The Impact of Task on the Usage of Web Browser Navigation Mechanisms

Melanie Kellar, Carolyn Watters, and Michael Shepherd

Faculty of Computer Science, Dalhousie University
Halifax, Nova Scotia, Canada
{melanie, watters, shepherd}@cs.dal.ca

ABSTRACT

In this paper, we explore how factors such as task and individual differences influence the usage of different web browser navigation mechanisms (e.g., clicked links, bookmarks, auto-complete). We conducted a field study of 21 participants and logged detailed web browser usage. Participants were asked to categorize their web usage according to the following schema: Fact Finding, Information Gathering, Browsing, and Transactions. Using this data, we have identified three factors that play a role in the use of navigation mechanisms: task session, task type, and individual differences. These findings have implications for the future design of new and improved web navigation mechanisms.

CR Categories: H.5.4 [Information Interfaces and Presentation]: Hypertext/Hypermedia—Navigation, User issues.

Keywords: Navigation, navigation mechanism, web browser, web usage, task, field study.

1 INTRODUCTION

Since its inception, the ways in which users interact with and navigate the Web have been shaped by the set of navigation mechanisms provided by standard web browsers, such as back and forward buttons, bookmarks/hotlinks, history, and more recently, auto-complete and search toolbars. These mechanisms allow users to access both new and previously viewed pages. Over the past ten years, a number of focused studies [9; 19; 16] have examined the use of new and improved navigation mechanisms. However, these mechanisms are typically studied in isolation and for a set of focused tasks. Throughout this paper, we refer to all methods of navigation, whether the result of a browser function (e.g., back button, history) or from actions taken within a web page (e.g., hyperlinks) as *web browser navigation mechanisms*.

At present, the research community has a general understanding of the usage frequencies of most navigation mechanisms [7; 25; 19]. However, general usage frequency in itself does not provide a complete picture of the usefulness and effectiveness of a given navigation mechanism. Individual differences have been found to play a role in the navigation [12] and organization strategies [26] of users on the Web. Therefore, we expect that factors such task and individual differences may also play a role in the use of navigation mechanisms. In order to design more effective mechanisms, it is important that designers and researchers have an understanding of the factors that influence the usage of current navigation mechanisms. For instance, when it is reported that a particular navigation mechanism is used infrequently, in comparison with the most commonly used methods, there may be several possible reasons: *Is the navigation mechanism simply not effective? Is the mechanism only appropriate for certain tasks? Or is the navigation mechanism preferred by a certain type of user?*

While there have been many studies examining aspects of user behaviour on the Web, there are few studies of the use of browser navigation mechanisms in the context of task. This can be partly attributed to the complexity involved in data collection of user behaviour on the Web. While server-side data allows researchers to study very large sample populations, very little is known about the users being studied. The participants are often anonymous and researchers have little knowledge of their tasks, goals, or use of navigation mechanisms. Also, researchers are only able to study participants within a particular web domain, such as a search engine [24] or a digital library [10].

Client-side logging allows researchers to observe all user activity over a given time frame but it can still be difficult to log fine-grained user interactions with the web browser. Most commercial web logging programs do not log the use of navigation mechanisms so researchers must often build custom logging tools. Previous research has coupled client-side logging approaches with secondary data collection methods, such as interviews [8] and electronic diaries [11], to gather contextual information such as task and privacy ratings.

We have recently conducted a field study [15] in order to investigate information seeking behaviour on the Web. A client-side logging approach was used via a custom built instrumented web browser. Over the course of the study, two main types of data were collected: task information and all interactions with the web browser, which included the use of all navigation mechanisms. Participants annotated their web usage with task information using an electronic diary tool. Tasks were categorized as follows: Fact Finding, Information Gathering, Just Browsing, and Transactions. Using the data collected from this study, we have explored how participants navigate the Web in normal day-to-day web usage.

