

Collaborative Search Revisited

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ABSTRACT

Despite recent innovations in technologies supporting collaborative web search [11, 13, 25, 34, 35, 37], the features of the primary tools for digital information seeking (web browsers and search engines) continue to reflect a presumption that search is a single-user activity. In this paper, we present the findings of a survey of 167 diverse users' collaborative web search practices, including the prevalence and frequency of such activities, the information needs motivating collaboration, the methods and tools employed in such tasks, and users' satisfaction with the status quo. We find an increased prevalence and frequency of collaborative search, particularly by younger users, and an appropriation of "old" technologies like e-mail as well as "new" technologies like smartphones and social networking sites, rather than the use of dedicated collaborative search tools. We reflect on how and why collaborative search practices have changed in the six years since the first survey detailing this phenomenon was conducted [22], and synthesize our findings to offer suggestions for the design of future collaborative search technologies.

Author Keywords

Web search, collaborative search, social search, CSCW.

ACM Classification Keywords

H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

INTRODUCTION

Information-seeking technologies and collaboration technologies are the two most popular online tools; a 2011 Pew Research survey [32] found that 92% of online American adults use search engines, and a similar proportion use email. However, this compartmentalization of practices as either search or collaboration is tenuous. Although web search is often considered a *de facto* solo activity, and nearly all mainstream search technologies are designed for single-user scenarios, a growing body of research suggests that active collaboration on search tasks among users with shared information needs is relatively commonplace [13, 22, 25].

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Our 2006¹ survey of 204 Microsoft employees [22] provided data regarding the prevalence of collaborative web search, the tasks motivating such practices, and the methods used to enable such collaborations. In the six years since we conducted that survey, the technology landscape has undergone significant changes, particularly the rise of social networking sites (only 16% of Americans had social networking profiles in 2006, compared with 66% in 2012 [4]) and the growing ubiquity of smartphones (46% of American adults owned smartphones as of February 2012 [36]) and other powerful portable technologies (e.g., tablet computers). The intervening six years have also seen a flurry of research and commercial technologies for collaborative search support, though none have had mainstream success.

In light of this changed landscape, we reassess status quo collaborative search practices through a survey of 167 American adults. Our results provide insight into the evolution of collaborative and social search practices; for instance, we find an increase in the prevalence and frequency of collaborative web search, as well as appropriation of new technologies like social networking sites and smartphones to support this phenomenon. We also find that users continue to piece together general purpose technologies to facilitate collaborative information seeking, rather than taking advantage of systems designed specifically for such experiences. In light of these findings, we reflect on barriers to adoption of collaborative information seeking tools, and identify key research directions moving forward.

RELATED WORK

The term *social search* is used to refer to a broad spectrum of information seeking behaviors, ranging from behaviors which are *implicitly* social (e.g., search over socially-generated data sets) to those that are *explicitly* social (e.g., interacting with other people during various stages of the search process) [13]. Evans and Chi [7] described the types

¹ Though published in 2008, the survey data was collected in November 2006. We refer to it (and other surveys discussed) by the year of data-gathering rather than the year of publication, when known, since the former more accurately represents the socio-technical context of the findings given the rapid evolution of technologies and practices.

of social engagements possible at different stages of the Web search process.

Collaborative search [11, 13, 25, 34] is a subset of social search in which participants work together to satisfy an information need. The collaborative nature of search tasks in pre-web scenarios (e.g., in libraries and paper-driven offices) has a long history of scholarship (e.g., [9, 38]). Academic investigation of the challenges and practices associated with collaborative *web* search is a more recent phenomenon, usually associated with the 2007 introduction of the SearchTogether [24] system, whose design was informed by a survey of collaborative web search practices conducted in 2006 (but not published until 2008) [22]. Collaborative search has many benefits, including enabling participants to achieve synergic effects such as greater recall [31, 35], offering the potential to improve search skills through exposure to others' behavior [20, 21], and providing an opportunity to strengthen social connections [27, 28]. Note that the investigation of collaborative web search differs from prior work on collaborative web browsers (e.g., [12]) in that its focus is not on general-purpose web browsing, but specifically on the use of the web for information-seeking tasks.

In [22], we reported the results of a November 2006 survey of 204 Microsoft employees' collaborative web search practices. It is unclear how representative this demographic's behavior was, as respondents differed in many ways from the general population, primarily on the basis of their technical expertise, as well as along other demographic dimensions that were also non-typical (e.g., 80.4% of respondents were male). However, [22] presents the most complete picture available of the prevalence and characteristics of the collaborative search phenomenon; it found that, despite the lack of any tools designed to explicitly support collaborative web search, 53.4% of those surveyed had engaged in such activities by using the *bottom-up* [41] approach of appropriating existing technologies (e.g., email, instant messaging, etc.) to supplement the web browser. A smaller, diary-based study of 20 Microsoft employees [2] conducted in 2007² provided additional insights into the specific scenario of co-located collaborative search. More recently, several studies have characterized the *asymmetric* collaborative search scenario (in which participants have different roles and/or motivations [25]) of using social networking sites to engage contacts in various stages of an information-seeking task [6, 17, 27, 29].

