Abstract

This paper presents the results of a questionnaire on user behaviour during searching the Web as part of information gathering tasks. In this study, users’ Web activities related to finding information, comparing information, managing information, and re-finding information, using different Web search and navigation tools, used for information gathering tasks are explored. The results indicate that current Web tools lack important functionalities for supporting how users find, re-find, and manage information during Web information gathering tasks. Furthermore, the results indicate that visual characteristics of search results, re-finding tools that bookmark complete and partial search sessions with user annotation, and integrated information management features may be useful in improving how users gather information on the Web.

1. Introduction

Research in Web information retrieval has largely focused on improving the formation of search queries [9, 24, 26], ranking and re-ranking search results [27], and presenting search results [1, 8, 29]. Many of the studies focus on Web search techniques in the context of the individual search or of reformulations of the original query. Evaluating the effectiveness of those techniques generally includes the relevancy of search results to the query [14, 19]. User satisfaction measures examine how useful the tools are to the user in accomplishing the specific query goal. However, in tasks, such as information gathering, the tools are used in a context that typically consists of more than one query perhaps over more than one session. The context of a sequence of activities may affect the performance of the search tool; hence, the user performance and satisfaction levels may differ from their use for the single query.

A broader context that should be considered in designing and investigating Web search tools is the notion of user task. Several studies in the literature have identified different tasks users perform on the Web [5, 18, 22, 25]. Those studies indicate that users’ interactions with the Web can be categorized into a few high-level tasks. Broder [5] classified Web tasks as informational, transactional, and browsing. Rose and Levinson [22] created a similar framework to that of Broder’s [5]. More recently, Kellar et al. [18] categorized user Web tasks into information gathering, performing a transaction, navigation, and fact finding. Web information gathering is a task that represents between 51.70% [5] and 61.50% [22] of the overall tasks on the Web.

To further understand user activities on the Web, several studies have been conducted to examine user behaviour during search sessions [11, 12], user behaviour in multi-session tasks [21], user viewing habits of Web search results [24], user exploration of Web search hits [13], user recall and re-use of Web search results [27], and user differences in search behaviour for information gathering (orienteering vs. teleporting behaviour) [28]. The study presented in this paper examines characteristics of user behaviour while searching the Web as a subtask of information gathering tasks with specific reference to the following:

- How do users choose sources of information on the Web, locate specific information, and re-find information during information gathering tasks?
- How do users characterize features of Web search interfaces in this context?
- What challenges do users encounter during information gathering tasks?
- What characteristics of interface features do users want to see implemented in future tools?

The results of the study will be used to inform more specific user studies in order to develop guidelines for designers of Web browser tools for information gathering tasks. The article is presented as follows. Section 2 explores the research rationale. Section 3 presents the research study. Section 4 discusses the study findings and highlights future research directions. Section 5 presents the study limitations. Section 6 concludes the paper.
2. Research rationale

Researchers have investigated how users perceive different presentations of search results [1, 19, 29], construct and formulate search queries [8, 16], recall and reuse Web search results [27], re-find preserved Web documents [20], and how they compare Web information [13]. Novel interface features have included using textual presentations [2], visual presentations [29], clustered results [19], multiple query results [10], alternate query keywords and phrases [1, 16], Web navigation interfaces [3], and other prototypes that combine several features and goals [1, 8].

2.1. Query formulation

Earlier results from Kawano [16] indicate that using visualized query terms and phrases allows users to construct more effective queries, using 45.5% of the suggested terms and phrases to construct alternate queries. In addition, Grewal et al. [9] showed that visualizing the process of assigning degrees of significance to query terms resulted in more accurate ranking of the search results. Alhenshiri et al. [1] used keywords and phrases extracted from the top ranked results of two underlying search engines to provide alternate query components that were used by participants 50% of the time for reformulating and constructing search queries.

