., 1997). While explicit interactions with others were not common (only 2/89 users), the examples demonstrate the usefulness of cooperation. A circulation clerk at a public library was asked to find the Cheetah Girls 2 (movie) soundtrack for her boss's daughter. She began by using an internal search tool where she entered "Cheetah Girls 2," although this failed to return the movie soundtrack. After the boss joined in the search process, the clerk reported [in response to Question #7]:

> We had to deduce a number of combinations in an attempt to obtain the item in question. We tried a number of ways to write Cheetah Girls, including hyphens and spelling out the number two. We even had to look up the actual product on Amazon.com for additional information.

The circulation clerk later commented that the boss was a useful resource during this process, providing "variations on the words in an attempt to solve the problem." This example illustrates the well-known "vocabulary problem" of human–system communication (Furnas, Landauer, Gomez, & Dumais, 1987). Importantly, people can help overcome this problem to a certain extent; in this case, the boss was able to suggest appropriate keywords for the topic domain that were obscured to the clerk.

Sensemaking. In fact, foraging and sensemaking loops are tightly coupled. After an initial pass at foraging, users may identify preliminary "evidence files" (Pirolli & Card, 2005) from which they can reflect and, if necessary, use to further modify their search schema and query. For example, while an English Professor at a University was preparing a lecture on a poem by Robert Frost, he "wanted to look up information on Frost himself as well as any information... specifically about the poem." To do so, he recalled [Questions #7 and 8]:

> I went to msn.com and typed in "Robert Frost" first. I found several websites that were helpful, then copied and pasted information into the Word document I had already set up. [Then] I typed "Frost + Out Out." [Finally] I went back to the Word document and began sorting my information. I placed like information together; summarized some information; deleted irrelevant information; and paraphrased other information.

Not only did the professor's foraging involve a series of search queries, he engaged in a classic sensemaking process. He reflected on the material he collected as he summarized and paraphrased the information.

Although the professor performed "information assimilation" by himself (Evans & Card, 2008), the sensemaking process could include social interactions. As an example, a programmer from Intuit was searching for a file transfer protocol (FTP) application programming interface (API) built in core JAVA. He began by brainstorming with the project's technical architect. Then he performed a search online, followed by "another round of discussion with the technical architect" on whether the API he found (the "evidence file") would be sufficient for their purposes. In this way, social input and exchange augmented the programmer's sensemaking process.

4.1.3. After search

We refer to the phase following the traditionally primary search act as *after search*. Following this period of online information seeking, an "end product" is often obtained (Twidale et al., 1997). This target information—new IRS mileage reimbursement rates, next week's weather forecast, or the latest news about autism—may then be "acted" upon through organization and/or distribution (Evans & Card, 2008). Fig. 5 presents an overview of this process.

4.1.3.1. Organizing information. The organization of information includes: saving or augmenting materials, bookmarking a webpage, or creating a new document or presentation. Pirolli and Card (2005) referred to this process as schematizing, where

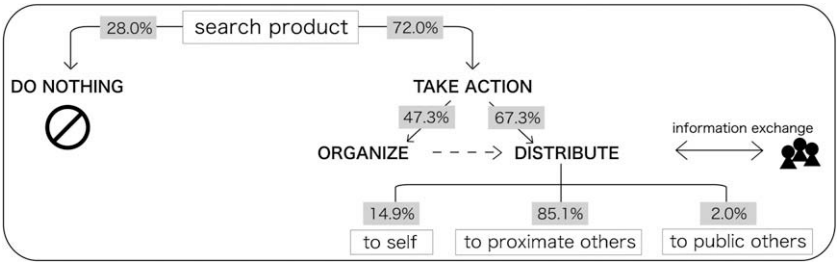

Fig. 5. The After search phase of our model. Some searchers do nothing after they find the relevant search products. Many other searchers take explicit action to organize and distribute information to others.

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raw evidence is organized and "represented in some schematic way." Surprisingly, nearly half of our users (71/150, or 47.3%) created artifacts based on their search products that served to organize, save, or synthesize important information:

- Printing results: One real estate agent printed and reviewed the results of a search (public records of a property owner) before "giving them to an attorney for legal inspection."
- Bookmarking: The president of a design company bookmarked online articles about web mashups to read later in the week.
- Creating a presentation: The manager of a data center created a PowerPoint presentation (for training subordinates) after finding technical information on cooling towers through a Google search.

4.1.3.2. Distributing information. Such organizational acts additionally served to distribute the search products to others. In other words, many documents and presentations were created *with the intention* of sharing with colleagues. Pirolli and Card (2005) observed that the end products of a search may be delivered to an audience as a "presentation or publication of a case." Evans and Card (2008) also remarked that users serve as information filters for others through their organizational, and consequent distributional, acts of bookmarking, tagging, or annotating items.

In our sample, two-thirds of respondents distributed end products either to others or to themselves for retrieval at a future date (101/150 users, 67.3%). Of these, 88 shared information with others (87.1%), typically face-to-face or verbally over the phone: For example, a floral designer relayed information about local spring blooming flowers to a bride-to-be. Fifteen users "shared" the content with themselves by printing out documents or bookmarking websites (14.9%), which are important actions for re-accessing and re-finding information in the future (Jones & Teevan, 2007). The IT Director for an automotive sales group reported [in response to Questions #7, 8, and 11]:

> I went to google.com, typed in Customer Relationship Management Software Solutions, then searched within results for Automotive Dealerships. I clicked several links and proceeded to read up on several programs that are available. Afterwards, I saved several links that I will be going back to and researching further. Once I am done with my research, I will put together a comparison of my top three choices and present it to the owner.

Additionally, two users reported sharing information "simultaneously for themselves and others" (Evans & Card, 2008). In one case, the manager of a retail store searched for an email containing a PDF memo describing the correct method of shipping goods to customers. He "printed the PDF for future reference" and subsequently explained the procedure to his employees, requiring each to read and sign a copy.

The majority of information was distributed within a small radius of collaboration, to proximate others (86 of 101 distributing users, or 85.1%). In other words, most shared information with close friends or colleagues—people who had requested the information previously, whom the searchers thought would have an interest in it, or from whom searchers wanted to get feedback. Only two users found information that they shared to public (largely unknown) audiences: the University professor giving the Robert Frost lecture and a graphic designer who maintains the website for a small bookstore. The graphic designer searched on Google and the New York Times online to find the current best selling mystery novels, and subsequently edited the bookstore's public website to reflect the up-to-date information.

In summary, these accounts—before, during, and after search—are meant to document the range of user search behaviors and illustrate that actions may occur individually or in collaboration with others. Our characterization is intended to illustrate that both highly and loosely coordinated social interactions may occur in any stage of the search process, and that "search" extends beyond a short human–system interaction episode. We observed that: (1) users take explicit actions to prepare for their search process; (2) they perform one of three types of information-seeking behaviors: *transactional*, *navigational*, and *informational*; (3) they organize and distribute information to friends and colleagues, extending their search activities beyond a single web browsing session.

