Everyday Cross-session Search: How and Why Do People Search Across Multiple Sessions?

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ABSTRACT

We report on a survey about people's cross-session search activities in their everyday work and life. We recruited a broad range of participants (N=110) using the Amazon Mechanical Turk service. The survey asked people to describe a recent task in which they searched across multiple sessions, to recall the reasons they started and stopped the most recent search session for the task, and to explain methods they used for reacquainting themselves with the task at the beginning of the most recent session.

Across a broad range of tasks reported by our participants, our results show that a majority of the cross-session work tasks involved high levels of cognitive complexity, consultation with additional *human* information sources (in addition to search engines), and often involved multiple devices (e.g., computer and smartphone). Our analysis of reasons why people stopped and restarted search sessions extends and validates the reasons outlined in Lin and Belkin's model of Multiple Information Seeking Episodes [28] and previous results from MacKay and Watters' study of multi-session search [32]. We also identified methods that searchers use to re-acquaint themselves when restarting multi-session searches, and reasons why they may choose not to use any re-acquainting method. Our results update prior work and provide insights about how search systems can better support cross-session work tasks.

ACM Reference Format:
Yuan Li, Rob Capra, Yinglong Zhang. 2020. Everyday Cross-session Search: How and Why Do People Search Across Multiple Sessions?. In *2020 Conference on Human Information Interaction and Retrieval (CHIIR '20), March 14–18, 2020, Vancouver, BC, Canada.* ACM, New York, NY, USA, 10 pages. https://doi.org/10.1145/3343413.3377970

1 INTRODUCTION

People search for information to fulfill a variety of needs in their daily life and work. Some of these searches are simple and can be easily completed in a single search session. However, in other cases, people may need to search multiple times to complete a task or solve a problem. A series of search activities for the purpose of achieving a single goal, but spread across multiple sessions, is often referred to as *multi-session search*, or *cross-session search* [26]. In a single-session search, the search activities for the task are performed all within one well-defined time period. For cross-session search, the search activities are spread across multiple different sessions (e.g. time periods or days) and may be mixed with periods of doing other work related to the task, or leaving the task to rest. In this study, we focus on everyday work tasks that people perform as part of their daily life and work [25]. We refer to tasks that cause people to search across multiple sessions as *cross-session work tasks* (CSWTs).

Cross-session search has long been understood to be challenging for users and has been the topic of multiple research studies. From 1996 to 2002, Spink et al. conducted a series of studies [43–45], finding that cross-session search was common both in web searching and searches within specific information systems. In work from 2002-2010, researchers further investigated cross-session search using interviews, diary studies, and surveys of *specific* sample groups (e.g., information workers, students, researchers) [13, 31, 32, 35, 40]. These studies found that cross-session search occurs across a variety of topics and task types, and that people employ a variety of methods for keeping information and resuming cross-session searches (e.g., bookmarks, notes, emails-to-self).

Other research has used search log data to investigate relationships among search queries and click activities across multiple sessions to build models for predicting task continuity and resumption [2, 24, 48]. Recently, studies examining people's work and daily life tasks found that cross-session tasks are common for planning, problem solving, and multi-step work tasks, and that users are often interrupted and use multiple devices to complete tasks [47, 50].

These prior research efforts provide insights about cross-session search in specific contexts (e.g., academic, corporate) and among specific populations (e.g. knowledge workers). In this paper, we aim to extend this prior work in several ways: (1) to report details about a broad survey (N=110) of diverse, everyday life cross-session search activities, (2) to report additional insights about cross-session behaviors including how and why people stop and resume cross-session search *sessions*, and (3) to provide an updated view of cross-session search behaviors.

Specifically, we address the following three research questions:

RQ1 What are everyday tasks that lead people to search across multiple sessions? What are characteristics of these tasks?
RQ2 What motivates people to stop and later continue a search across multiple sessions?
  a. How/why do people resume cross-search sessions?
  b. How/why do people stop cross-session search sessions?
RQ3 How do people reacquaint themselves with information about the task and previous results when resuming a search?

This paper is structured as follows. First, we introduce related work. Second, we describe the survey we developed, and our data

CHIIR '20, March 14–18, 2020, Vancouver, BC, Canada
ACM ISBN 978-1-4503-6892-6/20/03…$15.00
https://doi.org/10.1145/3343413.3377970

collection and analysis methods. Third, we present the results of our analysis of survey data. Finally, we discuss the results and conclude with a summary and description of potential future work.

2 RELATED WORK

2.1 Cross-session information tasks

Tasks play a central role in information seeking. Tasks motivate people to conduct information activities to fulfill goals and can influence searchers' information behaviors [11, 22]. Tasks can be considered at different levels: work tasks, information-seeking tasks, and search tasks [9, 17, 49]. Previous studies have characterized aspects of cross-session tasks and search activities at all three levels. For example, Spink [43, 44] found that multi-session information seeking tasks commonly occurred related to a variety topics and that cross-session search activities could occur at different stages of a task. Sellen et al. [40] showed that 40% of knowledge workers' information gathering tasks continued over a long periods of time due to task requirements (e.g., a need for large amounts of information). Morris et al. [35] reported that 83% of surveyed information workers had engaged in cross-session search, with searches being stopped and resumed across time periods ranging from several hours to days. MacKay et al. [31] conducted diary and field studies to investigate the CSWTs of students and university employees. They observed task groups along eight topics (i.e., school/work, general topic search, research, travel/tourism, projects, action-based, shopping, status checking). Their analysis found that participants searched on average 2 to 3 sessions for each CSWT and more than half (53%) of the sub-tasks were information gathering tasks. Agichtein et al. [2] analyzed large-scale longitudinal query logs in terms of search intents, motivations, and topics with the goal of developing algorithms to predict search task continuation. They found that information maintenance tasks, affectively motivated tasks, ill-structured tasks, and time-sensitive tasks were more likely to be resumed. Liu and Belkin [30] designed cross-session search tasks with two types of sub-task structures (dependent vs. parallel) and found that task stages and sub-task structures can both effect search behaviors and the prediction of document usefulness.