2.2. Results presentation

Teevan et al. [29] showed that combining text with the most important images on a Web page may help users recognize the page more easily and select pages of interest more effectively. The use of a 3D City Metaphor in the work of Bonnel et al. [4] showed that users favored a visual presentation of clustered results. Visual thumbnails of Web search results that accompany textual presentations were also shown to be effective in searching the Web when revisiting Web pages [26]. Alonso and Baesa-Yates [2] argued that the familiarity of Web users with text-based rendering may result in users avoiding visualization-based techniques. Consequently, they developed a search interface that relied entirely on text rendering, which was shown to be effective in gathering information.

2.3. Comparing information

Suvanaphen and Roberts [26] designed a search interface that allows users to compare sets of results from multiple queries. The objective was to permit users to observe similarities and differences among the result sets, reduce the cognitive effort that would result from switching from one result set to another, and thus enable users to browse more effectively. Similarly, Havre et al. [10] introduced Sparkler, a technique that visualizes the results of multiple queries as alternatives to a user query. The interface showed the contribution of each query alternative to the overall relevance of documents in the result set. The usability test showed that users preferred Sparkler to the more typical list presentation because they could see the differences between the initial query and the alternatives in the visual presentation of Sparkler.

2.4. Re-searching and re-finding

Information gathering on the Web often requires multiple sessions [21]. Users usually find it useful to refer to results they have found previously on the Web. Search engines, however, may change their ranking depending on factors such as the popularity of the document which may change over time [27]. Cockburn et al. [7] showed that up to 81% of Web search visitations are actually for revisiting. Teevan [27] designed a ranking technique that keeps track of previous search sessions and merges user-relevant results of previous sessions with the results of the current session based on similarities of the search queries. The technique was shown to be effective for revisiting Web pages.

The Web browser back button is heavily used as a re-finding technique. Cockburn et al. [7] altered the behaviour of the back button to a temporal behaviour to maintain a complete list of previously visited pages. Bookmarks were also designed to facilitate re-finding but difficulties in searching bookmarks occur when the list grows extensively [6]. To enhance the user’s ability to revisit pages and bookmarks, Kaasten and Greenberg [15] used recency-ordered lists of visited pages with thumbnails of pages shown with the page titles to capitalize on the user’s mental model of previously seen pages. This technique was shown to be effective in searching bookmarked documents. In addition, Mackay et al. [20] investigated the use of Landmarks to assist users in re-finding previously located documents. The technique showed improvement and was preferred by participants in the experiment. However, these re-finding strategies work well on limited numbers of information sources, and do not help in comparing information sources.

In this paper, we are concerned with user behaviour during searching subtasks of information gathering tasks on the Web. Information gathering
tasks involve collecting information from a variety of sources through searching for sites and information on pages, deciding which information to keep, and often re-finding sites and information. Information gathering tasks are, however, mostly search-based [17]. In addition, information gathering is the most frequent task in which re-finding information on the Web occurs [18]. Information gathering tasks have been widely studied as a category of user interactions with the Web for searching and navigation [1, 18].

3. Research study

3.1. Study design

For this research, we used a Web-based questionnaire. A total of twenty five participants, a sample of convenience, completed the questionnaire. The participants regular Web users who were graduate students and professors at Dalhousie University (fourteen participants) and regular Web users who were not in academia (eleven participants). No inexperienced Web users took part in the study.

3.2. Questionnaire

The questionnaire consisted of 25 questions. Questions varied between open-ended and close-ended, largely using Likert scales. Three types of questions were used in the study. The first type was multiple-choice in which the answer was restricted to one item. The second type was multiple-choice with the ability for selecting more than one answer. The third type allowed written descriptions. The questions covered: user experience, search behaviour, information gathering, information management, and re-finding in the context of information gathering on the Web.

3.2.1. User experience. Participants were asked about their experience using search engines and their satisfaction with search tools they use on regular basis. They were given a list of conventional search engines from which they could select preferred search engines. They were also given the chance to include other search engines that were not listed.