In the intervening six years since our survey [22], a number of research prototypes supporting collaborative search have been introduced. Some innovations have proposed algorithmic techniques to enhance the collaborative search experience, including role-specific weightings of input [31],

group personalization of results [26], expertise-matching of potential collaborators [16], and agents that use context from social network Q&A exchanges to suggest relevant links [15]. Others have proposed user interface enhancements, such as enhancing collaborators' awareness of each other's search process [20, 24], enabling distribution of control in co-located settings [1], supporting collaborative search among users with asymmetric access to devices [42], and supporting collaborative search on emerging technologies such as large touch surfaces [23].

Some commercial technologies have also included features supportive of specific subsets of collaborative search activities. Examples include Aardvark (a service to match users with experts to support their information-seeking; 2007), Flock (a web browser that incorporated social networking as a first-class feature in its design; 2008), HeyStaks (which uses feedback from communities of users with common interests to re-rank search results; 2008), Pinterest (a shared bulletin board for collections of web imagery; 2010), SearchTeam (a tool whose features are highly reminiscent of SearchTogether [24], 2011), and So.cl (a social network based around sharing collections of search results [8]; 2011). None of these commercial tools has achieved mainstream adoption – some, like Aardvark and Flock, have already become defunct; others, like Pinterest and So.cl, are still in limited, invitation-only beta stages.

This paper adds to this body of work on collaborative web search by presenting survey results that give an updated and more complete view of the current state of practice. Our survey reports on the collaborative search practices of a more representative sample of the general public (as opposed to highly technical knowledge workers, e.g., [22]), and reflects recent changes in the technological landscape (such as the growing prevalence of social networking [4] and smartphone use [36]).

SURVEY

We conducted an online survey over a one week period in March 2012 to assess current practices regarding collaborative information seeking. The survey consisted of both open-ended and multiple-choice questions. Respondents were asked whether they had ever collaborated with other people to search the Web; if they answered affirmatively, they were asked to describe their most recent collaborative search experience and to answer a series of questions about that specific search incident (a critical-incident approach [7, 10]). Additional survey questions addressed demographics and use of specific search and collaboration technologies.

The survey was advertised as a questionnaire on “Information Seeking Practices” via the Survey Monkey Audience recruiting service³ to 1,025 adult American

² Data gathered in 2007; published in 2009.

³ <http://www.surveymonkey.com/mp/audience/>

participants; 167 completed the entire survey, yielding a 16% response rate.

RESULTS

We first characterize the demographic details of our 167 respondents. We then report our findings regarding the prevalence of collaborative search and the nature of such searches. We also report findings on the use of specific technologies for collaborative information seeking, including smartphones, social networks, and Q&A tools.

Note that we use non-parametric statistical tests when analyzing Likert responses, due to the subjective and potentially non-linear interpretations of the “spacing” between adjacent items on such scales.

Demographics

Our 167 survey respondents were all residents of the United States; 40 of the 50 states were covered by our sample. 56% of respondents were female. 38% of respondents were aged 18 – 29; 24% were aged 30 – 44; 27% were aged 45 – 60; and 11% were older than 60 years. 5% had a high school diploma or less, 57% had completed some college, 29% had a college degree, and 9% had a graduate degree.

Occupations were varied, with students making up the largest single group at 25% of respondents. An additional 8% of the group was comprised of retirees. The remaining 67% of respondents had diverse vocations including sales person, customer service representative, teacher, nurse, school counselor, homemaker, mortgage broker, physician, stock analyst, insurance adjuster, cosmetologist, accountant, software engineer, dentist, paralegal, copy editor, and heavy equipment operator.

Respondents used search engines frequently; most (79.9%) reported using a major search engine (Ask, Bing, Google, or Yahoo!) several times per day, and nearly all (94.1%) reported doing so at least once per day.

Collaborative Search

All respondents were asked “Have you ever collaborated with other people to search the Web?” If they answered negatively, they skipped ahead to the questions about specific technologies (see the “Beyond ‘Traditional’ Search Engines” section) and demographics. However, the 109 respondents (65.3%) who answered affirmatively were asked several follow-up questions about their experiences with collaborative search.

Finding that 65.3% of respondents had engaged in collaborative search indicates an increased prevalence of collaborative search behavior – our 2006 survey [22] found the prevalence of collaborative search to be only 53.4% (and that was with a more “tech-savvy” audience, Microsoft employees, whom one would assume might be more likely to appropriate technologies in novel ways than the more diverse audience of the current survey). The prevalence of collaboration we found differs significantly from the

	2006	2012
Daily	0.9%	11.0%
Weekly	25.7%	38.5%
Monthly	48.6%	15.6%
Less Often	24.8%	34.8%

Table 1. Percent of respondents reporting collaboratively searching at various frequencies. 2006 numbers are taken from Table 2 of [22].

hypothesized proportions based on the 2006 survey, $\chi^2(1, N = 167) = 9.62, p = .002$).