Although there is no generally accepted classification, cross-session tasks are often more complex than single-session tasks [2, 24, 30] and may spawn sub-tasks with additional information requirements [2, 13, 24, 31, 37]. In this study, we will specifically focus on exploring the characteristics and relevant information behavior of *cross-session work tasks* (CSWTs).

2.2 Reasons for successive searches

People search across sessions for to a variety of reasons. Lin and Belkin [28, 29] proposed a model of Multiple Information Seeking Episodes (MISE) that included eight reasons why people resume searches: (1) transmuting – the problem gets elaborated and changes from its original form to a transmuted form; (2) spawning – the problem spawns sub-problems; (3) transiting – the original problem transits to another, different problem; (4) rolling back – something that was thought to have been solved by a previous search turns out to be unresolved; (5) lost-treatment – "the information... once found, is not available in the treatment application stage" [28, p.396]; (6) unanswered – the problem was unanswered by previous searches; (7) cultivated – occurs when a searcher is trying to stay abreast of an area of interest; (8) anticipated – the information problem has not occurred yet, but is anticipated based on the current information.

Spink et al. [45] investigated the reasons why people conducted "successive searches" (i.e. cross-session searches), identifying six reasons: (1) to refine and enhance the search using results from previous searches, (2) to seek additional information, (3) to search different databases, (4) to refine the search because too much data was retrieved in a previous search, (5) to refine the search due to increased problem complexity due to previous search results, and (6) because their first search was just exploratory [45, p.719-720]. Studies of everyday information seeking needs have also identified several reasons that people engage in cross-session searches. For example, Capra et al. [13] found that 17% of users in their study started a successive search with the intention of finding information that was not found in prior searches.

In addition, there are many reasons that may cause users to stop an on-going search before they complete their overall work task. Distinct from "search stopping behaviors" that focus on why people choose to stop using a search query or stop searching on a specific topic [51], cross-session stopping reasons refer to anticipated or unanticipated causes that interrupt a person's on-going search process. Lin and Belkin's [26] MISE model outlined two types of interruption reasons: (1) external factors not directly related to the task (e.g., time running out, distraction, mental or physical fatigue), and (2) internal factors directly related to the task (e.g., lack of understanding the information problem, need to consult with other sources, need to validate found information). MacKay and Watters [32] observed both these types of interruptions in data analyzed from diary studies and field studies, and found that the most frequent reasons for stopping a search session were: finishing a sub-task, the main work task was completed, or the user needed to take a break to do other things.

Not discounting the importance of these previous results – many of these studies involved limited samples of participants, limitations of the data collection (e.g., through intermediaries), or were conducted 10 to 15 years ago. In the study we present here, we seek to build on the results from prior work to extend our understanding of how multi-session searches manifest in current real-world work tasks in people's everyday lives.

2.3 Information keeping across sessions

Although prior work has identified that cross-session search tasks are ubiquitous [20], there are relatively few integrated tools for supporting it. One critical issue is how to keep and transfer the information found from previous sessions to later sessions for completing one's tasks. Keeping found information for future use in a cross-session search can help searchers to re-familiarize themselves with the suspended search state (e.g., reviewing previously used queries and visited pages) and can also help searchers to realize types of information that may have missed in the earlier sessions.

Generally, people use a variety of methods for keeping and re-accessing information found on web, for instance, bookmarking relevant pages, keeping tabs open, taking notes electronically and/or on paper notebooks, emailing themselves, repeating searches, using query/page view histories (e.g., purple links) [5, 24, 46]. Prior

studies found that people kept using these methods when they search *across sessions*. For instance, MacKay and Watters [31] found that participants frequently mentioned using bookmarks, browsing history, and saved pages for keeping information between sessions. Capra et al. [13] found that printing, creating bookmarks/favorites, saving to disk, and taking notes were common strategies for academic researchers to organize and manage search results across multiple sessions. However, they also reported that 53% of their participants reported relying on their memory to resume searches and re-find information across multiple sessions. Morris et al. [35] categorized the strategies people used to re-familiarize themselves based on two dimensions: *initiative* (whether the user is active or passive), and *stage* (whether the strategy applies to the storage or retrieval stage of the task). However, many of the information keeping methods observed in prior studies have drawbacks (e.g., re-finding, require manual effort, unreliable memory).

Researchers have developed and studied tools to help support users' cross-session search. For example, tools have explored ways to help users resume their previous search by keeping search histories, search queries, and records and annotations of visited pages [8, 20]. Other systems have sought to provide more comprehensive assistance by supporting a users' information management at a project-level (either manually being tagged as cross-session project or automatically detected) [15, 32, 35]. Despite these research efforts, many search engines provide only limited features to support CSWTs and many users still rely on manual methods for keeping information across multiple search sessions [13, 31, 35, 37].

While prior work has documented different types of methods used to save and re-use information during cross-session tasks, less attention has been given to understanding which methods people choose to help reacquaint themselves when resuming an interrupted task, and why they choose these methods. We address this aspect in the results from our survey.

3 METHOD

To address our research questions, we developed an online survey using the Qualtrics survey tool and distributed it using the Amazon Mechanical Turk service (MTurk). Since our goal was to gain insight into participants' real-world cross-session search tasks, we used a modified version of the critical incident technique (CIT) [38] in which we asked participants to think of a specific, recent task that involved cross-session search. The critical incident technique typically involves questions that ask participants to recall a specific activity and to describe aspects related to the activity, such as when and how it happened, whether it succeeded, and what problems were encountered [38]. CIT is an effective method to gain insight into the most memorable aspects of participants' experiences.