The key contribution of this paper is a characterization of the factors that influence the usage of web browser navigation mechanisms. This understanding is used to provide design implications for the development of new navigation mechanisms as well as to improve existing ones. In the next section, we present an overview of the related work in the area. We then outline the methodology and data collection techniques used during the field study. The results section presents three factors that are shown to be related to the use of navigation mechanisms, followed by a discussion of our results. We then present implications for the evaluation and design of web browser navigation mechanisms. Finally, we conclude with a brief overview of our future work.

2 RELATED WORK

In this section, we report on previous work that examined the usage frequencies of different web browser navigation mechanisms, against which we will compare our results. We also present an overview of new and improved navigation mechanisms that have been evaluated in the research community, followed by a synopsis of the research that guided the development of the task categorization used by participants during the field study.

2.1 Usage of Web Browser Navigation Mechanisms

Despite the many modifications and new features introduced by web browsers, the primary methods of web navigation have

remained relatively constant. Catledge and Pitkow [7] reported in 1995 that the two most commonly used methods of web navigation were hyperlinks (52%) and the back button (41%). In 1997, Tauscher and Greenberg [25], while studying the revisitation strategies of users, reported that hyperlinks accounted for 50% of all navigation and the back button accounted for 30%. In both studies, the individual use of all other navigation mechanisms was less than 3%. Recent work by Milic-Frayling, Jones, Rodden, Smyth, Blackwell, and Sommerer [18] reported that 43% of all web navigation was a result of hyperlinks while the back button accounted for 23% of all navigation. The reported usage of other navigation mechanisms such as bookmarks, typed-in URLs, the home button, the refresh button, and the forward button, has been relatively minimal and each navigation mechanism individually accounted for 0-3% all navigation.

2.2 Evaluation of Web Browser Navigation Mechanisms

Web page revisitation accounts for a large percentage of user's navigation [25; 9] and as such, much of the previous work investigating web browser navigation mechanisms has centered on those that support both immediate and post-session revisitation [13]. The three most commonly studied navigation mechanisms are designed to support revisitation: back button, bookmarks, and history. However, new navigation mechanisms are emerging, such as embedded browser toolbars to support search activities (e.g., Google toolbar, Yahoo! toolbar).

Research surrounding web browser navigation mechanisms is often motivated by the consistently high reported use of the back button. Enhanced back navigation mechanisms such as SmartBack [18] and gesture based back/forward navigation [21] have been evaluated with the aim of improving the speed and ease with which users can return to recently viewed pages. Other research has examined issues related to the back button's standard stack-based navigation model [9].

The reported use of bookmarks in the literature has been relatively low, especially in comparison with back button and hyperlink usage. Although some enhancements to bookmarks have been evaluated, such as landmarks [16], much of the bookmarks research has studied the information management issues associated with the collection and use of bookmarks [1; 4; 5].

The history function appears to be one of the least commonly used navigation mechanisms [25; 2]. One of the leading issues with the history mechanism is how to represent the large number of previously viewed pages in a way that is meaningful to users [3; 14]. Other navigation mechanisms that have been evaluated include integration of back navigation with bookmarks and history [9; 14].

2.3 Studies of User Tasks on the Web

Although many studies have examined specific aspects of web tasks, we present three studies that have examined high-level user task on the Web. In particular, the findings of these studies were used to shape the task categorization provided to participants during our field study, which is discussed in further detail in the Methodology section.

Choo, Detlor, and Turnbull [8] studied critical incidents of information seeking on the Web among 34 knowledge workers. Using interviews, questionnaires, and data logging over a two week period, significant episodes of information seeking were characterized as undirected viewing, conditioned viewing, informal search, and formal search.

Morrison, Pirolli, and Card [20] studied significant web actions through a large scale user survey. Participants were asked to describe a recent episode in which they found information on the Web that led to a significant action. The participants reported four main goals: collect, find, explore, and monitor.

Sellen, Murphy, and Shaw [23] studied the web activities of 24 knowledge workers over two days. Participants were interviewed in front of their of web history at the end of the second day and described the different activities in which they engaged. Activities were classified into six main categories: finding, information gathering, browsing, transacting, communicating, and housekeeping.