Age was significantly negatively correlated with the likelihood of engaging in collaborative search (e.g., younger respondents were more likely to engage in this behavior), $r = -.26, p = .001$.

Note that percentages given in the remainder of this section (“Collaborative Search”) and its sub-sections are out of the 109 people who indicated that they had searched collaboratively rather than out of the full 167 survey respondents.

11% of respondents who had searched collaboratively reported doing so on a daily basis, and an additional 38.5% report searching collaboratively at least once per week. This is a marked increase over the self-reported frequency of collaborative searching in 2006 [22], as illustrated in Table 1, $\chi^2(3, N = 108) = 155.26, p < .001$.

After indicating whether they had ever searched the Web collaboratively and how often they did so, participants who had searched collaboratively were asked to engage in a recent critical-incident self-report [7, 10]. They were asked in a free-text question to “think about the most recent time you collaborated with others to search the web,” and then to “describe the nature of the information need that prompted this incident.” They were then asked several follow-up questions about that specific incident. The following four sub-sections (“Topics,” “Group Configurations,” “Methods and Tools,” and “Satisfaction”) are based on the follow-up questions about the respondents’ most recent collaborative search incident.

Topics

In addition to describing the information need prompting their most recent collaborative search in a free-response question, we also asked respondents to classify the nature of the information need they investigated collaboratively by selecting one or more topics from a list. The list of topic choices was created by combining the topics reported as prompting collaborative searches in [22] and the list of topics reported as likely and unlikely to prompt requests for search help from members of one’s social network in [27].

Topic	# of Respondents	Example Task Description
professional	26	“we split up research for software development, searching individually for coding issues, gui design, and what would be appealing to our audience”
health/medicine	21	“we needed to find information about iron deficiency and hypokalemia”
news/current events	19	“looking for reference footage and images for a school project”
technology	18	“looking for printer parts for our business operation”
travel	16	“we were planning a trip to Alaska and all the details that go into it for a group of 10 of us”
shopping	15	“looking for a used car”
entertainment	14	“searching for music on YouTube and lyrics”
home/family	11	“genealogy”
finance	11	“we were researching different kinds of e-portfolios”
restaurants	10	“find local restaurants”
social events	10	“planning a wedding”

Table 2. The most common topics motivating respondents’ recent collaborative Web searches.

Table 2 shows the most popular topics (those which 10 or more respondents said described their most recent collaboratively-investigated information need), and gives examples from respondents’ free-form descriptions of their most recent search incident.

Group Configurations

Small-group collaboration was more common than larger groups. Pairs were the most common configuration (31.2%). Triads were also fairly common (22.9%), as were quartets (23.9%). Groups larger than four members were infrequent – 9.2% reported working in groups of five, 4.6% in groups of six, and 8.3% in groups having seven or more members.

Our 2006 survey [22] also found that smaller group sizes were more common than larger ones, though that survey found much smaller group sizes, reporting that 80.7% collaborated in pairs and 19.3% in groups of three or four, with no larger groups at all. Comparing our frequencies of pairs, groups of three or four, and larger groups to this earlier finding shows a significant change in group sizes, $\chi^2(2, N = 109) = 610, p < .001$. Our 2007 diary study of co-located collaborative search [2] also found smaller group sizes than our current study, with 85.7% collaborating in pairs and 9.5% in groups of three or four.

We also asked respondents to characterize their relationship with their collaborators on their search task. 55.0% reported collaborating with colleagues or classmates. Family was the next most common type of collaborator relationship, at 25.7%, followed by close friends (19.3%), and then casual

acquaintances (11.0%). Collaboration with strangers or professionals (e.g., librarians) was rare, at 5.5%. Note that these values total to greater than 100%, as some respondents indicated that they worked with a group comprised of multiple relationship types.

Synchronous collaboration was more common than asynchronous, comprising roughly two-thirds of the incidents (64.2%). Remote collaboration was more common than co-located, characterizing 61.5% of the described searches. This is in contrast to the 2006 survey [22], which found a slight prevalence of co-located search configurations, although their question was phrased differently (asking respondents which of the following behaviors they had ever engaged in, versus asking them to describe a single recent critical incident as we do here), making direct comparisons difficult.

Methods and Tools

Participants used a checklist to indicate what tools they employed in their most recent collaborative search incident (they could check as many items as applied). The use of search engines was common (67.9% of respondents used them in their most recent collaborative search task), but other methods of online information-seeking were also employed, such as using a social networking site (19.3%) or Q&A site (6.4%). We explore the use of these latter two technologies in further detail in the “Beyond ‘Traditional’ Search Engines” section.