3.1 Questionnaire design

In our survey[1], we first defined the terms *search query, search session,* and *multi-session search*. Then we asked participants to recall and describe a recent task that: (1) "required you to do a multi-session search (e.g., that involved multiple online search sessions at different times during your task, or across different days; OR (2) a task for which you have only searched for one session so far, but you plan to search again in the future because the task is not finished yet". These two criteria were designed to help us collect data about cross-session tasks at different stages.

The questionnaire contained three sections: (1) questions about the participant's work task, (2) questions about the most recent search session for the task, and (3) questions about the methods used for keeping and transferring information between search sessions (although this third section is not covered in this paper). We also asked demographic questions (i.e. age, gender, education level, occupation). The survey included open-response questions, multiple-choice questions, and 7-point Likert-type questions. The survey was designed to take 15 to 20 minutes to complete. We conducted 4 rounds of pilot testing with 17 participants on the MTurk to ensure that the survey questions were clear and understandable.

Work task description. In this section, participants were asked to recall and describe a specific task that involved cross-session search. Using open-ended response questions, we asked them to describe their goals for the task and the information they wanted to find online. We then asked them to classify their task outcome into one of five categories (adapted from Li and Belkin [25]): (1) physical products, (2) digital products, (3) ideas, concepts, learning, (4) information for helping decision making or problem solving, (5) other (describe). Next, using multiple-choice questions, we asked about the time required for completing the task, the number of search sessions they have conducted so far for the task, the different devices they used, and what information sources they consulted.

The most recent search session. In the second section, we asked questions about participants' *most recent search session*. We defined this as "the latest session, or a period of time, that you continually searched online for information about this task." We asked participants to recall and describe their most recent search session for the work task they described earlier. Then participants were asked multiple-selection questions about the reasons why they started and stopped the most recent search session.

For the question about why they started the most recent search session, we provided 10 multiple-selection responses as options. Seven responses were based on the search renewal reasons outlined in Lin and Belkin's [26] Multiple Information Seeking Episodes (MISE) model (see Section 2.2). Table 1 shows the MISE reasons (*transiting* was outside our scope and was not included). We included two additional options to gain insight into the specificity of the information need: "I needed to find general knowledge (e.g., domain knowledge, background information) about this task", and "I needed to find specific information to help with this task". We also included an option "other (describe)" to allow additional responses.

For our question about why participants stopped (or interrupted) a search session, we also adapted options from Lin and Belkin's [26] MISE scheme, supplemented with additional options based on MacKay and Waters' findings [32]. To gain insight about whether interruption reasons were rooted in the tasks, we grouped the options into: 1) task-related interruptions; 2) non-task-related interruptions. Our list of *task-related interruptions* included eight options directly related to the task they were working on: need to consult other sources, couldn't find needed information, need to process/think about the gathered information before taking next step, need to validate information, found all information needed, task deadline

[1] Survey at: https://ils.unc.edu/searchstructures/resources/chiir2020_crosssession.pdf

was approaching, and could not complete the task. The *non-task-related reasons* list included options describing reasons why they stopped searching that were not directly related to the task (e.g., need to work on something else, they were distracted, a technical problem occurred, couldn't access information sources, got tired).

Table 1: Reasons for resuming a session (adapted from [26])

MISE mode	Option in Questionnaire
Transmuting	The task requirements were not clear.
Spawning	The task had subconcepts that I needed to understand.
Rolling-back	Information I found previously did not work.
Lost-treatment	I needed to re-find information I had seen before.
Unanswered	I wanted to continue a previous search that stopped without finding satisfactory information.
Cultivated	I wanted to find updated (e.g., the most recent) information related to the task.
Anticipated	I did not have a specific goal about the task, but thought the information might be useful in the future.

Methods for reacquainting. The third purpose of our study is to gain insights about how users reacquaint themselves with information and task context across sessions. In the *most recent search session* section of the survey, we asked: (a) Did you do anything to help reacquaint yourself with previous search results? and (b) Did you do anything to help you continue the search task in the future? Participants answered these questions in their own words.

A final section of the survey asked participants about methods they used to keep information for the work task, but for space reasons we do not present those results here.

3.2 Data collection and analysis

Survey distribution on Amazon Mechanical Turk. Our goal for using the Mechanical Turk (MTurk) to distribute the survey was to collect responses from a diverse sample of participants. The MTurk has been widely used in social science studies and in information retrieval research during recent years [3, 33]. Compared with other convenience samples (e.g., college students, employees), MTurk workers are more diverse in terms of background characteristics [7, 16, 23] that can help us gain rich descriptions of people's daily life cross-session tasks.

We posted our survey in batches of MTurk human information tasks (HITs) at different times of day across 13 days from August 15th to August 30, 2019. We restricted our HITs to MTurk workers that: 1) were located in the US; 2) had at least a 95% approval rating, 3) had 100 or more approved HITs. Similar criteria have been used in previous studies; researchers' have found that workers with more completed HITs and higher acceptance rates are more attentive than other participants [16]. Participants were paid $2 USD for a complete submission of the survey questionnaire. We used MTurk and Qualtrics features to discourage participants from trying to complete the survey more than once.

Based on our MTurk postings, we received 161 submissions. Of these, we paid 130 and rejected 31 because they were incomplete. Out of the 130, an additional 9 were excluded from our analysis because: 1) participants described a single-session search task; 2) the task described happened many years ago; 3) few details were provided about the task. Another 11 responses were not included in our analysis because their descriptions of the most recent search session was not related to the work task they described (i.e., they misunderstood the question). Thus, the data analysis for this paper is based on the remaining 110 responses. Overall, the 110 responses included an average of 210 words and for 80%, participants spent more than 10 minutes completing the survey. These measures reflect our qualitative perception that participants provided thoughtful and detailed responses.