3.2.2. Search behaviour. The second set of questions related to user behaviour during search activities. The items covered how users scan search result hit lists, how many items they usually open in the hit list, and their reaction to irrelevant results. The participants were asked about their perception of search result presentation modes. Participants were presented with snapshot examples of search results generated by the search engines Nexplore, Viewzi, Quintura, Search-cube (shown in Figure 1) in addition to Google. Nexplore provides alternate search queries, search categories from Wikipedia¹, and thumbnails of the results presented along with the result surrogates. Viewzi presents search results as snapshots of Web documents in a dial view layout. Quintura presents a tag cloud of alternate query terms along with search results. Search-cube uses snapshots of pages in the result set and information about a page is displayed by hovering over the corresponding snapshot.

Figure 1. Snapshots of search engines used in the study

3.2.3. Information management and re-finding. The third set of questions examined how users manage and re-find information. The participants were asked about their strategies, reasons for saving search results for later use in the task, and their openness to other ways to manage useful search results, such as annotation.

3.2.4. Information gathering. The fourth set of questions focused on how users locate relevant

¹ http://en.wikipedia.org/wiki/Main_Page
information. In particular, choices between orienteering (URL-based and following hyperlinks) and teleporting (keyword search based) models of searching. Participants were asked whether they usually gather the required information for their task in one session or in multiple sessions. Participants were asked about how they compare information using the browser during information gathering tasks and how they decided on which results to keep. Finally, the participants were asked about their perceptions of features for Web tools including textual and visual features, clustering features, social features in Web search results and queries, and results rendering layouts.

3.2.5. Comments. Participants could provide comments on any aspects that were not specifically mentioned in the questions. In addition, participants were able to include and report on any tools they used that were not among the choices provided. Comments regarding how participants perceive future Web information gathering tools provided additional insights for analysis.

3.3. Study results

3.3.1. User experience. The participants were all regular users of Web search engines. The majority (72%) of the participants indicated that they always use Web search engines. The remaining participants (28%) indicated that they use search engines on regular basis. Only 8.70% of the participants indicated that they have only moderate experience with information gathering on the Web. As a result, we considered all participants in the sample to understand the concept of collecting and gathering Web information for tasks such as work and study projects. In addition, no significant differences were found between the academic and non-academic participants.

Most of the participants (76%) use Google as their preferred search engine, and a further 16% preferred Google Scholar. When participants were asked about all the search engines that they use for different search activities, 63% indicated that they use Google, 11% used Bing, and 5% used Yahoo. Each of the search engines Alltheweb, Clusty, and Gceel was selected by only one user. The choice of “other” received 15% of the responses in this item. Most users were not familiar with alternative search engines such as Alltheweb, Gceel, and Clusty. In the results, 30.43% of the participants are completely satisfied with the search engines they use. The remaining participants reported either good (52.17%) or moderate (17.39%) satisfaction levels. Most participants in the study use the Web on a regular basis for information gathering tasks.

3.3.2. Search behaviour. Of the participants, 42.50% read only the titles of the documents in the result hit list and 30.00% read both the documents’ titles and summaries in the hit list. Consequently, 72.50% of the participants rely on the title and/or the summary to make decisions about the relevancy of results. Only 27.50% of the participants preferred to open pages from the hit list to decide on their relevancy, i.e., they could not make decisions based on the information provided by the search engine. The z-test results (z = 2.82, α < 0.003) show a significant difference between the proportion of participants who rely on the title and/or summary and the proportion of participants who open Web pages to decide on their relevancy.

Figure 2. Participant viewing behaviour of search results

The data show that none of the participants look at only the first or first two top ranked documents, and only 8.70% look at only one hit on the first page of result hits before changing their current queries; which contradicts previous findings in [24]. Most participants, 52.17%, look at more than the first two hits but less than the whole list on the first page of results. Interestingly, 17.39% of the participants look at the whole list of result hits on the first page. And 13.74% stated that they keep scanning the list until they find interesting documents. Most participants (77.49%) look at some of the results, as shown in Figure 2, if not the entire list, however, before reformulating their query. The z-test results show a significant difference between the proportion of participants who look at some or all of the results and

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2 www.yahoo.com
3 www.alltheweb.com
4 www.clusty.com
5 www.gceel.com
those who have no specific strategy for scanning the results ($z = 3.5, \alpha < 0.0001$).