4.2. Part 2: factors of social interaction and content sharing

In this next section, we go beyond our initial characterization to review more global patterns in the data. In particular, what factors lead someone to be social? What class of users is likely to engage in social interactions during search tasks? Both inherent motivations and query needs are important factors.

Table 1 below summarizes the results that we will present in this section. First, we review how the motivations of the searchers (top rows) affect their social interactions before and after the search act. (Social interactions "during search," as we defined it, were surprisingly rare, so we exclude that from our discussion here.) We then analyze how various query needs resulted in important social interactions in the moments leading up to the main search act (*before search*) and following the retrieval of an end product (*after search*).

4.2.1. Factors that influenced social activities (pre-search)

4.2.1.1. User motivations. Many more externally-motivated users engaged in social interactions before searching than self-motivated users (Table 1, top of column A). Of those who were motivated by external sources ($N = 47$), nearly three-quarters

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Table 1
A breakdown of social activities before and after search is shown for motivation and query needs.

	A. Total number of users: *raw number* (% of whole)	B. Significant social interactions before search	C. Social sharing behaviors post-search
Motivation type			
External	47 (31.3%)	33/47 (70.2%)	39/47 (83.0%)
Self-motivated	103 (83.0%)	31/103 (30.1%)	49/103 (47.6%)
Query need			
Informational	89/150 (59.3%)	36/89 (40.4%)	49/89 (55.1%)
Navigational	42/150 (28.0%)	20/42 (47.6%)	30/42 (71.4%)
Transactional	19/150 (12.7%)	8/19 (42.1%)	9/19 (47.4%)

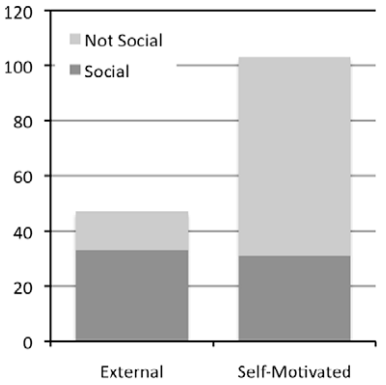

Fig. 6. Proportion of social versus non-social behaviors before the primary search act for externally-motivated and self-motivated users.

had a significant interaction with another person before their search (70.2%). Self-motivated searchers ($N = 103$) had social exchanges much less often—around one-third of the time (30.1%) (Table 1, top of column B). While it may seem that external prompts inherently involve a type of social input (e.g., the search was requested by another individual), requests may have been part of a prior to-do list or may have been triggered by an unexpected environmental circumstance. For example, when a technician learned from a colleague that a frosted outdoor glass electrical fixture broke, the technician had to figure out "exactly what kind of fixture it was" and, subsequently, the lowest price available. He quickly saw that replacement fixtures were not in the supply closet, so he turned to Google to complete his task. We considered this account to be externally-prompted but not consisting of significant social interactions prior to search. Consequently, our operational definition of significant *social interactions*—in the context of requests for information—meant interactions *other than* delivery of the request itself (e.g., mostly due to a face-to-face or telephone conversations).

It is somewhat expected that externally-driven information needs result in significant social interactions. Proportionally speaking, this was substantiated by our data (Table 1; Fig. 6); however, the reasons *why* users engaged with colleagues were markedly distinct. Externally-motivated searchers were social almost always out of obligation. Self-motivated searchers engaged with others for a greater variety of reasons, including seeking advice, feedback, and personal guidance.

The externally-motivated searchers conversed with others (33/47 users, 70.2%) primarily to identify the requirements and guidelines for the search they were requested to perform. These information exchanges were with the source of the request, such as a client or boss. A social worker for the State of Washington was helping a homeless, disabled client find temporary housing, which required learning about the "client's disability accommodations." The need for more information resulted in an obligatory conversation between the social worker and the client, after which the social worker had the resources necessary to complete the request.

The breakdown for externally-prompted social motivations were as follows:

- necessary for establishing the search guidelines (23/33 users, 69.7%);
- resulting from a direct conversation with the requester (10/33 users, 30.3%).

Social interactions occurred for a greater variety of reasons for self-motivated searches (31/103 users, 30.1%). Some searchers wanted to seek the advice of others (8/31 users, 25.8%): When an associate at Circuit City wanted to improve his commission-based sales, he solicited a colleague's personal opinion before searching on Yahoo! for additional suggestions. Others used it as the first stage of search (6/31 users, 19.4%). A public health official, having lost an Excel file necessary

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for writing his weekly report, first asked his colleague where the files might be located on the server. Pre-search social interactions were additionally used to:

- establish the search guidelines (10/31 users, 29.4%);
- brainstorm (3/31 users, 9.7%);
- collect search tips (e.g., keywords, URLs) from friends and colleagues (2/31 users, 6.5%).

Of course, these reasons are not mutually exclusive: Establishing guidelines may involve collaborators as the first stage of an extended search episode. A salesperson for a company that imported tile and natural stone received a customer request for 5000 square feet of Pennsylvania Blue Stone for a pool deck. This "search" involved finding a supplier who had the stone in stock, and really began when the salesperson called several local suppliers to see if they carried the material. Only after learning that his regular suppliers were out of stock, he completed the request by performing an *informational* search on Google for additional suppliers.

As these examples illustrate, activities occurring before and up to interactions with a computer database or search engine are equally essential for a successful search.

4.2.1.2. Query needs. Social interactions before search were about equally likely for *informational*, *navigational*, and *transactional* searches. *Transactional* queries ($N = 19$) involved pre-search interactions among eight users (42.1%) (Table 1, bottom of column B). In most cases, these interactions were themselves transactional—a necessary engagement to obtain details from the source of the request before proceeding with the actual search. For example, a placement advisor for a dental staffing agency spoke with a new applicant to get credentials and position availability. Following this interaction, the advisor went to a "specific program/site that lets you verify people's licenses," entered the applicant's information, and verified that the license was current.

Navigational queries ($N = 42$) involved pre-search interactions among 20 users (47.6%) (Table 1, bottom of column B). These interaction were often necessary to establish the information need. The membership chairman of the Embroiderers' Guild of America recalled [in response to Questions #4 and 7]:

> I spoke with the prospective member who needed the information [about membership dues and meeting times]. I did not contact anyone else regarding the searches I was about to do, since the information was needed immediately, and I knew what I was looking for. So I Googled to find the home site for the Embroiderers' Guild. After finding the link, I went to the pages that had the information I needed.