Our participants reported as 61 (55%) male and 49 (45%) female. Their ages ranged from 20 to 68 years (M=35, SD=10). The self-reported educational level of participants was: high school degree or equivalent (5.5%, N=6), some college but no degree (26.4%, N=29), associate degree (15.5%, N=17), bachelor degree (43.6%, N=48), graduate degree (9.1%, N=10). Participants came from a wide variety of backgrounds including: artist, office support, marketeer, restaurant manager, IT consultant, scientist, engineer, doctor, student, freelance, retried people, nurse, chef, and business owner.

Data analysis and qualitative coding. To investigate our research questions two of the authors qualitatively analyzed responses to the open-ended questions on the survey. With respect to the *work task description* section of the survey, we coded: (1) the topical domain of the task, (2) the level of complexity of the task, and (3) the task goal type (work or personal). With respect to the *most recent search* section of the survey, we coded: (4) the search type of the most recent search, and (5) methods used to reacquaint with results from previous searches (if any).

The topical domains (1) were grounded in prior work by [2, 31], and extended based on additional topics identified in our data. For task complexity (2), we used the cognitive process dimension of Anderson and Krathwohl's [4] taxonomy of learning to classify tasks according to the cognitive behaviors that would be involved when people used the information they found to complete their work tasks. We coded four levels of increasing complexity: remember, understand/apply, analyze/evaluate, and create. Prior work in interactive information retrieval has used Anderson and Krathwohl's taxonomy to consider task complexity [12, 18, 22]. With regard to the search type of the most recent search (4), we adapted the commonly used classifications established by Kellar et al. [21] (information gathering, fact-finding, transaction, maintenance) to allow us to compare our data to previous studies. Finally, to classify the methods used for reacquainting (5), we developed codes informed by findings from Morris et al. [35] and MacKay et al. [31].

Table 2: Qualitative coding intercoder agreement (Cohen's Kappa)

	Category (# of possible codes)	Kappa
1	Task topic (14)	.858
2	Task complexity (4)	.712
3	Task goal type (2)	.881
4	MRS search task type (4)	.773
5	Reacquainting methods (7)	.680

Our coding process was as follows. First, one author went through the survey responses and developed an initial coding scheme by consulting extant literature and adding new trends that emerged from our data. Then the two authors independently coded four responses and met to discuss the codes and revise the coding scheme. Next, the same two authors independently coded 10% (N=17) of the data and we calculated inter-coder agreement using Cohen's

Kappa. To achieve an acceptable level of reliability, we reconciled the disagreements and each coder coded another 10% of randomly selected data for the third round. At the end of this third round, we achieved inter-coder agreement levels ranging from high to acceptable (Table 2). Then one author coded the remaining data.

4 RESULTS

4.1 RQ1: Types and characteristics of CSWTs

Our first research question (RQ1) asks, "What are everyday tasks that lead people to search across multiple sessions? What are characteristics of these tasks?" To address RQ1, we analyzed data from the *work task description* section of our survey.

Cross-session work tasks features. Participants provided detailed descriptions about their CSWTs, including their motivations, what information they needed, and their information search process. For instance, one participant described: *"I was tasked with finding a rare car for a customer. I had to search for a couple weeks online and over the phone. I started with the usual car websites and custom used cars websites. I ended up finding the item on a forum for classic cars that was not heavily used. I did several searches on different forums to see if I could find more then one."*

Across the 110 tasks, participants reported 59% (N=65) personal tasks and 41% (N=45) work-related tasks. As shown in Figure 1, the most frequent reported topics were: shopping (N=14), computers (N=14), research (N=13), hobbies (N=11), and business (N=11). Other less reported task topics were: real estate, web technology, health, engineering, politics and law, travel, employment, and education. Participants self-classified their task outcomes as: 1) problem solving/decision making tasks (32%, N=35), 2) physical products (30%, N=33), 3) ideas, concepts, learning (25%, N=28), and 4) digital products (13%, N=14).

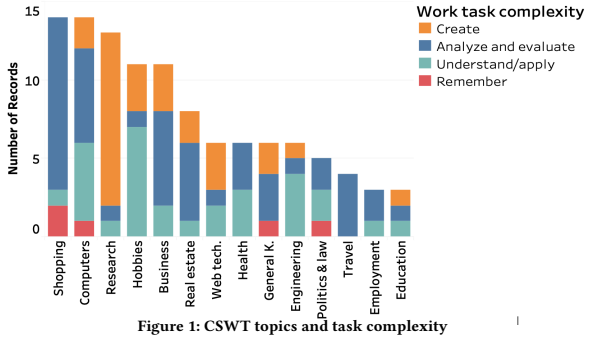

Figure 1: CSWT topics and task complexity

Figure 1 also shows the distribution of the four levels of task complexity across the task topics. As can be seen in the figure, many of the work tasks our participants described were at high (create, analyze/evaluate) or medium (understand/apply) levels of cognitive complexity. Across all topics, the distribution was: create (25%, N=28), analyze and evaluate (42%, N=46), understand/apply tasks (28%, N=31), remember (5%, N=5). These results suggest that cross-session searches may be likely to involve work tasks at the higher levels of cognitive complexity.

With respect to the time-frame of the work task, participants reported that 10% (N=11) tasks needed to be completed within 1 to 2 days, 33% (N=36) within a few days, 40% (N=44) between a few weeks to months, and 17% (N=19) tasks had no time limitation.