The participants were presented with five choices to select pages: a) click and skim the page quickly then go back to the result list, b) click, read the page content carefully, and continue looking for information by following links on the page, c) choose a page and click on the ‘see similar’ feature or pages under the same category to continue looking for information, d) click, skim the document quickly, and go back to the results list for further clicking, and e) click only documents of interest based on reading the summary. The first choice, click and skim, was selected by 36.59% of the participants followed by click, skim and go back (24.39%) and click on document (19.51%). Click, read and continue and ‘see similar’ received 7.32% and 12.20% of the responses respectively (see Figure 3).

**Figure 3. Participant click and scan behaviour**

To examine participant reactions to irrelevant results on the first page of hits, participants were given the choice of a) changing the search query, b) looking at results on following pages, c) switching to a different search tool, d) re-scanning the results of the first page, and e) doing something else. Of the 25 participants, 53.4% selected changing the search query as their usual reaction to irrelevant information. Surprisingly, 30.00% chose to look at results on following pages. Only 4.60% indicated that they switch to a different search engine. None of the participants would re-scan the results on the first page. The remaining 11.00% included switching to specialized search methods such as to look for images or scholarly articles. The difference between switching to a different search engine and reformulating the search query was significant according to the z-test results ($z = 3.4, \alpha < 0.001$). The results are shown in Figure 4.

The perceptions of the participants in different ways of presentation of search results were also examined. Two queries were given to the participants for comparison on five search engines: Google, Quintura, Search-cube, Viewzi, and Nexplore. First, participants were provided with the results of a multi-term fairly specific search query, ‘how to write a good technical report’. Of the participants, 40.48% selected Google, 16.00% selected Quintura, and 8.00% selected Search-cube. Both Viewzi and Nexplore was selected by 4.00% of the participants. The remaining participants (27.52%) entered answers different from the choices provided including not being able to decide due to unfamiliarity with the search tool and uncertainty about a particular choice.

**Figure 4. Participant reactions to irrelevant results**

The second query ‘jaguar’ was a single term somewhat ambiguous query. Again, the participants were asked to select one of the five search engines for this query. Search-cube was the most often chosen at 40.00%, Google was chosen by 32.00%, Quintura was selected by 20.00%, Nexplore and Viewzi were each chosen by only 4.00%. Participants were asked to include reasons for their selections. Most users who selected the visual search engine Search-cube stated their reason as the thumbnail views, which made it easier to decide on the results provided for the ambiguous query. Some participants indicated that they selected Google because of trust and familiarity issues. The difference between the number of selections of the visual search engine Search-cube in the first query and the number of selections to the same engine in the second query was significant ($z=2.32, \alpha < 0.03$).

There were 87 responses to why participants selected specific search engines. From a list of 14 choices, the most important reasons chosen by participants were clarity of the results and ability to see documents of interest instantly (21.80%), order of the results (17.20%), showing the most important results in an easy to perceive manner (10.30%), visual views of clusters (5.70%), highlighted query
keywords in the results summaries (5.70%), and interesting and appealing views (10.00%).

In brief, most participants (60.98%) prefer quick scanning of pages clicked from the hit list. Participants did not see the benefit of either clustering or following hyperlinks to located related information. Users tend to reformulate queries to find further information instead of following hyperlink connectivity or cluster similarities. Moreover, the high percentages of participants who would change their queries or scroll over multiple pages when they encounter irrelevant results indicate that current Web search techniques can be improved especially regarding effectiveness in results presentation. Due to the variety of information sources and topics that might be required in information gathering tasks, relying on lists of result hits may increase task overhead.