Devices: “Traditional” devices like laptops (61.5%) and PCs (39.4%) were the most common devices used in the

	Very Dissatisfied	Dissatisfied	Neutral	Satisfied	Very Satisfied
quality of answer found	2.8%	1.8%	12.8%	55.0%	27.5%
ease of working with others	1.8%	2.8%	16.5%	42.1%	35.8%

Table 3. Respondents' satisfaction with the informational and social aspects of their most recent collaborative search incident.

course of collaborative information seeking. Newer device types were also common, with 30.3% of the searches involving a smartphone and 11% involving a tablet. Technologies that might facilitate public sharing such as TVs and projectors were rarely employed, in only 1.8% and 0.9% of the searches, respectively. Non-digital tools were also an important part of collaborative search processes; for instance, 11% of respondents reported using paper to support their collaborative search task.

Communication: Since mainstream web browsers and search engines don't incorporate communication tools (which are important for facilitating remote collaborative search [24]), respondents often employed out-of-band communication channels. Email was the most common communication tool, involved in 46.8% of the searches. Other communication channels used were talking on the phone (27.5%), text messaging/SMS (30.3%), and instant messaging (12.8%). Videoconferencing was rare; only one participant reported employing it as a communications channel during a collaborative search.

Satisfaction

Respondents used a five-point Likert scale to rate their level of satisfaction with both the informational (quality of answer found) and social (ease of working collaboratively) aspects of their most recent collaborative search. Table 3 summarizes those results. 82.5% reported satisfaction with the informational outcome and 77.9% reported satisfaction with the ease of collaboration. Though positive overall, these figures still indicate that there is room for improvement of both the informational and social aspects of the collaborative search experience.

Respondents were also given space to compose a free-form response regarding suggestions for how their collaborative search experience could have been improved. The most common response (7 people) was for facilities to make it easier to share the products of search with group members and increase group awareness of mutual activities (two issues that systems like SearchTogether [24], Coagmento [35], and WeSearch [23] sought to address). For example, one respondent said, "It might have helped if we had some sort of online bulletin board on which to post our findings..." Another noted that he would have liked "an

	Daily	Weekly	Monthly	Less than once per month	Never
% of smartphone owners	36.1%	24.7%	21.6%	10.3%	7.2%
% of co-located searchers	38.9%	26.7%	23.3%	11.1%	N/A

Table 4. The reported frequency of engaging co-located multi-party smartphone searches among all smartphone owners in our sample (97 participants), and among those who reported engaging in this behavior at least occasionally (90 participants).

easier way for the rest of the group members to access the information each of us found separately," and one person desired the ability to have "real-time comparisons between mine and my colleagues' information." Redundant work [22] remained problematic, with one respondent noting that "if there was a better way to communicate where one person had already looked it would have prevented overlap

of seeking for information," and another observing that it would be helpful to have "a database that tracks collaborators' searches in a private group, so that you can see which papers others have already found."

Beyond "Traditional" Search Engines

Although the questions surrounding respondents' most recent collaborative search incident were asked only to the 109 respondents who indicated that they had engaged in collaborative Web search, all 167 respondents were asked a series of questions about their use of several specific technologies, independent of the critical incident inquiry. In particular, we were interested in investigating the collaborative use of information-seeking technologies other than the traditional "using a search engine in a PC web browser." Our questions focused on three kinds of tools that have experienced significant changes or growth since 2006 – smartphones, social networking sites, and Q&A sites.

Smartphones

Though smartphones (which permit browsing the web and running third-party applications) existed in 2006, the capabilities and adoption of smartphones changed dramatically in 2007 with the introduction of Apple's iPhone, whose Safari browser provided the ability to view and interact with "real" web pages (rather than special mobile versions). By early 2012, 46% of American adults owned a smartphone [36]. Recent work suggests that mobile local searches (i.e., searching for businesses or services near a user's current geo-location) are often undertaken in a social setting, but does not offer detailed insight into multi-phone collaborative search practices [39].

In our survey sample, 58.1% of respondents reported owning a smartphone. Of these 97 smartphone-owning respondents, 48.5% had Android devices, 34.0% had iOS (Apple) devices, and the remainder had devices running the

	Facebook	Twitter	Google+	LinkedIn
have accounts	139 (83.2%)	49 (29.3%)	42 (25.1%)	50 (29.9%)
have ever asked a question	50.0%	33.3%	24.6%	24.6%
ask questions at least once per week	15.4%	9.5%	9.8%	4.6%
lurk (read content but never post)	4.3%	8.8%	12.5%	15.9%

Table 5. The first row reports how many of the 167 respondents had accounts on each social networking site. Additional rows report the percentage of those account-holders engaging in specific behaviors.