Our findings show that CSWTs reported by our participants cover a wide range of real-world topics and involve a variety of types of task outcomes. Most of our participants' tasks (95%) were above the *remember* level of complexity, suggesting that CSWTs often involve higher-level cognitive processes.

Sessions, stages, sources, and devices. To gain further insights into the CSWTs reported by our participants, we analyzed the number of search sessions involved, the current task stage, what devices were used, and what additional information sources (beyond search engines) they consulted, if any. As shown in Table 3, for about 80% (N = 66+21 = 87) of the tasks, participants reported having engaged in three or more search sessions so far. In addition, many reported that they were still working on the task at the time of the survey (N = 10+30 = 40). These results support the finding that cross-session tasks tend to be high in complexity.

Table 3: Search session numbers and stage of task

Task stages	1 sess.	2 sess.	3 sess.	>3 sess.	Total
Still working on the task	8	4	10	30	**52**
Done with task & no more search		11	8	24	**43**
Searched after task completed			3	12	**15**
Total	**8**	**15**	**21**	**66**	**110**

Additional information sources. We were also interested in understanding if/how participants consulted multiple sources of information for their CSWTs. In the survey, we asked participants to indicate what *additional* information sources they used (beyond search engines). Table 4 shows the list of choices we presented and the frequencies of participants' responses. Participants were allowed to indicate multiple sources, so the counts in Table 4 sum to greater than 110. Table 4 shows that the most popular sources were *online forums, friends, videos, family members, and colleagues.* Interestingly, three of these five sources involve interacting directly with other *people* (friends, family, colleagues), and the other two (videos, forums) also have significant person-to-person interaction. Further analysis found that 71% (N=78) of participants consulted 2 to 4 different sources (including search engines), while 17% (N=19) participants consulted at least 5 different types of information sources (including search engines). Only 12% (N=13) of our participants reported only using search engines for their tasks. These result further support the conclusion that CSWTs are often complex in nature, requiring not only high-levels of cognitive processes, but also consultation and interaction with other people for advice, tips, and guidance.

Search across devices. We asked participants to indicate what devices they used to search for information as part of the work task they described. Our participants overwhelmingly reported using desktop/laptop computers for their CSWTs (99%, N=109). Smartphones were used by 51% (N=56) and tablets were used by 18% (N=20) of our participants. For their CSWTs, about 43% (N=47) participants used only one type of device (desktop/laptop computer), 45% (N=50) used two types of devices, and 12% (N=13) used three types of devices. These results indicate that (1) among our sample, desktop/laptop computers were very commonly used for cross-session searches, perhaps due to the complexity of the work tasks, and (2) that smartphones were a commonly used second device. These findings are consistent with Trippas' [47] recent finding that

desktop/laptop computers are widely used for different types of tasks in work settings, and that phones and tablets are less used for complex tasks. Another possible explanation is that our sample of MTurk workers may skew toward desktop/laptop computer users.

Table 4: Additional information sources used for CSWTs

Info. source type	Freq.	Info. source type	Freq.
Specific online forums	46	Brochures or pamphlets	13
Friends	42	Magazines	13
Videos	35	Newspapers	12
Family members	29	Television	8
Colleagues	23	Libraries/unspec. readings	7
Books	21	Others (e.g., radio)	8
Specific agencies/Experts	14		

Table 5: Reasons for (re)starting the most recent search session

	General/specific	Freq.
1	Need to find specific information	87
2	Need to find general knowledge	36
	Lin & Belkin MISE reasons	
3	Cultivated (need to update)	24
4	Unanswered problem	19
5	Spawning (sub-problems emerged)	17
6	Lost treatment (need to re-find)	12
7	Rolling back (previous info did not work)	9
8	Transmuting (task was unclear)	7
9	Information anticipated	2
10	Other	1

4.2 RQ2: Cross-session resumption & stopping

Our second research question (RQ2) asks, "What motivates people to stop and later continue a search across multiple sessions? How/why do people stop and resume cross-session search sessions?" To address RQ2, we asked participants to recall and describe details about the *most recent search session* conducted for the work task. Specifically, we asked: what types of information they searched for during the most recent session, whether or not they found the information they wanted, what types of methods they used for reacquainting themselves with the task when starting this most recent session, and the methods they used to help continue searches in the future. We also asked them to select the reasons for why they started this session, as well as why they stopped the session.

Using the definitions outlined in [21, 31], we classified the most recent search sessions reported by our participants as information gathering (62%), fact-finding (27%), transaction (7%), or maintenance (4%). These results suggest that a majority of the sessions were for information gathering or fact-finding, and that transactions and maintenance were reported less by our participants.

Reasons people started their most recent search session. In the survey, we asked people to indicate their reason(s) for starting their most recent search session for the CSWT. For this question, we provided a list of choices adapted from Lin and Belkin's MISE [26] model of mulitple-information seeking episodes, and allowed participants to select multiple options. Table 5 shows the reasons and the response frequencies. Below, we discuss insights and give examples about each (re)starting reason.

1) *Needing to find specific information* was the most frequent reason that participants' noted (79%, N=87) for starting their most recent search session. This often corresponded to a particular information need for their work task. For example, p107 described, "I was looking for how to calculate square footage. I need to order wood flooring."

2) *Needing to find general knowledge* was reported by 33% of participants as a reason for starting their search sessions. For example, p45 said, "I was just looking up ideas," and p61 commented, "I was looking for the early history of the product."

3) *Needing to update themselves with the latest information* was reported by 22% of participants. In Lin and Belkin's MISE model, this reason is described as *cultivate*, meaning that the person wants to stay up-to-date with the interested area. For instance, p16 described "(I) needed to identify the latest trends with regard to [type of] activity", and p18 noted, "I was not looking for specific information, just to see if results changed or not."