3.3.3. Information management and re-finding.

The responses to how participants manage documents during information gathering show that 35.29% of the participants leave the results pages open and keep gathering information on different browser tabs and/or pages. An additional 25.49% of the participants bookmark results pages, and 17.65% copy interesting links on their computers and come back to use them later. Some participants (13.73%) indicated that they would email themselves interesting pages, write links in documents being edited, and/or use the browser history to look up search results from past search sessions (see Figure 5). Only 5.88% save the page on their computers and even fewer, 1.96%, save the search query.

Figure 5. Participant information management behaviour

The questionnaire explored bookmark use as part of information gathering. Of the participants, 31.25% bookmark documents if they think that they will not be able to find them later, and 22.92% bookmark when they think that the results will be useful for other tasks. Of the participants, 20.83% use bookmarks in order to save sources of information for further analysis; 12.50% use bookmarks to track pages they had lost earlier and found again. Finally, 12.50% reported that they either never use bookmarks for search results or they bookmark only if it was difficult to find the pages and they did not want to spend time trying to re-find them (see Figure 6).

Figure 6. Why participants bookmark search results

The participants were asked how they would value a feature that would allow them to save individual search results. The results of this item are shown in Figure 7. Of the participants, 19.40% felt that this feature would help when comparing information from different sessions; 19.40% stated that it would save time while trying to find the same results later; 22.30% thought it would help them to gather and compare information in a task related to the original topic; 10.40% stated the feature might help them to recognize what they have saved in order
to compare it to current session results; 13.40% indicated the feature would help them to create information collections related to their current task. Of the participants, however, 14.80% stated that such feature would not be helpful. The \( z \)-test results show that there is a significant different between the pros (85.20%) and cons (14.80%) of the feature (\( z = 7.9, \alpha = 0 \)).

The questionnaire also included questions related to the perceived value of a feature to annotate documents and search sessions. Of the participants, 31.06% stated that this feature would make the stored sessions clearer and more understandable; 17.90% thought annotation would be more effective if they can annotate not only on saved sessions but also on individual documents and search queries; 15.50% thought annotation would help them search within the stored information and ease the process of finding preserved documents. Some participants indicated that annotating on information stored for later use would be a waste of time (13.30%), would be distracting and demanding (6.60%), or it would make no difference (9.70%). The remaining 5.30% indicated that the use of annotation depends on the task and the search topic. Approximately, 64.46% of the participants were in favor of the annotation feature while 29.90% were not. The last 5.30% were neutral. The \( z \)-test results show a significant difference between cons and pros of annotation (\( z = 2.95, \alpha < 0.003 \)) excluding the neutral case.

The results indicate that for these participants, there is no common approach to a tool for saving documents and yet they expend a great deal of effort to manage information manually. Using varied strategies to bookmark and save documents with no significant preference of certain techniques highlights the difficulties for participants with current Web tools. The participants reported losing interesting results and having difficulty re-finding previously seen results. This may be due to ineffectiveness of current bookmarking techniques or ineffectiveness of search tools that makes finding the same results harder. The results indicate that participants may find it more effective to search their own annotations rather than searching bookmarks.

### 3.3.4. Information gathering

Participants were asked whether they follow orienteering (type-in URL and follow hyperlinks) or teleporting (keyword-based) search behaviours when they gather information. Interestingly, 68.00% indicated that they rarely or never use orienteering behaviour while 32.00% indicated that they often or always do so. The \( z \)-test results show a significant difference between participants who use orienteering and those who use teleporting behaviour on the Web (\( z = 2.26, \alpha < 0.02 \)) which contrasts the findings in the work of Teevan [27]. The results indicate that keyword search is still much more popular than typing-in a URL and following hyperlinks.

The questionnaire included questions related to time management preferences during information gathering. Of the participants, 28.00% indicated that they prefer to collect and gather the information required in the task in one session while 52.00% gather information over multiple sessions. The rest of participants stated that they do not have a specific strategy (20.00%). These results agree with the findings in the work of Mackay and Watters [21] and Spink [23]. The \( z \)-test results show no significant difference between the proportion of participants who gather information over multiple sessions and those who prefer the one-session gathering approach (\( z = 1.44, \alpha < 0.09 \)).