Indeed, social interactions were typically sought to help establish guidelines and obtain more information about the search topic. However, six self-motivated *navigational* searchers (6/42 users, 14.3%) used social interactions as the first stage of the extended search, seeing if others had answers or advice prior to searching.

Informational queries ($N = 89$) led to social experiences before search for 36 users (40.4%)—and not simply out of obligation (Table 1, bottom of column B). Social exchanges were useful for a variety of reasons: to establish search guidelines (to obtain "the exact specifics of the product"); to seek coworkers' opinions (e.g., a behavioral consultant first spoke to "other consultants for advice and ideas for a novel way of teaching colors" to autistic children); to brainstorm ("through instant messenger... to confer with my group"); or to improve search schemas ("to know what kind of material would be useful" and "for wider search options and different opinions"). Moreover, a majority of users who engaged with others in this stage were self-motivated (22 of the 36 users, or 61.1%).

As we have illustrated, social interactions in the search process occur quite regularly, whether we look at inherent search motivation or query needs. In particular, external requests for information led to high rates of social interactivity. Activities observed during *informational* searches suggest that social inputs can be invaluable when the information need is undeveloped or poorly specified. Finally, self-motivated use cases illustrate how other people are integral to the search process.

4.2.2. Factors that influenced sharing behaviors (post-search)

Social behaviors extend beyond the preliminary phases of a search. This is to be expected since searching is a fluid process, deeply embedded in physical and digital social environments. What factors lead someone to share information with others, be it early presentations of material (Pirolli & Card, 2005) or final end products (Twidale et al., 1997)? The most striking factors stem from user motivations, although query need seems to play a role, as well.

4.2.2.1. User motivations. Search acts motivated by external requests for information ($N = 47$) resulted in post-search sharing 83.0% of the time (among 39 externally-motivated users) (Table 1, top of column C; Fig. 7). Of these, nearly all sharing was out of obligation (34 of 39 users, or 87.2%). Users were required to report on product availability to customer requests, provide details on upcoming conferences and workshops to the CEO, or send a map to a friend because he had asked for help. Only five of the 39 users (12.8%) shared information because they thought others would find it interesting. As an example, an information technology (IT) specialist for the US Navy needed to figure out the cause of an error in a new software program (per a user request). After performing several iterative searches on Google, he emailed the answer to a team of colleagues since he assumed others would eventually face this same problem.

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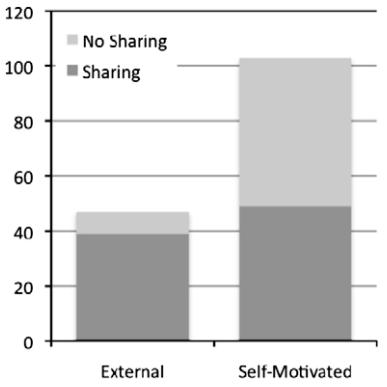

Fig. 7. Proportion of sharing versus non-sharing behaviors following the primary search act for externally-motivated and self-motivated users.

In contrast, self-initiated searches ($N = 103$) resulted in post-search sharing slightly less frequently (among 49 self-motivated users, or 47.6%) (Table 1, top of column C; Fig. 7), but for a greater variety of reasons. Many still distributed information out of obligation (24/49, 49.0%). Upon suspicion of a plagiarized homework assignment, one teacher searched Google with several sets of keywords. A suspect site was found, and it was, therefore, the teacher's responsibility to share this information back with the student. Many others shared information because they thought friends and colleagues would find it interesting (17/49, 34.7%): after learning that the life insurance payout for health clinic staffers was larger than expected, one nightshift worker shared this with a colleague who had expressed an interest in it previously.

Finally, self-motivated users also distributed information to others to get feedback and advice: to make sure the information was accurate and valid, or to see if the search should be refined and repeated. For example, an audio transcriptionist, unsure of the spelling of one person's name, performed a sound-alike search on Google before sharing the translation over instant messenger for colleagues to verify. In another case: a US Army Medical Chief was investigating Master's programs in education at Johns Hopkins. After getting preliminary results from Google, he shared his findings with colleagues (in a face-to-face discussion) to get their opinions on the degree program.

4.2.2.2. Query needs. Sharing behaviors by query needs indicate that products from *navigational* queries are more likely to be shared than results from *informational* or *transactional* queries. Of the 42 users who performed *navigational* queries, 30 distributed information to others post-search (71.4%) (Table 1, bottom of column C). In many ways this is expected because *navigational* acts often involve finding directions on a map or weather at a destination, information that is usually meaningful as part of a joint search task. Just over half of these searches were indeed external prompts for information; and 25 of these 30 users (83.3%) shared information out of obligation to a partner or external requester.

Users with *informational* and *transactional* query needs shared information about half the time (55.1% and 47.4%, respectively) (Table 1, bottom of column C). While this is less than we observed for *transactional* queries, this is nevertheless noteworthy. Users' post-search actions were important for organizing, reflecting upon, and distributing search products; some users obtained critical feedback and validation on their results. In other words, users were engaged in social cognition with others. As we addressed earlier, most information was shared within a small radius of collaboration (primarily with close friends and colleagues). Together this indicates the need for post-search organizational tools for distributing information to interested parties, integrated especially with platforms that support *navigational* search acts.

4.2.2.3. Motivation × query needs. Another way to look at this data is to break it down by both motivation and query needs (Table 2; the data are plotted in Fig. 8). We see that the results reflect the same basic observations that we have reported above. A greater proportion of *informational* queries are performed by self-motivated users (65.0%) than externally-motivated (46.8%) (column A). Externally-motivated searches are equally divided between *informational* and *navigational*, with

Table 2
A breakdown of social activities before and after search for motivation × query needs. The data are plotted in Fig. 8.

Motivation × query needs	A. Total number of users *raw number* (% of whole)	B. Significant social interactions before search	C. Social sharing behaviors post-search
External			
Informational	22/47 (46.8%)	14/22 (63.6%)	17/22 (77.3%)
Navigational	19/47 (40.4%)	14/19 (73.7%)	17/19 (89.5%)
Transactional	6/47 (12.8%)	5/6 (83.3%)	5/6 (83.3%)
Self-motivated			
Informational	67/103 (65.0%)	22/67 (32.8%)	32/67 (47.8%)
Navigational	23/103 (22.3%)	6/23 (26.1%)	13/23 (56.5%)
Transactional	13/103 (12.6%)	3/13 (23.1%)	4/13 (30.8%)