Palm, RIM (Blackberry), or Windows operating systems. Smartphone ownership was not significantly correlated with any demographic factors.

Although they may not have previously self-identified as having engaged in collaborative search, nearly all of the smartphone owners (92.8%) reported using their phones to engage in co-located collaborative searches in which several people simultaneously used their smartphones to look up information (Table 4). This behavior was surprisingly frequent – of the 90 respondents who reported engaging in this behavior, 38.9% reported doing so at least once per day, and 65.6% at least a few times per week. Younger respondents engaged in co-located multi-phone searches more frequently than older respondents ($r = -.26, p = .01$). These initial findings suggest that studying co-located collaborative smartphone search may be a rich area for further investigation to answer questions beyond the scope of our current survey, such as exploring what role specialized “apps” might play in such scenarios.

Social Networking Sites

Social networking sites were used by only 16% of Americans in 2006 (the year in which Facebook opened enrollment to the general public rather than merely to students at selected universities); by 2012, 66% had an account [4]. Social networking sites have taken on an increasingly prominent role in asymmetric collaborative information seeking [25], through mechanisms such as posting search results directly to social network feeds (e.g., Bing and Ping [5] or So.cl [8]), using socially embedded search engines (e.g., SearchBuddies [15]), or asking questions via status messages [6, 17, 27, 29]. For instance, a 2009⁴ survey of Microsoft employees [27] found that 50.6% had posted questions to Facebook or Twitter.

⁴ Survey conducted in 2009; published in 2010.

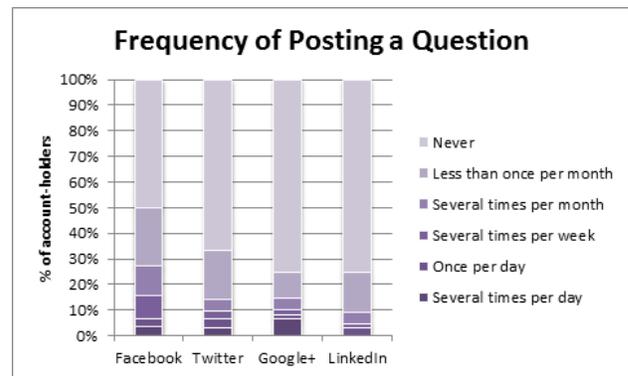


Figure 1. Self-reported frequency of posting a question as a status update, a form of asymmetric collaborative search, by account-holders on each social network.

87.4% of our survey respondents reported having social networking accounts, with Facebook being by far the most popular, distantly followed by Twitter, LinkedIn, and Google+ (Table 5). Other networks like MySpace, Orkut, Tumblr, and Yammer had negligible representation. Younger respondents were more likely to have social networking accounts than older ones ($r = -.27, p < .001$).

Asking questions on these social networking sites was common. 50.0% of those with Facebook accounts reported having used that network to ask a question, as did 33.3% of those with Twitter accounts, and 24.6% of those with LinkedIn and Google+ accounts. Our finding that half of Facebook users have engaged in status-message question asking is similar to the findings of a survey we conducted in 2009 [27], despite the fact that the 2009 survey audience was comprised of Microsoft employees while our current survey draws from a more diverse demographic. However, it conflicts with the findings of a survey by Lampe *et al.* conducted in 2011⁵ [17] that found that most Facebook users in their sample did not view Facebook as an appropriate venue for information-seeking (i.e., via status message Q&A). The Lampe survey’s audience consisted of employees at a U.S. university, who were less diverse (e.g., more educated, more female, older) than our sample population, which may explain this difference.

While prevalent, this behavior appears to be relatively infrequent (frequency of social network Q&A was not reported in prior surveys such as [27], which focused primarily on prevalence, motivations, and topics associated with this phenomenon). Only 15.4% of the Facebook users, 9.8% of Google+ users, 9.5% of Twitter users, and 4.6% of LinkedIn users reported asking questions at least once per week. The low use of LinkedIn for question-asking may reflect competition from other professional forums, such as internal enterprise SNS sites [40]. Figure 1 shows the reported frequency of question-asking by respondents holding accounts on each of those social networking sites.

⁵ Survey conducted in 2011; published in 2012.