There were also questions related to how the participants make decisions about sources of information provided by search engines. The results are shown in Figure 8. We found that 46.00% trust the search engine, yet 16.00% send multiple queries to be confident about the results. In addition, 12.00% continue navigating on the page to make sure it is a trustworthy source of information, and 12.00% make decisions about the validity of the information directly from the text on the hit list. None of the participants indicated that they would use more than one search engine. The rest of the participants (28.00%) had different ideas including inspecting the URL of the document (7.00%) and using specialized search services such as online libraries and Google scholar (7.00%).

![Figure 8. How participants make decisions during search for Web information gathering](image)

Participants provided valuable responses on what features they would prefer in future Web information gathering tools. They were allowed to select more than one feature from a list resulting in 78 responses.
Of the responses, 13.00% favored text only presentations, 14.00% preferred both views of visual and textual results, 2.00% wanted fully visualized pages one at item (similar to the approach of the former search engine ‘searchme.com’), 14.00% preferred visualized clusters to categories on a sidebar (categories on a sidebar is an approach implemented in the search engine ‘Clusty’). Of the participants, 12.80% stated that they prefer similar pages connected visually on the display so that they could find related information. For the display of search results, 11.00% preferred to see more pages on the display and to be able to explore them quickly. In addition, 5.00% of the participants wanted to see more information about each result in the hit list in a visualized way. Only 2.50% wanted to see bigger titles and smaller summaries on the result set. With regard to involving social features, 9.00% of the participants thought it would be useful to see choices of keywords other users had used to search for information in similar tasks and 6.40% found it interesting to see pages other users found interesting to similar queries. The total percentage of responses that favored visualization to straight text rendering is 45.80% compared to only 13.00%. The z-test results show a significant difference ($z = 4.23, \alpha < 0.0001$).

These participants do not show any specific strategy for gathering information. The lack of specific information gathering tools may explain why they explore using different strategies to complete information gathering tasks. The results of the study indicate that Web information gathering is a task that is not well-served by current Web search and browsing tools.

4. Discussion

The results reveal several important factors of participant behaviour during Web search as part of information gathering tasks related to finding, re-finding, and comparing information. The participants, although to a certain extent satisfied with the tools they use, are willing to explore utilities and features that are not currently provided by such tools. Visualization and clustering aspects are considered potentially useful for certain subtasks such as comparing, re-finding, and managing information. The study also indicates that these participants view more result hits for information gathering tasks than for their general Web search activities. In addition, the study shows that information gathering tasks often take multiple sessions to complete. It is clear from the participant responses that they find it difficult to select and manage Web search results.

The study confirms that keyword-based search is still the most common for finding information on the Web. Further investigation into tools that support orienteering or navigation for information search may be useful in the context of information gathering. The participants follow unorganized, spontaneous, and mostly manual strategies to accomplish most of the subtasks in the information gathering task requiring additional effort on their part to make confident decisions regarding information gathered for the task. The study also indicates that the design and evaluation of new Web search features should focus on the concept of task. In Web information gathering, users are likely to need different types of information and follow different sequences and strategies to locate and re-located such information. In brief, future investigation for improving how users gather Web information should take into account the following aspects:

- Visual characteristics of search result presentations for information gathering.
- Re-finding tools that bookmark complete and partial search sessions with user annotations.
- Integrated information management features that support information gathering tasks.

5. Study limitations

The study was questionnaire-based with a small population of 25 participants, all frequent users of the Web, and a sample of convenience. Consequently, the participants in the study do not reflect the diversity of the Web population. Further exploration of the key findings will follow with a larger more diverse pool of participants using more robust methodologies, both qualitative and quantitative.

6. Conclusion

The research presented in this paper was based on a questionnaire completed by experienced Web users, both academic and non-academic, to provide insights on how users search the Web during information gathering tasks and to gain their evaluation of potential tool features. The results revealed important factors that should be further investigated in order to provide useful guidelines for the design of new tools for information gathering tasks.

7. References