3 METHODOLOGY

In this section, we present the methodological details of the field study including the sample population studied, a description of the instruments and data collection methods used, and the study procedure.

3.1 Study Population

Twenty-one university students from Dalhousie University took part in a one week field study held in March, 2005. Laptop users were recruited to capture the greatest amount of web usage and to facilitate installation of the custom software. Since we wanted to study participants' web usage in their natural environment (or as natural as possible) Microsoft Internet Explorer (IE) users were recruited because the custom web browser used during the study was a clone of IE. Students interested in taking part in the study completed a screening questionnaire to ensure they were qualified to participate.

Participants consisted of both graduate (15/21) and undergraduate (6/21) students and were from Computer Science (11/21), Health Informatics (2/21), Management (4/21), Economics (2/21), Kinesiology (1/21), and general Arts (1/21). The median age category of the participants was 20-29 and the gender was almost evenly split with 11 males and 10 female participants. The median category of web usage reported by the participants was between 30-39 hours per week. Although students with a Computer Science background are typically considered to be more technical than others, all users were frequent web users and were the primary users of their laptops. In addition to their laptops, participants also reported using a desktop computer, either at home or work, for some of their web usage.

3.2 Instruments and Data Collection

Data collected during the study consisted of participants' web usage, task information, and questionnaire data. Capturing a detailed picture of participants' web usage can be difficult. We explored several commercial and academic software logging tools; however none of the standard logging solutions met all our needs. Therefore, we built a custom web browser (shown in Figure 1a) in C# using the browser control function provided by Microsoft .Net. The custom browser mimicked the appearance of IE, the functionality (including a Google search toolbar), and logged all usage. Byrne, John, Wehrle and Crow's [6] taxonomy of WWW user tasks was used as a guide for the types of interactions that were logged. All history and bookmark files were shared between IE and the custom web browser, meaning that on the first day of the study participants had full access to their recent history data and did not need to create new bookmarks.

3.2.1 Task Information

Participants were asked to categorize their web usage based on the following five tasks:

1. Fact Finding: Looking for specific facts, files, or pieces of information.

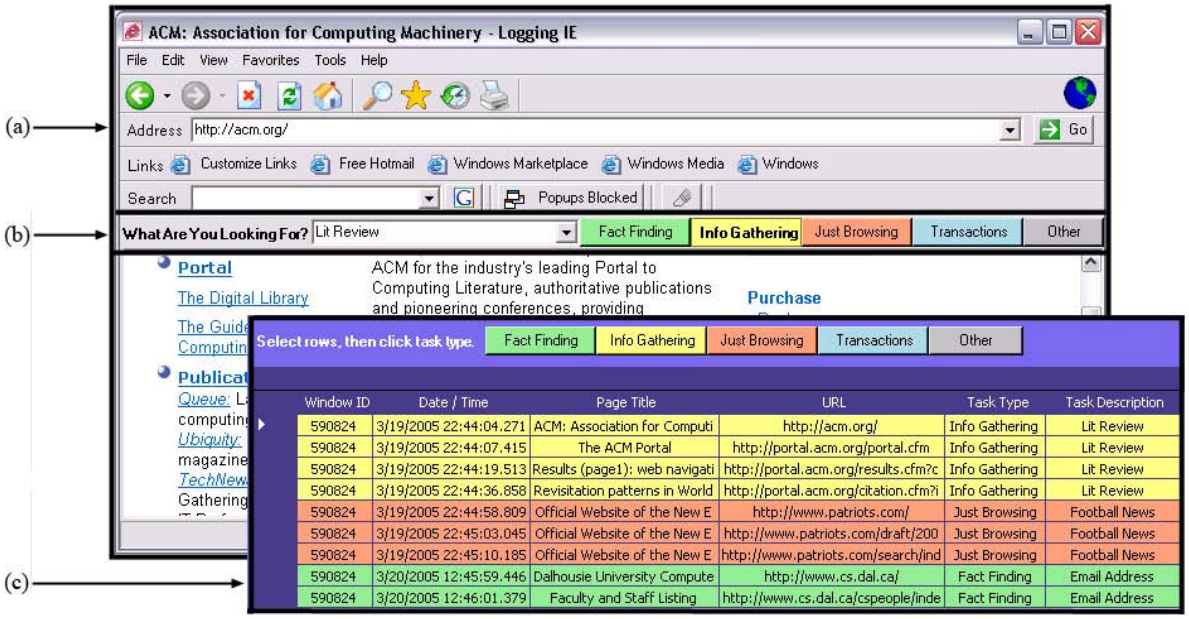

Figure 1. The custom web browser (a) was built to mimic IE and provided a task toolbar (b) for participants to record their task information in real-time. Participations could also use the task diary (c) to record their task information at the end of each day.

2. Information Gathering: Collecting information, often from various sources, in order to make a decision, write a report, complete a project, etc.
3. Just Browsing: Viewing web pages, with no specific goal in mind, often just for entertainment.
4. Transactions: An online action, such as email or banking.
5. Other: Tasks that do not fit into any of the above categories.

The task categorization is based on previous studies of information seeking behaviour and web tasks [8; 20; 23] presented in Section 2.3. We also conducted a pilot study and focus group to ensure that participants were able to categorize their web usage according to the categories provided. Six participants took part in a four day pilot study in which they used the custom web browser and categorized their web usage. The pilot study allowed us to refine the task categorization. We then conducted a 10 person focus group to further iterate on the tasks. The tasks that evolved out of this focus group were in fact very similar to the tasks reported in the literature but it was important to validate the tasks before commencing the field study.

In addition to task categorization, participants were also asked to provide a short textual description of the task (e.g., "reading the news", "looking for a recipe"). Although Transactions and Other aren't classified as information seeking tasks, participants were still asked to categorize all usage for a complete view of all web use.

Based on the results of the pilot study, where user preference was evenly split, participants were given the option to provide their task information (both categorization and description) in real-time using a toolbar embedded in the custom web browser (shown in Figure 1a) or at the end of the day using a task diary (shown in Figure 1b). Participants could also choose to use a combination of both tools. Those participants who used the toolbar method were asked to fill in task information at the beginning of a new task. Regardless of the method used to collect task information, each URL visited was associated with a task categorization and description.

Upon completion of the study and before analysis of the data, a single researcher manually reviewed all participants' data. We encountered instances where the task information did not appear to match the URLs recorded. In many cases, participants had forgotten to update their task information as they switched to a new task. Only in cases where the behaviour was habitual and obvious, such as email, did the researcher alter the task information. In all other cases, participants were contacted in order to clarify the task information.

3.2.2 Navigation Events

Overall, 15 navigation events were logged by the custom web browser:

Auto-Complete	Forward Menu	New Window
Back Button	Google Toolbar	Other
Back Menu	History	Reload Button
Bookmarks[1]	Home Button	Select URL
Forward Button	Hyperlinks	Typed-in URL

The custom web browser differentiated between the use of the auto-complete function, selecting a URL from the drop-down address menu, and typing a URL directly into the address bar; the use of these navigation mechanisms were logged as separate navigation events. In the case of bookmarks, we recorded whether they were accessed through the side window, the drop-down menu or the links toolbar. We encountered some navigation events that could not be easily identified, such as form submissions and hyperlinks loaded through JavaScript or Flash. In these cases, we could detect that a high-level document complete event fired (i.e., a single page loaded) but could not identify the direct source of the navigation event. In these cases, the navigation was categorized as "Other". We observed that these events often occurred within web-based email and other online applications, which often use forms and JavaScript. New Window typically consisted of new windows initiated either by the user or automatically from a script. However, the custom web browser provided a pop-up blocker so pop-up advertisements likely did not account for much of the new window usage.