4) *Problem unanswered.* About 17% of our participants reported needing to restart a search because their work task was left unanswered from their previous searches. For example, p07 described, "I needed to finish getting relevant information so that I could find a suitable product."

5) *Spawned/subconcepts emerged.* About 15% of our participants reported that their previous searches had revealed (spawned) new information needs. For example, p52 noted, "I found answers to some of my questions, but then the more I learned the more questions came up," and p20 described "I am currently looking for the answer... It tells me to look at a log which I don't seem to have which lead me into another search to find out where this log is."

6) *Lost treatment (need to re-find).* About 11% of our participants described needing to re-find information that they had seen previously as part of resuming a search. For example, p34 commented, "My most recent search session involved checking the facts that I had already put into my plan... I also wanted to recheck that I was offering the best ideas that I had come across and that I did not miss anything." In addition, some participants needed to re-find information to verify its correctness. For example, p60 noted, "the last time I searched I wanted to confirm why a fourth satellite was required for a GPS system."

7) *Rolling back / previous information did not work.* About 8% of our participants reported needing to resume a search because information they had previously found did not work. For example, p75 noted "The other fixes hadn't worked and I needed another in order to resolve the issue with the computer."

8) *Other reasons.* Participants also noted additional reasons for resuming their multi-session search, including *transmuting* and *information anticipated* from Lin and Belkin's MISE [28].

Our results about why participants resumed their multi-session search sessions validate and extend Lin and Belkin's theoretical model of MISE. To the best of our knowledge, our results are the first empirical data gathered to provide illustrative examples and frequency data about real-world instances of Lin and Belkin's MISE renewal reasons. Our results suggest that all of Lin and Belkin's MISE renewal reasons are present in real-world CSWTs, and that the most frequent are: need to update (cultivated), problems unanswered, and sub-concepts emerge (spawning).

Reasons people stopped the most recent search session. Based on Lin and Belkin [28]'s two categories (internal and external) of interruption reasons and the session stopping reasons observed

by MacKay and Watters [32], we asked participants two questions about: (1) task-related (Table 6), and (2) non-task reasons (Table 7) that led them to stop a their most recent search session. The most commonly reported *task-related* reason was that they had found all the needed information (48%, N=53). Other common task-related reasons include needing to process the gathered information (30%, N=33), to consult other sources (15%, N=17), and to validate the found information (15%, N=16).

Table 6: Task-related session stopping reasons

	Task related interruptions	Freq.
1	Found all needed info	53
2	Need to process the gathered info	33
3	Need to consult other sources	17
4	Need to validate the found info	16
5	No task-related reasons	8
6	Task deadline approaching	4
7	Cannot find needed info.	1
8	Forgot the reason	1
9	Cannot complete task	0

Table 7: Non-task-related session stopping reasons

	Non-task related interruptions	Freq.
1	No non-task related reasons	48
2	Need to work on something else	36
3	Tired of searching	29
4	Being distracted	17
5	No access to info sources	8
6	Technical problems	5
7	Cannot remember	2

The three most commonly reported *non-task* related session stopping reasons were: need to work on something else (33%, N=36), tired of searching (26%, N=29), and being distracted (15%, N=17). About 44% (N=48) participants reported that there were no specific non-task related reasons that made them stop searching. We further asked participants about their plan for future searches and found that 40% of participants clearly knew that they would search again on the same task, 25% of them reported being sure that they would **not** search anymore for their task, and 35% were not sure if they would search again.

Our findings provide real-world examples of Lin and Belkin's [28] framework of internal and external interruptions, and provide an updated view (based on a more diverse sample) of the session stopping reasons found by MacKay and Watters [32]. Our findings suggest that a majority of our participants were aware of their search session stopping reasons and a majority knew whether or not they planned to continue their search in the future.

4.3 RQ3: Re-acquainting methods

Our third research question (RQ3) asks, "How do people reacquaint themselves with information about the task and previous results when resuming a search?" To investigate this, we asked specific questions about participants' re-acquainting practices.

Re-acquainting methods. Based on qualitative coding of participants' open-ended responses regarding their most recent search session, we identified the following methods for reacquainting:

1) No methods. Many participants (36%, N=40) did not report using any specific methods for reacquainting themselves when they came back to the most recent search session. We will say more about these cases at the end of this section.

2) Re-read saved information. Re-reading saved information was the most frequently reported reacquainting method (15%, N=17). This included materials saved manually by participants (e.g., bookmarked webpages, articles, or videos in a subscribed channel) and materials that had been automatically saved/marked by search engines or web browsers. For example, p82 noted, "I had saved a few websites that had the products I was looking for so I went back to those to take a look."

3) Re-read personal notes or completed parts of work. Participants described keeping notes when they searched which became a useful tools for reacquainting themselves during future searches. In addition, some participants reported referring back to a previously finished part of their work product when restarting a new session. In total, 12 participants (10%) described using one of these methods. For example, p34 described, "I went back through the notes I had taken earlier and also the information that I had included in the proposal/plan that I had created."

4) Re-do search/re-find information. A few participants (5%, N=5) described reacquainting themselves by searching again for information they had already found. For example, p28 reported, "I had forgotten from previous results the exact name... so I had to research the names and remind myself."