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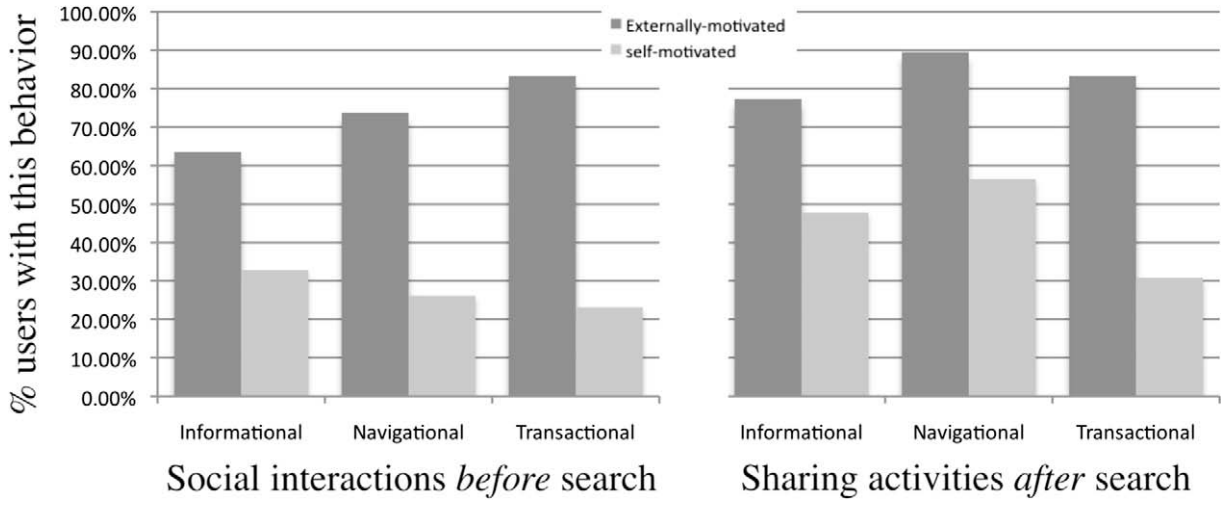

Fig. 8. Percentage of social activities by motivation and query needs. Left plot shows social interactions before search. Right plot show post-search sharing behaviors. Both are broken down by motivation and query needs.

many fewer *transactional* queries, simply because there are fewer *transactional* queries in general across all users. Similarly, because *informational* queries dominate the self-motivated users' search acts, there are many fewer *navigational* and *transactional* queries for this class of user.

Across all classes of queries, externally-motivated users were more engaged in social activities *before* and *after* search than the self-motivated users (Fig. 8). Furthermore, they maintained about equal social involvement in both pre- and post-search phases. In contrast, self-motivated users are slightly more socially active during post-search than pre-search phases, for all query needs (Table 2, bottom of column C versus bottom of column B).

4.3. Part 3: patterns between pre-search and post-search social interactions

An additional analysis we wanted to perform looks at the likelihood for someone to have both significant social interactions before search as well as content sharing interactions after search (Table 3, columns A and B).

Table 3 presents our first analysis of these patterns. Column A presents the number of users within each group who engaged in significant social interactions prior to searching, who later went on to distribute or share information with others. Column B shows the number of users who were *not social before* searching, but who shared information post-search. The last column (C) indicates how many users never reached out to others during their search—these are the true *solo searchers*.

Table 3 further divides the data by motivation type: external or self-motivated. From Table 1 earlier, we saw that externally-motivated users shared information 83.0% of the time. Table 3 provides some clarity on who these distributors were. Since post-search sharing was common among this class of user already, it's not surprising that we see significant sharing behaviors among those who were both social beforehand (column A) and among those who were not (column B).

Of the 33 searchers who had significant social interactions early in their search, 29 concluded by sharing information with others (87.9%). For example, a software developer was looking for a way to program a certain ringtone for a client. He first asked his colleagues if they knew how; then he turned to Google. He eventually shared the solution back with his colleagues because he believed in "knowledge sharing... to [further] our discussion and understanding." Only 14 users were not social before search, but of these 71.4% (10 users) also distributed their search results. Finally, four out of 47 externally-motivated users (8.5%) performed solo searches, usually for high priority items on a to-do list or environmental circumstances that required the user's involvement (the printer's color settings needed adjusting). Three of the four cases were highly exploratory (*informational*) search tasks.

Table 3
A breakdown of patterns in the data of pre-search and post-search social activities. Column A: Percent of users who were social before search and shared information after. Column B: Percent of users who were not social before searching, but who shared information after. Column C: Percent of users who were never social (*solo searchers*).

Motivation type	A. Users who were *social* before search *and shared* information after	B. Users who were *not social* before, *but who shared* information after	C. Users who were *not social at all* before, during, or after search
External	29/33 (87.9%)	10/14 (71.4%)	4/47 (8.5%)
Self-motivated	24/31 (77.4%)	25/72 (34.7%)	47/103 (45.6%)

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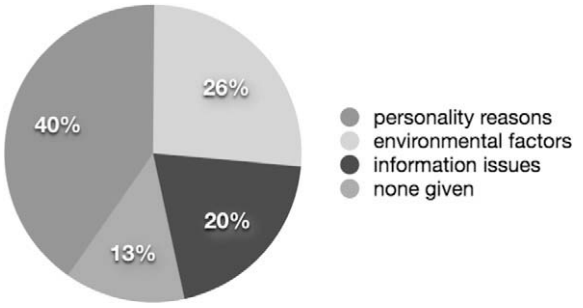

Fig. 9. Breakdown of reasons for why some solo searchers were not social during the search process.

Self-motivated users show a slightly different story. On the whole, these users were much more likely to share their end products if their early search process involved social interactions (Table 3, column A versus column B). Of the 31 searchers who had significant social interactions before searching, 24 (77.4%) shared information with others. In contrast, users who were not social before search ($N = 72$) were less likely to distribute information later (only 25/72 users, or 34.7%). Furthermore, nearly half (47/103, or 45.6%) of self-motivated users did not engage in social interactions during their search.

4.3.1. Solo searchers

The *solo searchers* are also an interesting user type (Table 3, column C). Why were social interactions not part of their search process? Was it the makeup of the environment, their information needs, or their personalities that made it easier or preferable to search alone? To get a better sampling of reasons, we extend this next analysis to include all users who *did not* reach out to others before search ($N = 86$, but 89 explanations since some gave multiple reasons) (Fig. 9):

- Issues related to the information needs (*"It wasn't necessary*" or *"I knew where to find it online.*") were the least common (18/89, or 20.2%). Such cases included: programmers who were looking for a specific C++ library file; the owner of a Gilmore Gang fan site who checked Google for new mentions every day; a film director looking for sound loops that he could use in a documentary.
- Environmental factors made up about a quarter of the reasons (23/89, or 25.8%). Some users were too busy to talk to their colleagues; others did not know anyone to ask for help or no one else was around. In other cases, the user did not know anyone more knowledgeable. A tax processor, for example, needed to learn about the deductions allowed for job hunting. Because he had "been doing this a long time," he knew how to "narrow [his] search parameters" on the IRS website quite effectively. The one person he had thought to ask, who was "more knowledgeable than [himself], broke his leg and was out of the office for the day."
- Personalities or personal preferences were more often the cause of solo search activities (36/89, or 40.4%). These revealed that some users have an independent mindset about their work, stated as: *"I can find it on my own*"; *"It's easier to look online first*"; *"It is my job to do this*"; *"I didn't want to bother other people about this.*" In one case, a financial planner was researching stocks for a new investment. In another (mentioned first in Part 1), the manager of a data center needed to collect materials (including images) for a PowerPoint presentation that would be used in a training session on cooling towers. The manager, in responding to our prompt about why he did not use any social sources, replied: "because I can find answers quickly online."