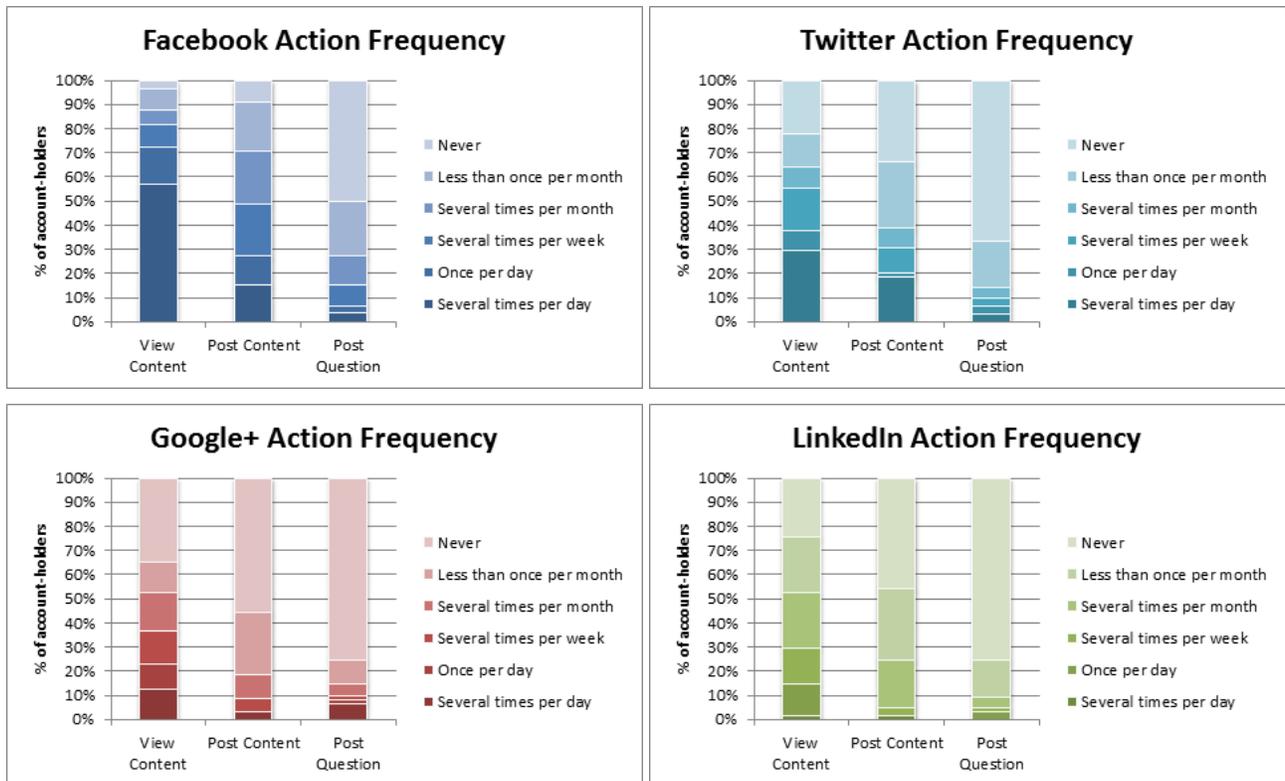


Figure 2. Frequencies of viewing content, posting content, and posting questions by account-holders on four social networks. The higher frequency of lurking (users who view but never post content) on Google+ and LinkedIn may contribute to their being viewed as less useful venues for getting questions answered.

On all of these social networks, viewing content is more common than posting content, which is more common than posting questions. “Lurking” (having an account and logging in to view content, but never posting any content yourself) was relatively uncommon. Only 4.3% of respondents with Facebook accounts were lurkers. Lurking on Twitter was more common, at 8.8% (note that this figure only includes respondents with Twitter accounts; many additional people likely read Twitter without having accounts at all). The lurking rates for Google+ and LinkedIn were higher still, at 12.5% and 15.9%, respectively. The lurking rate is strongly negatively correlated ($r = -.94$) with the rate of question-asking on each service, perhaps because it relates to the likelihood that someone who views a question will chime in with an answer. Figure 2 shows the frequency of different interactions on each social network.

The frequency of question asking on the three less popular social networks was significantly correlated ($p < .01$) (Twitter/Google+: $r = .36$; Twitter/LinkedIn, $r = .34$, Google+/LinkedIn: $r = .44$), perhaps representing a clique of “hard-core” askers who try many social venues in pursuit of an information need. In contrast, the frequency of asking on Facebook (a more popular activity overall), was not correlated significantly with asking on LinkedIn (the least popular venue for question asking), and had relatively weak

correlations with asking frequency on Google+ and Twitter ($r = .19$, $p = .03$).

Demographic factors correlated weakly with the frequency of question asking on certain social networks. Younger respondents were more likely to ask questions on LinkedIn frequently ($r = -.24$, $p < .01$), as were respondents with lower education levels ($r = -.18$, $p = .03$). Among Facebook users, women reported asking questions more often than men ($r = -.18$, $p = .03$).

Q&A Sites

Q&A sites provide an alternative method of online information seeking than traditional Web search. These forums allow users to post questions for answering by either the general Web population (e.g., Yahoo! Answers, Mahalo Answers, Ask MetaFilter [14]), paid staffers (e.g., ChaCha, kgb), or self-identified topical experts (e.g., Quora [30]). Such sites typically archive past questions and answers, which are browseable and/or searchable by other users.