Reasons for not using re-acquainting methods. For the 40 participants that did not report using any specific method for reacquainting themselves with the task, we asked a follow-up question about why they did not. We identified five main reasons:

1) Needing to search about new sub-tasks. Searching for information to solve one problem can sometimes spawn new sub-problems, or a task may involve multiple sub-goals [28]. Our participants reported these as reasons for not reacquainting themselves with prior search results. For example, p103 noted, "This particular search session was not one that I had done before, it was just an aspect of the entire vacation and was not previously searched for. "

2) Needing to check for new information. In some cases, participants reported searching for similar types of information as they did in a previous search session, but were specifically looking for new information that they might have missed. Therefore, they purposefully tried to *avoid what they had seen before* and changed their search terms/queries. For example. p06 described, "In previous searches, I'd just gotten vague general answers to basic questions, but I needed more specific information this time around."

3) Already familiar with the task. Some participants reported not needing to reacquaint themselves because they were already very familiar with the topic. In some cases, this familiarity was a result of previous searching. For example, p29 reported, "I think I spent enough time and took good notes so I was able to understand and know what I needed to know."

4) New information reviewed previous. Some participants reported not needing to reacquaint themselves because (through multiple rounds of searching), they noticed that the information they found would often contain a *review* of information they viewed previously. This might occur when a participant found a more comprehensive information resource in the later session. For example, p52 noted, "In some videos... there was a review of the information I had already learned before new information was presented, which was helpful."

5) Previous searches were not fruitful. Finally, some participants reported not needing to review previously found information because the previous information was not useful.

Our results indicate that manual approaches including re-reading saved information and personal notes are still commonly used by searchers to reacquaint themselves with previously found information. Morris et al. [35] found similar results in their study from over ten years ago, suggesting that cross-session search still involves challenges for users. Furthermore, a large percentage of our participants (36%) reported not using any specific method for reacquainting themselves when resuming their most recent search session. Our findings extend previous work by investigating the reasons participants noted for not using reacquainting methods, including: needing to search for a new sub-task, needing to check for new information, already being familiar with the task, and that previous searches were not fruitful.

5 DISCUSSION

In this section, we will review our findings, compare our results with previous work, and discuss the implications of our findings.

RQ1: Types and characteristics of CSWTs. RQ1 investigated the types and characteristics of CSWTs. Our findings show that people encounter CSWTs in their work and daily life that cover a wide range of topics (e.g., shopping, computer problems, personal hobbies, travel plans, real estate issues). The task topics that our participants reported are similar to those found in large-scale query log analyses of cross-session searches [2, 6, 19], indicating that our use of the MTurk to recruit participants led to a good sample of everyday, real-world cross-session tasks. Below, we summarize and discuss insights about our RQ1 results.

Outcome type and task complexity. Our participants reported CSWTs related to problem solving and/or decision making tasks (32%), physical products (30%), learning (25%), and creating products (13%). More than 95% of the work tasks involved medium to high levels of cognitive processes (i.e., understand, analyze, evaluate and create). Our findings confirm and extend results from previous studies showing that CSWTs often involve complex topics [31] and multiple sub-goals [2]. Our findings further suggest that features of real-world CSWTs such as task outcome type and cognitive complexity could have impacts on cross-session search behaviors and users' needs [27, 30]. For example, users engaged in understand-level cross-session tasks may benefit from tools to help reacquainting with context, whereas create-level tasks may involve multiple sub-goals with differing needs across sessions [53].

Timeliness and sessions. Our participants reported that 10% of their CSWTs were required to be completed within 1 to 2 days, 33% needed to be done within a few days, 40% ranged from a few weeks to months, and 17% had no time restriction. For more than 80% of the tasks, participants reported conducting three or more search sessions. These results update and extend prior studies that have observed multi-session searches that have spanned across several weeks [31] to months [44], and that found time gaps between search sessions ranging from several hours to several days [35]. These dimensions of timeliness, the number of search sessions, and the time between sessions have implications for how systems can best support CSWTs. For example, CSWTs that span long periods of time may have different task resumption and information keeping needs than shorter-term CSWTs.

Information sources. About 88% of our participants reported consulting additional sources besides search engine results for their CSWTs. The most popular sources were: online forums, friends, videos, family members, and colleagues. Notably, these sources all involve either direct or indirect communication with other *people* who could provide advice, guidance, and opinions about the cross-session work task. We also found that the *need to consult other information sources* was one of the main reasons that participants reported stopping a current search session (see section 4.2). Work on information seeking behaviors by Byström [10], found that the use of *people* as an information source increases as the amount of effort and the types of information required by the task increase. Considered together, these results further reveal the complex nature of CSWTs and illustrate that they are likely to require different types of information, including advice and opinions from other people.

Cross-device search. Cross-device search is common nowadays and people use a variety of devices to search for information [34]. While 43% of our participants reported using only a desktop/laptop PC for their cross-session search, 45% reported searching on two types of devices (mainly PC and smartphone) and 12% of participants used three devices. Previous work on cross-device use has found that both PC-smartphone and PC-Tablet are commonly reported patterns [34]. However, it is not clear if work tasks remained the same across the device switches examined in their study. Our results extend this work to show that switching between PCs and smartphones was the most commonly reported pattern for CSWTs among our participants. Our participants further mentioned using multiple devices *at the same time* when working on their tasks. For example, one participant described using a computer to look for hotels while also using a smartphone to look for map information and communicate to family members. Understanding how and why people use multiple devices simultaneously when working on CSWTs is an interesting topic for future investigation.

RQ2: Cross-session resumption and stopping.

Most recent search task. Similar to MacKay et al.'s [31] findings from over 10 years ago, we found that the majority of the CSWTs our participants reported were *information gathering* (62%) and *fact-finding* (27%), with fewer being transactions (7%) and maintenance (4%). Interestingly, the most popular CSWT topic reported was *shopping*. We interpret that for many shopping tasks, users spend a large amount of their cross-session searches on information gathering and fact-finding to make product comparisons. Understanding these aspects of CSWTs can help us better support the goals that users have for particular search sessions in a CSWT.