4.3.2. Motivation × query needs

If we break down this data by motivation and query needs (Table 4), we see about the same results as reported above. Regardless of their query needs, externally-motivated users who were social before searching were equally likely to share end products (top of column B). We see nearly the same result for non-pre-social searchers who went on to share information (top of column C). Actually we see a slightly lower rate of post-search sharing for non-pre-social searchers with *informational* queries (62.5%) when compared to the overall average (71.4%, Table 3); and a slightly higher rate for *navigational* and *transactional* queries (80% and 100%, respectively), although the number of users represented in these categories is small.

Similarly, self-motivated searchers with *informational* and *navigational* queries showed a high likelihood for sharing information after social activities early in the search process (Table 4, bottom of column B). This pattern was not present for *transactional* queries, although there were proportionally many fewer *transactional* queries. Again, sharing behaviors are distributed about equally among query needs for self-motivated users who were not social before they began searching (Table 4, bottom of column C).

Solo searchers' behaviors varied somewhat (Table 4, column D). Since few externally-motivated users avoided social interactions altogether, dividing the data by query needs is practically meaningless. Solo behaviors among self-motivated searchers, in contrast, are about equally distributed between the different query needs and are fairly reflective of the overall trend for self-motivated users (45.6%) (Table 3).

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Table 4
A breakdown of patterns in the data of pre-search and post-search social activities by motivation × query needs.

Motivation × query needs	A. *Number users* (% of whole)	B. Users who were *social* before search *and shared* after	C. Users who were *not social* before, *but who shared* information after	D. Users who were *not social at all* before, during, or after search
External (N = 47)				
Informational	22/47 (46.8%)	12/14 (85.7%)	5/8 (62.5%)	3/22 (13.6%)
Navigational	19/47 (40.4%)	13/14 (92.9%)	4/5 (80.0%)	1/19 (5.3%)
Transactional	6/47 (12.8%)	4/5 (80.0%)	1/1 (100%)	0/6 (0%)
Self-motivated (N = 103)				
Informational	67/103 (65.0%)	17/22 (77.3%)	15/45 (33.3%)	30/67 (44.8%)
Navigational	23/103 (22.3%)	6/6 (100%)	7/17 (41.2%)	10/23 (43.5%)
Transactional	13/103 (12.6%)	1/3 (33.3%)	3/10 (30.0%)	7/13 (53.9%)

In summary, there are some persistent patterns in the data. *Informational* queries are slightly more common than other query needs. Externally-prompted search tasks are deeply embedded in social activities, both before and after the search proper, although their reasons for social outreach were largely due to obligations to a customer, client, or boss, for identifying search guidelines or reporting back on findings. Self-motivated users exhibited fewer social behaviors overall, but remained selectively social. When they solicited the help of others, then tended to stay engaged throughout the search process, sharing end products back to collaborators for feedback, advice, and knowledge dissemination. There may be another class of user who avoids social interactions, but their reasons for acting independently may be readily addressed by new social search tools. Not knowing who to turn to, not wanting to bother other people, and not knowing where to find information online were a few of the reasons they cited. Given this, we suggest that externally-prompted information tasks, self-initiated *informational* queries, as well as certain classes of solo searchers may benefit from social, collaborative, and organizational platforms to support search.

4.4. Part 4: preliminary results of failed and difficult search data

The goal of our work is to provide both a characterization and a few patterns of social and sharing activities during everyday search acts. To gain power in our analysis, we collected a sizable 150 unique reports of search behaviors. We were surprised, therefore, to learn that very few of our subjects reported search failures (7/150, 4.7%). In other words, nearly everyone found the information they were looking for. As a reminder, we asked users about their *most recent* search acts, which could easily have been failed search attempts instead of successful ones. In any case, this data set is surely biased towards common activities during successful searches. We have performed a follow-up study using nearly identical methodology to solicit and analyze, instead, failed search acts. We present our preliminary findings here.

4.4.1. Procedure

This second survey polled users on Mechanical Turk about their most recent search that experienced great difficulties or failures. Users provided their self-reports in response to a critical-incident style survey, which was nearly identical to the original search survey. Our additional questions—specific to understanding search failures—were as follows:

1. Did you find what you were looking for?
   [ ] yes
   [ ] no
2. What do you think your main problems were in searching for this information?
   [free-form answer]
3. If you were going to re-do this search, what would you do differently?
   [free-form answer]
4. If you were going to re-do this search, what would you keep the same?
   [free-form answer]
5. What was different about your search process this time that prevented you from finding your item as easily?
   [free-form answer]

Of the 152 responses we received, we discarded only two due to spam. Each subject was paid $0.20 for a completed survey, for a grand total of $30.40 for the collected data. As before, we were surprised at the ease and cost of doing this survey.

In the rest of the paper, we generally refer to the first survey as 'everyday searches,' while referring to the second survey as 'difficult searches.'

4.4.2. Preliminary results

In contrast to the everyday (and generally successful) searches described earlier, failed and difficult searches last much longer (Fig. 10). Average search duration in this sample was 10–20 min, although 41.3% lasted more than 20 min. Only

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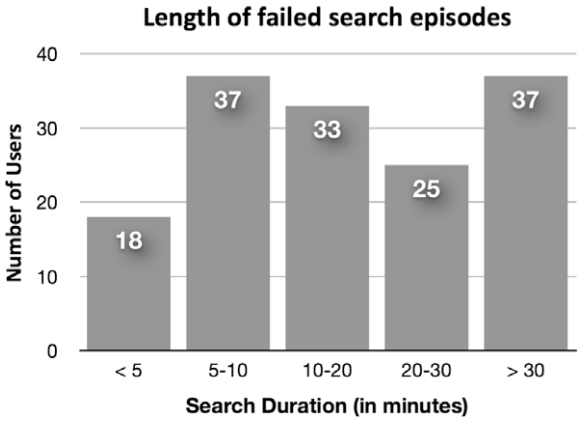

Fig. 10. Number of users whose searches lasted between less than 5 and greater than 30 min.

Table 5
This table presents a comparison between the everyday search survey and the difficult search reports, with a breakdown along a few primary factors: motivation type, query needs, and social activities.