The past few years have seen an increase in the prominence of tools that form social structure around non-anonymous Q&A exchanges (e.g., Quora [33], founded in 2009) and of those that operate on a paid-staffer model, which is a modern-day analog of the reference librarian, (e.g., ChaCha, founded in 2006, whose answer volume surpassed

that of Yahoo! Answers in 2011 [18]). Use of such “next-generation” Q&A sites could be construed as a form of asymmetric collaborative search [25].

We asked all respondents how often they posted questions to a variety of Q&A sites. Most respondents reported that they had never posted a question to Ask MetaFilter (97.3%), ChaCha (93.2%), kgb (98.6%), Mahalo Answers (100%), or Quora (99.3%). The only Q&A site in our survey that was occasionally used was Yahoo! Answers – 24% of respondents had posted a question at least once, though this behavior was infrequent (only 4.8% reported posting a question at least once a week).

The frequency of posting questions to Yahoo! Answers was not significantly correlated with demographic factors (age, gender, or education). There was, however, a significant negative correlation between the frequency of posting to Yahoo! Answers and the frequency of posting questions to some of the less popular social networking sites (Google+: $r = -.30$, $p < .01$; LinkedIn: $r = -.17$, $p = .04$). This might indicate that users employ two distinct “backup” strategies for seeking answers to difficult questions – either posting to a Q&A site or posting to a “secondary” social network.

We also asked whether respondents perused the archives of these Q&A sites for answers, even if they did not post a question themselves. 48.6% of respondents reported using Yahoo! Answers in this manner at least once, and 11% reported using ChaCha in this manner. The use of archived answers from Ask Metafilter, kgb, Mahalo, and Quora was negligible. Reusing answers was a more frequent behavior than posting new questions; 1.4% of respondents used the ChaCha archives at least once per week, and 11.7% did so for Yahoo! Answers (a Wilcoxon test comparing the frequency of posting vs. perusing Yahoo! Answers found that the latter was significantly more frequent, $z = -5.41$, $p < .001$). Reusing existing answers on Yahoo and ChaCha was significantly inversely correlated with age – younger users were more likely to engage in this behavior frequently (Yahoo! Answers: $r = -.41$, $p < .01$; ChaCha: $r = -.23$, $p < .01$).

DISCUSSION

In this section, we reflect on our survey findings. First, we compare and contrast our results with those of prior studies of collaborative search behavior, and discuss possible causes of differences. We then discuss the implications of our findings for the design of technical solutions supporting collaborative search.

Comparison with Prior Findings

Compared to six years ago [22], we found that more people are engaging in collaborative web search, and that they are doing so with greater frequency. 65.3% of our respondents reported having collaborated on web search, with 49.5% of those collaborative searchers engaging in such activities at least once per week. When asked about specific behaviors (such as engaging in co-located smartphone searches), even

higher prevalence and frequencies were reported, suggesting that the 65.3% number may be an underestimate, perhaps due to the generic nature of the question (“have you ever collaborated with other people to search the web?”).

The typical group size involved in such collaborations has increased, as well, likely due to the adoption of technologies that facilitate simultaneous interaction of larger groups of users for remote collaboration (e.g., social networking sites), and technologies that support larger group engagement in co-located collaboration by providing each group member with their own input device (e.g., smartphones). Despite the considerable press attention some emerging social information seeking solutions have received (e.g., Quora [33]), community Q&A sites do not appear to be part of a typical user’s collaborative search repertoire.

We found that younger users were more likely to engage in collaborative searches. It is unclear whether the observed increase in collaborative search activities is due primarily to the coming-of-age of a new generation of technology users who are more comfortable pushing the bounds of a tool’s intended use and/or have differing attitudes toward collaboration, or whether it is due to the invention and adoption of new technologies (smartphones, social networking, etc.). It is likely that both of these factors played a role in shaping our findings.

The tendency of respondents to appropriate existing communications technologies to create de facto collaborative search solutions (rather than using increasingly available dedicated collaborative tools) remains similar to six years ago. Consequently, respondents reported many of the same frustrations with collaborative search (lack of awareness, wasted duplication of effort) as in our earlier survey [22].

Our findings suggest that the meaning of the term “collaborative search” has evolved (or should evolve!). Our initial conception of collaborative search in our survey [22] and SearchTogether prototype [24] involved the synchronous or asynchronous use of search engines by multiple parties with a shared information need. However, our survey findings indicate that collaborative search now occurs beyond the search engine (e.g., in apps on smartphones, in questions on social networking sites, etc.).

Limitations

The reader should note that differences between our findings and prior work (particularly [22]) are difficult to attribute to a single cause. Differences may be due to social and technological changes occurring between 2006 and 2012, which is our primary hypothesis. Other sources of differential findings may be in the survey audience (highly technical respondents in [22] versus the more general population we reached with this survey), or in the nature of the questions themselves (the “have you ever” approach

employed in [22] versus the recent critical-incident approach [7, 10] employed in the current work).