Restarting reasons. In their model of Multiple Information Seeking Episodes (MISE), Lin and Belkin [29] outlined reasons that a searcher might renew a search task from a previous session: transmuting, spawning, transiting, rolling back, lost-treatment, unanswered, cultivated, and anticipated. In later work, Lin [28] and Lin and Xie [27] partially validated aspects of the MISE model. However, to the best of our knowledge, our study is the first to investigate how these reasons manifest in real-world, everyday life CSWTs.

Our results provide contextualized examples of Lin and Belkin's restarting reasons, provide frequency data about how often the reasons were reported by our participants, demonstrate that the

reasons were able to be understood by our participants, and provide validation that the reasons covered the range of responses by our participants (e.g., few choose "other").

Each of the restarting reasons suggest specific approaches and system features that could be helpful to users:

1) *Transmuting* (problem gets elaborated): Help users track how the problem evolved and the relationships of information found.

2) *Spawning* (problem spawns sub-problems): Show the user related concepts and sub-topics related to the task.

3) *Transiting* (problem transits to a completely different problem): Given that the user has a completely new conceptualization of the task, help them avoid old information.

4) *Rolling back* (thought problem was solved, but turns out not): Remind users of previous "leads" that they chose not to follow.

5) *Answer lost* (a once found answer is now lost): Remind user of previously found information and sources.

6) *Cultivated* (user is trying to stay abreast of a topic): Send the user notifications when new, relevant information is available.

7) *Anticipated* (user anticipates a future information need): Help the user save information in order to use it in the future.

Based on analysis of our survey data, we see these as promising approaches for assisting users who are engaged in cross-session searches. Future work should investigate ways to detect when users are in these modes and to evaluate methods to provide assistance.

Stopping reasons. Similar to the previous work of MacKay and Watters [31], we observed a variety of task-related and non-task related reasons why people stopped a particular search session in a CSWT, including: they found all the information they needed, they needed to process/validate the found information, and they need to consult other sources.

Interruption has been well-studied in other fields (e.g., psychology, marketing, HCI [39]) and from various dimensions (e.g., user characteristics, environmental factors, and interplay among people, task, and system [42]). Results have found that different types of interruption can cause different effects on users' perception, task process, and task outcomes (see [39] for a comprehensive review). In the area of information seeking, several studies have found that interruptions can effect the effort, time that users spent on tasks, their search process, and satisfaction of the outcomes [1, 14, 36, 41, 52]. However, most of these studies focused on the effects of external interruptions (e.g., pop-up ads, phone calls, multi-tasking) on tasks that were completed within one experimental session. The impacts of task-related interruptions and interruptions that are initiated by searchers themselves have received less attention, especially in terms of their impacts of cross-session search.

Our survey findings show that both task-related and non-task related reasons play important role in understanding cross-session search interruptions. Furthermore, the type of interruption may also influence the reasons a user resumes a search in the future and the type of assistance that would help the resumption. For example, a user who stops a search session in order to "try out" or validate found information may end up resuming a task for very different reasons (and with different resumption needs) than a user who stops a session because they needed to answer a phone call. Our results provide insights about different types of interruptions, how they manifest in real-world CSWTs, and the types of resumption assistance that may be needed.

RQ3: Reacquainting methods. Our participants reported using many different methods to continue incomplete tasks when they resumed a search. Many factors influenced the use of reacquainting methods (e.g., different stages of the tasks, users' familiarity with the topic, the information sources involved, and their purposes/goals for the tasks). In addition, we observed reasons that participants described *not* using any reacquainting method other than their own memory: needing to search about new sub-tasks, needing to check for new information, already being familiar with the task, new information included a review of previous information, and previous searches were not fruitful. Of particular interest are cases where searchers explicitly did not want to return to previously seen results, either to find new information or because the previously found information was not useful. This implies that the purpose and intent of a resumed search session is an important factor in determining how a search system could provide task resumption support. In addition, the search sessions and users' primary work task are not isolated from each other. On the contrary, these efforts interleave in many different ways, and can influence users' future information needs for the work task.

6 CONCLUSION

We report results of a survey study to investigate cross-session search. Our results update and extend prior work. We found that: 1) cross-session search tasks vary in topic and scope, and tend to be complex across a variety of characteristics (e.g., time period, number of searches, cognitive processes involved), 2) CSWTs often involve consulting with other people to gain insights, advice, and/or guidance, 3) the resumption reasons outlined in Lin and Belkin's [28] MISE model were validated by our participants' real-wold experiences and the MISE provides a comprehensive, understandable framework for addressing real-world cross-session task resumption, 4) CSWTs are stopped/interrupted for a variety of task and non-task related reasons that can impact future search resumption needs, 5) reaquainting with a task can involve considerable effort to re-read saved information, notes, completed work, and/or to refind information, and 6) reacquainting may not be necessary in all cross-session tasks (e.g., when new sub-tasks are involved, or when the user is very familiar with the task domain).

These results have implications for how search systems can help support users in CSWTs. First, complex tasks often require subjective information (advice, opinions) and consultation with other people [9]. This implies that people working on CSWTs may have needs to be loosely collaborative with others in order to share/discuss/guide their task. Second, Lin and Belkin's [28] MISE modes provide an excellent model for considering the design of tools to support search resumption based on users' needs and the reasons they stopped their previous search session. A significant future challenge is to use interaction data to determine when a user is in a mode such as transmuting, rolling-back, or spawning. Third, since people may stop an on-going session expectedly or unexpectedly, tools are needed to help users in both situations. Fourth, we need to consider how (and when) reacquainting is needed (or not) in CSWTs, and how systems can respond appropriately.

Acknowledgements: This material is based upon work supported by the National Science Foundation under Grant No. 1552587.

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