	A. Motivation type		B. Query needs			C. Social activities			
Survey	External	Self-motivated	Informational	Navigational	Transactional	Social before	Social during	Sharing after	Informational (social B and D)
Search	47 (31.3%)	103 (68.7%)	89 (59.3%)	42 (28.0%)	19 (12.7%)	64 (42.7%)	2 (1.3%)	88 (58.7%)	36/89 (40.4%)
Failures	41 (28.0%)	109 (72.7%)	130 (86.7%)	17 (11.3%)	3 (2.0%)	72 (48.0%)	42 (28.0%)	71 (47.3%)	79/130 (60.8%)

12% of failed searches were completed in under 5 min. On the one hand, we might expect users to persist in searching for hard-to-find information, extending them beyond 5 min. On the other hand, much of the search literature has reported short search durations (Jansen, Spink, & Saracevic, 2000; Russell & Grimes, 2007; Silverstein, Marais, Henzinger, & Moricz, 1999)—less than 5 min—suggesting that failed searches have a unique time profile.

Table 5 presents a comparison between the everyday search survey and the difficult search survey. In Fig. 11, patterns from the failed search reports are shown in the *before*, *during*, and *after* stages of search in our canonical model, plotted side-by-side with data from our initial search survey.

The proportion of *informational*, *navigational*, and *transactional* query needs differ between the failures and initial search survey cases (Table 5, column B). Whereas *informational* searches accounted for 59.3% of our initial 150 reports, in this data they account for 86.7% (130 of 150 reports) of failed searches. As an example of a difficult *informational* query:

> A camp director was looking for new ways to make friendship bracelets. His first search on Google for 'easy friendship bracelets' turned up only advanced patterns and ready-made bracelets for purchase. The director continued searching, but was unable to articulate his specific information need without being able to demonstrate the technique. Ask.com and other search engines produced similar results. After 30 min of searching he eventually purchased a book of easy ideas, which satisfied his need, but did not provide immediate results.

In contrast to *informational* queries, *navigational* (17/150, 11.3%) and *transactional* (3/150, 2.0%) searches are therefore under-represented with respect to our original survey (Table 5, column B). While this does not explain the reasons for failures, it suggests that *informational* queries, in particular, may present difficulties for the searcher.

This is interesting considering the proportion of externally-motivated and self-motivated users was nearly identical across both surveys (Table 5, column A). Failed searches were performed by externally-motivated users 28.0% of the time (41 of 150 users) and self-motivated users 72.7% of the time (109 of 150 users), compared to a 31.3% and 68.7% representation in the everyday search data.

Additionally, there were consistent patterns in social activities between the search efforts in both surveys (Table 5, column C). During difficult and everyday searches alike, people turned to their friends for help in the *before search* stage: 48% of the time (72/150 users) during difficult searches and 42.7% (64/150 users) during everyday searches. However, social interactions were much more prevalent in the *during search* phase for failed searches (42/150 users, 28.0%) compared to everyday searches where this occurred for only two users with *informational* queries (1.3%).

Following the main search act, both cohorts distributed information to friends and colleagues at almost similar rates: 47.3% for failures and 58.7% for everyday searches. However, what is not shown in the table is that, since many users in the second survey never found what they were looking for (62 of 150 users, or 41.3%), post-search sharing during failed

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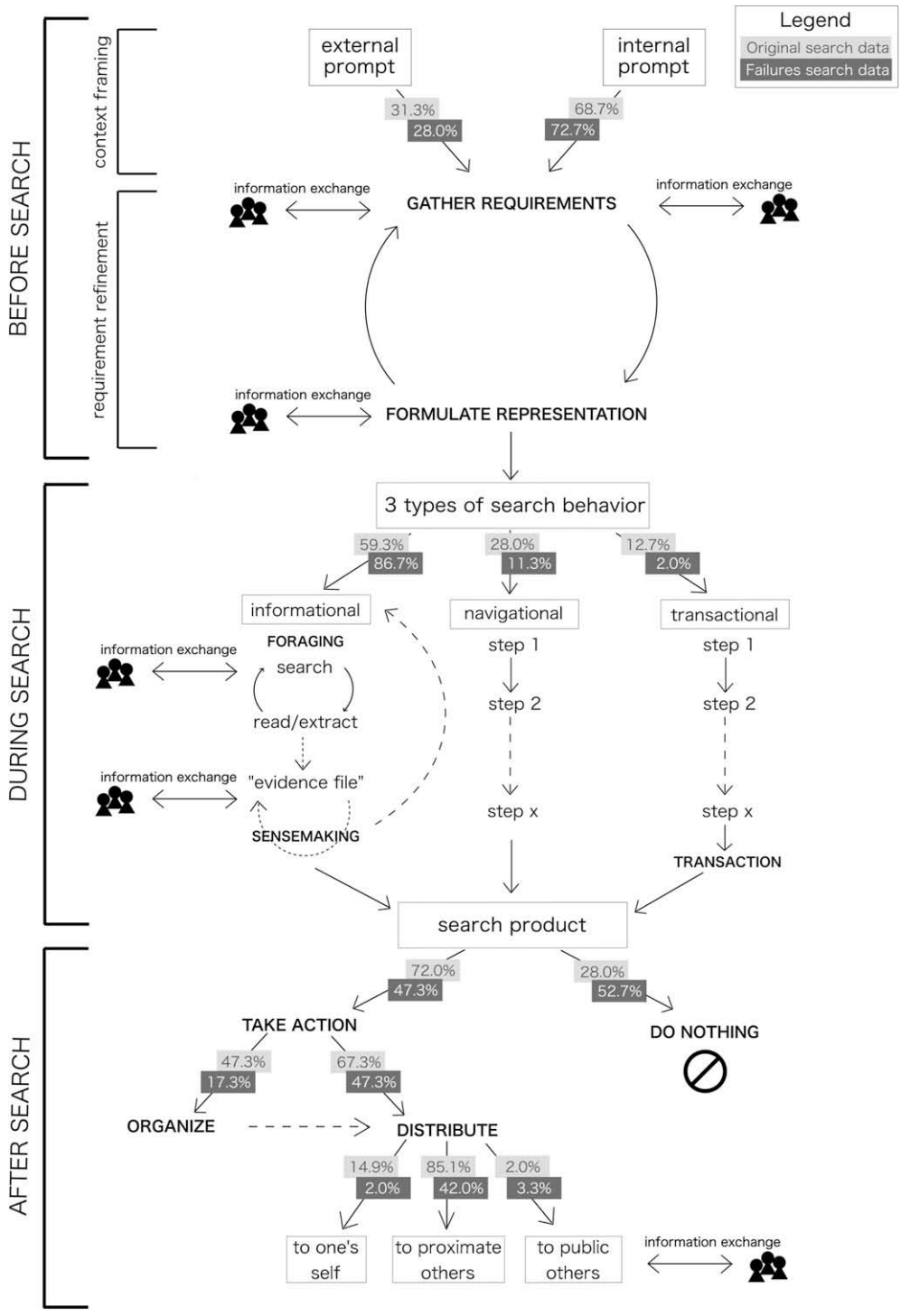

Fig. 11. The canonical social model of users' search activities with data from both everyday searches (first survey) and difficult searches (second survey).

and difficult searches is much more common. Because post-search sharing only occurs if the search was successful ($N = 88$), actually a large percentage of these users (71/88, 80.7%) shared their end products in the difficult search survey. For example, a fisherman was trying to identify the name of a specific fish to relay to his supplier. They first conversed by phone, trying to find the common name; then the fisherman performed extensive searches online. The search was not productive, however, so he resorted to taking a photo of the fish and emailing it to his supplier.