To explore whether our findings were due to audience background rather than sociotechnical changes occurring between 2006 and 2012, we issued the same survey to 250 randomly selected U.S.-based Microsoft employees in July 2012; 63 completed the survey (25% response rate). The results from this group were very similar to the results of the more diverse 2012 audience discussed in this paper – for instance, 61.9% of the 2012 Microsoft employee respondents reported having engaged in collaborative Web search, which is not significantly different than the 65.3% figure for the diverse group ($\chi^2(1, N=63) = .279, p = .597$). Similarly, of the 2012 Microsoft employees who searched collaboratively, 49.5% reported doing so at least once per week, which is quite similar to the 47.3% of our more diverse sample that collaboratively searched at least weekly. The similarity between the diverse and tech audiences' responses increased our confidence that differences in audience background between our survey and the 2006 survey are *not* the primary source of the differences in our findings.

Additionally, the reader should bear in mind the inherent limits of all self-report studies, such as potential inaccuracies in participants' memory or biases in what they choose to report (for more detail on the pros and cons of retrospective self-report methods, see [19]). It is also unclear whether these findings extend to other demographics, such as children or people outside the United States (e.g., staffed Q&A sites are reportedly a popular form of asymmetric collaborative search amongst Korean teenagers [18]). Combining our survey findings with other approaches, such as interview or observational methods, would provide a richer understanding of this phenomenon, and is a suggested direction for further study.

Challenges for Collaborative Search Solutions

Despite the increasing availability of tools designed specifically to support collaborative web search (e.g., free online tools including Coagmento [35], HeyStaks [37], SearchTogether [24], and So.cl [8]), none of our respondents utilized such technologies. General-purpose tools that could provide rich collaborative experiences, such as videoconferencing or projection technologies, were also rarely used. Instead, respondents repurposed simpler communications technologies that were part of their everyday routines (e-mail, texting, instant messaging, phone calls, and social networking) as a way to supplement status quo web browser and search engine technologies and enable collaborative information seeking. This suggests that technologies for collaborative web search must be sufficiently *lightweight* compared with status quo ad hoc solutions. One of our survey respondents articulated this well, observing, "It might have helped if we had some sort of online bulletin board on which to post our findings – but only if posting something to the bulletin board was faster

and required fewer mouse clicks than copying a link into an e-mail message." The tension between dedicated, "top down" solutions versus ad hoc "bottom up" solutions is not unique to collaborative search; lessons learned about similar issues in areas like cyberinfrastructure development [41] may be applicable. Reflecting on our survey findings in light of this related work suggests that rather than creating dedicated tools for collaborative search, creating "glue" systems that offer integration, tighter coupling, and symbiotic functionality between existing social and information-seeking technologies might be a more promising approach.

Despite the challenge of striking a proper balance between having a low barrier to entry and offering rich collaboration support, there appears to be an unmet need for technologies supporting collaborative web search, as evidenced by the increasing prevalence and frequency of such activities. Our finding that collaborative search is more common among younger demographics suggests that its prevalence might continue to increase as a new generation of users with different attitudes about collaboration and technology emerges into the marketplace.

Our results suggest that systems that address users' frustrations regarding lack of awareness of collaborators' activities and the resulting redundant work that occurs would be particularly valued; these findings reinforce similar findings from prior work [22, 24], indicating a need that has continued to go unmet by technical advances. Solutions that can enhance common scenarios, such as the use of social networks for Q&A activities or the use of several smartphones for synchronous co-located searching, may be a particularly promising direction for research and development.

Shortly after the completion of our survey, Microsoft introduced collaborative search support into its Bing search engine with the "sidebar" feature [3], which enables a user to start a conversation with social network contacts around a query and a set of curated search results. The introduction of collaborative features into a mainstream search engine could potentially significantly alter the status quo reliance on bottom-up solutions. Revisiting the state of collaborative search practice in a few years seems prudent given the rapid evolution of technologies and attitudes in the social search space.

CONCLUSION

In this paper, we added to the growing body of knowledge about collaborative web search by presenting survey data about 167 diverse users' status quo collaborative search practices. We found that collaborative search has become an increasingly common type of information-seeking experience (and that the notion of what constitutes a "collaborative search" has evolved to include technologies beyond search engines, such as smartphones and social networking sites). We also found that ad hoc combinations of everyday technologies are used to support such

collaborations, rather than dedicated solutions designed specifically for collaborative information seeking.

By contrasting our findings with earlier work, we identified changes in the prevalence of this practice and in the technologies employed. We also identified important challenges that remain to be addressed by designers of collaborative web search technologies. Our results indicate that there is great potential for technological innovation to enhance the surprisingly commonplace practice of collaborative information seeking in the digital era.

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