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Finally, we draw attention to social behaviors during *informational* searches since this query need was more common in the difficult search sample. In fact, there was a higher rate of social engagement (before and during search) with *informational* queries under failing or difficult conditions (79 of 130 users, or 60.8%) (if users were social before *and* during search, we only counted them once in this tally). In contrast, there were almost 20% fewer cases of social activities for similar queries in our original, everyday search sample (36 of 89 users, or 40.4%).

5. Discussion

In support of recent findings (Morris, 2008; Twidale et al., 1997), our results demonstrate that users have a strong social inclination throughout the search process, interacting with others for reasons ranging from obligation to curiosity. Self-motivated searchers, users conducting *informational* searches, and failed or difficult queries provided the most compelling cases for social support during search.

Despite the fact that direct cooperation with others *during search* was uncommon in our everyday search sample—likely a result of the poor collaborative options in today's search facilities—users reported extensive social activities before, during, and after users' *search episodes* broadly. In the following section, we present a detailed summary of our findings and discuss design implications for social and collaborative search tools.

5.1. Summary of results

We presented the results of two studies of information seeking based on 300 (total) collected reports from Mechanical Turk. In both studies—of successful everyday searches and of failed or difficult searches—social interactions played a key role throughout the search process for *transactional*, *navigational*, and *informational* query needs.

Parts 1 and 2 (Sections 4.1 and 4.2). In our original, everyday search sample, social inputs early in the search process sometimes framed users' search motives (with external prompts for information) and were often sought to refine task guidelines, to provide tips and brainstorming opportunities, and to inform relevant search schemas. Externally-motivated searchers were typically obligated to interact with the requester to establish the necessary guidelines for the search; for self-motivated searchers, social interactions were often used as the first stage of search, to gain knowledge, explore a search space, or collect search tips and advice. While pre-search social interactions were equally likely with all query needs, most of the *transactional* and *navigational* queries were dominated by externally-motivated users who were obligated to interact; *informational* searches were dominated by self-motivated searchers, whose social goals were to brainstorm and gain advice and opinions prior to searching.

Following the main search act, users took explicit actions to organize and distribute their end products to friends and colleagues. In contrast to externally-motivated searchers, who were obligated to share results with the search requester, self-motivated users often shared information to get feedback and validation on their search process. *Navigational* queries led to the most post-search sharing, but these were nearly all externally-prompted requests. *Informational* and *transactional* queries led to sharing for reflection on the end products or to get critical feedback and advice from others.

Part 3 (Section 4.3). There were interesting patterns in the data around social activities in different search stages. Externally-motivated users engaged in heavily social search processes. Regardless of whether they sought social inputs before searching or not, they were much more likely to share information after their search than self-motivated searchers. Instead, self-motivated searchers were much more likely to share information if they had solicited social inputs earlier in the search process. At the same time, there were some *solo searchers* who avoided social interactions altogether, but may have done so because of personal preferences (*"It's easier to look online first"*), environmental factors (they did not know who to ask for help), or query-specific reasons (*"It wasn't necessary for this search"*).

Part 4 (Section 4.4). Finally, we introduced and characterized a new set of data on search failures and difficulties. The breakdown of user motivations was remarkably similar to the breakdown in the everyday search survey. However, query needs were markedly different. *Informational* searches comprised nearly 90% of failed searches; and social interactions were more prevalent around difficult *informational* queries than everyday ones. On the whole, social activities were more common *before*, *during*, and *after searching* when users were facing search difficulties than when not.

5.2. Design implications

Next, we offer generalized design principles from the social elements within the model and provide design suggestions for supporting social sharing behaviors.

5.2.1. Before search

Even prior to the formal composition of a search query, nearly half of users in everyday (42.7%) and difficult searches (48.0%) talked with friends, colleagues, and clients as primary sources of information. These interactions were critical for receiving clarifications on the task, seeking advice, suggestions, keywords, URLs, and at times, exploring information available in existing social networks first. In particular, self-motivated searchers with ill-formed questions or with queries in novel domains (*informational* queries) as well as users who may be struggling with their search are obvious candidates for social support.

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Design principle. Users need access to resources while preparing for search tasks.

Design suggestion. Software tools could support this resource need by exploiting online social or expertise networks. This might include providing instant messaging access to one's personal connections alongside the Google, Yahoo!, or MSN search box. Or it might exploit a website's existing community to reveal domain-specific experts who would be willing to advise searchers. In other words, *social answering systems* may provide the right type of support during this stage of search (Chi, 2009). A few existing systems have this aim in mind: Mechanical Zoo's Aardvark (<http://vark.com>) and ChaCha's mobile search (question–answering service) (<http://chacha.com>). These directions promise to deliver information resources or access to resources (experts) while users prepare for their search tasks, possibly even outside of their primary search tools (e.g., Aardvark works over email and instant messenger).

5.2.2. During search

During the main search act, users with *informational* query needs engaged with others while investigating new material. Failed and difficult searches led to even greater social involvement with others during foraging and sensemaking to refine the query and get feedback on preliminary results.

Design principle. Users need help evaluating and validating search results.

Design suggestion. Since search websites theoretically maintain a history of users' query terms, hit results, and search trails, a framework exists for providing social feedback from attention data (Chi, 2009) to searchers. Put another way, the experiences of other users could be aggregated and presented to guide new searchers through a search episode. As a starting point, we can take clues about the search topic from the user's initial query. Of course Google's "Did you mean" feature and Yahoo!'s Search Assist aid in query formulation at this stage, but do not necessarily reveal the scope of a search space. They merely present aggregated data based on popular (or average) user behaviors, providing mostly spelling corrections and common suggestions.

Instead, MrTaggy (<http://mrtaggy.com>) was designed to present *concepts* related to a user's search query (Kammerer, Nairn, Pirolli, & Chi, 2009). This tool works by aggregating tags from social bookmarks and displaying semantically related keywords to users while they are still actively foraging and browsing for information. Related work in the social recommendation literature has explored personalizing search with related queries from a community's collective history (Glance, 2001) or from like-minded searchers (Smyth, 2007). Such social inputs and high-level feedback may be especially critical for difficult *informational* queries where users make multiple attempts to find the right (query) keyword combination or engage in long search sessions.

Websites could reveal different types of social support depending on how involved the session appears to be. The solo searchers in our data remind us that some people prefer to try searching on their own first. Thus, users may be more receptive to passive or implicit social feedback in the early phases of their search. However, since some users do not know who to turn to for help, sites could *later* suggest available domain experts from the wider community or encourage users to seek social answering support before the search becomes too prolonged.

5.2.3. After search

Post-search organization and distribution was prevalent in both survey samples, but reasons for sharing varied greatly. Sometimes information was shared out of obligation or because others might find it interesting. At other times, searchers wanted additional feedback or advice, especially for self-motivated, *informational* inquiries. Moreover, several users saved information for their future needs.

Design principle. Users need facilities for organizing and sharing search findings.

Design suggestion. All users may benefit from features built into web interfaces that facilitate post-search communication and sharing, such as email, instant messaging, bookmarking, or tagging. The Spartag.us system (<http://spartag.us>) currently supports the low-cost tagging of webpages, and the subsequent storage of tagged content in personal notebooks (Hong, Chi, Budiu, Pirolli, & Nelson, 2008). Because the tool works in any webpage (not just in search engine result pages), it becomes naturally integrated with the process of exploring a search space, providing real-time sharing support.

5.3. Coordination in collaborative and social information seeking

This paper partially points out that the social interactions and other collaborative acts during information seeking is certainly more nuanced than simply how people are working jointly while issuing queries to search engines. The data show that people may be coordinated before, during, *and* after a search episode, and that the degree of coordination varies from case to case.

Some searches may require collaboration before search, but not during nor after search, while others may include only post-search coordination. Highly coordinated information-seeking tasks may in fact include coordination during all three phases of the search process. Fig. 12 depicts how coordination with others may occur in any phase of the information-seeking process. (Note: the figure is a rough schematic illustrating the variety of coordination possible in online information seeking. Although the "low" category only depicts partner interactions *before search*, we mean to suggest that low coordination is characterized by cooperative activities in *only one phase of search*, be it before, during, *or* after).

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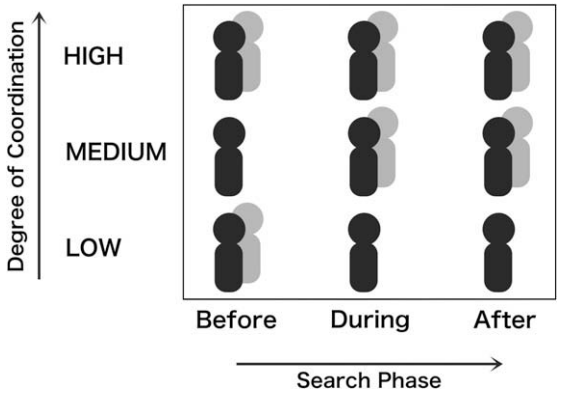

Fig. 12. The range of cooperation in information seeking. Low coordination is characterized by cooperative activities in only one phase of search, which could be before, during, or after search. Similarly, medium coordination involves partner cooperation in any two phases of search.

5.4. Limitations of the study

Despite the surprisingly thorough self-reported search experiences we collected, our study faces several limitations based on our sampling technique. Mechanical Turk is a relatively new tool for academic research, as mentioned in our section on Procedures earlier. Yet the workers are still largely anonymous, which raises questions about how demographics affects search behavior. Future work should take into account factors we were unable to consider here, including how socio-economic status, technical and computer literacy, or individual personality traits may influence search experiences or users' ability and inclination to access social resources.

There are additional limitations with the critical-incident technique. Each user only recounted one search act. While we prompted users for their latest search experience, the episodes "fresh in their minds" may have been salient or noteworthy, not necessarily the most recent. One way of overcoming these concerns is through a large sampling where individual (and conspicuous) differences become attenuated. Nevertheless, self-reported critical incidents surely vary from daily, typical, or less significant search events; this will be especially true of data from the survey on search failures. Diary studies may be one way to complement our methodology with a sampling of day-to-day search activities.

Third, our survey explored user interactions with the social and technical environments in which they are currently embedded. In fact, this is both a limitation and a benefit. On the one hand, many of our users did not have tools that effectively supported social search; therefore, we were only able to measure existing behaviors with users' current tools and practices. On the other hand, this revealed users' natural inclination to interact with others, suggesting where in the search process both explicitly and implicitly shared information may be valuable to individual searchers.

Finally, there are certainly more fine-grained analyses that can be applied to our data. It would be worthwhile in future work to classify our raw search data by topic (e.g., Shen et al., 2006), to co-classify using multiple taxonomies, and to compare our findings to other samples of web search data (e.g., Jansen et al., 2008; Rose & Levinson, 2004).

6. Conclusion

This study was intended to document the ways in which social interactions play a role in search tasks online. We believe that it complements related work in online collaborative information seeking (e.g., Morris, 2008) that has examined active cooperation during co-located, synchronous searches. Although most of our users were not explicitly collaborating with others in joint search tasks, we have shown how people can be momentarily recruited to collaborate during certain phases of search to help with individual, but otherwise non-collaborative, search goals.

We further contribute to an understanding of *social searches* in natural contexts. We have presented over 30 specific examples from our search surveys, which we believe to cover a range of possible scenarios of how social interactions support user search tasks. These interactions further illustrate the range of coordination with others that is possible through the course of extended search episodes.

Our challenge as a community will be to design tools that take into account the nuanced search behaviors and social and collaborative activities of users from many different sectors. We hope that our detailed characterizations of when, where, and why social interactions occur in the search process begin to offer solutions for design. An optimal solution will avoid cluttering the interface or cognitively overloading the user, while still delivering social solutions appropriate to the target circumstance.

Additionally, the majority of social activities we observed in both surveys were accomplished through real-world interactions, emphasizing the social importance of others. Therefore, our second design challenge will be to introduce tools that positively augment user behaviors, but behaviors that may not currently exist. People are known to seek the help of others

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during search tasks in physical settings (Cross, Rice, & Parker, 2001; Hatch & Gardner, 1993) but these activities are fairly new online and will require attentive integration with search engines and other searching-related work practices. There are a suite of tools for explicit collaborative information seeking that begin to address these concerns (Amershi & Morris, 2008; Morris et al., 2007; Paul & Morris, 2009; Pickens et al., 2008); we must develop a suite of tools for non-explicit, but nevertheless collaborative, social search practices for individual web workers. We hope that the characterizations and design suggestions we have offered enable designers in this endeavor.

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