[1] Favorites in Microsoft Internet Explorer

3.2.3 Questionnaires

Participants completed three separate questionnaires. During the pre-study session, a background questionnaire was used to collect demographic information and perceived use of the web. Participants also completed a web browser navigation inventory during the pre-study session to capture their perceived web browser navigation methods. Upon completion of the study, participants completed a post-study questionnaire which examined any difficulties they encountered during the study.

3.3 Procedure

On the first day of the study, each participant met with the researcher administering the study for a one hour session in which the custom web browser and task diary were installed on the participant's laptop. The custom web browser was configured with the participant's current IE settings, such as the use of auto-complete, the bookmarks toolbar and the Google toolbar. The background questionnaire and web browser navigation inventory were both administered at this time. The researcher then carefully described the different task categories and explained how to use both the task toolbar and task diary. Participants then took part in a short training exercise in which they practiced using both the toolbar and task diary methods of providing task information. Finally, participants were given printouts of the task definitions (also available online) and instructions for recording their task information.

Each participant was asked to email their data to the study researcher at the end of each day using a custom email application. This application emailed all new data to the researchers, ensuring that participants were correctly recording their data. Researchers contacted participants if more than two days passed without any data submitted to determine if there were any problems.

After a one week period, participants met with the same researcher. The software was uninstalled and all logging data was copied onto a backup disk and then deleted from the participants' laptop. Participants completed the post-study questionnaire and were paid $25 for their participation in the study.

4 Results

In this section, we first present participants' overall usage of web browser navigation mechanisms. We then explore how task and individual differences influence the use of different navigation mechanisms. Due to the exploratory nature of the study and the large number of comparisons required (potentially increasing Type I errors), we presented only descriptive statistics. This allowed us to explore an overview of the data and relative trends.

4.1 General Usage

Over the week of the field study, participants viewed a total of 13498 web pages (mean = 642.8, range = 98-1733). Table 1 displays the overall usage of each navigation mechanism across all participants. Overall, the most common methods of web navigation were hyperlinks (41.7%), 'other' navigation (23.6%), and the back button (18.9%). These three navigation mechanisms were used by all participants and together accounted for 84.2% of all navigation during the study.

The use of bookmarks (2.6%), the Google toolbar (1.3%), new window (5.2%), and typed-in URLs (4.5%) was relatively minimal, when compared with the above mentioned methods of navigation. In addition, we observed that several navigation mechanisms accounted for less than 1% of all usage: auto-complete (0.9%), back drop-down menu (0.21%), forward button (0.7%), home button (0.1%), reload button (0.1%), and select URL (0.4%). We did not observe any usage of the history or forward drop-down menus.

4.2 Task Sessions

We examined the use of navigation mechanisms within the context of a task session. A task session was defined as a session of web use, annotated with the same task information. Similar to Catledge and Pitkow [7], a 25.5 minute period of inactivity was used to demarcate sessions.

Overall, we observed a total of 1192 task sessions (mean = 56.8, range = 16-140) with the following breakdown: Fact Finding (18.3% - 218/1192), Information Gathering (13.4% - 160/1192), Browsing (19.9% - 237/1192), Transactions (46.7% - 557/1192), and Other (1.7% - 20/1192). Due to the relatively small number of task sessions classified as Other, we did not consider this task in our analysis. For a detailed discussion of the task information collected during the field study, see [15].

At first glance, the usage frequencies of navigation mechanisms such as hyperlinks and the back button appear to dwarf the usage of other methods such as bookmarks and auto-complete. However, when we examined all navigation events in the context of a user's task session, we saw a division between two groups of navigation mechanisms. The first group, which we refer to as New Task Session (NTS) navigation mechanisms, were employed either when initiating a new task session or when changing navigation strategies within a session. The second group, referred

Table 1. Displays the overall usage of each navigation mechanism, % of new task session navigation, % of within task session navigation, and the % of participants who were observed using the navigation mechanism.

Navigation Mechanism	Total Usage	Task Session		% of Participants Who Used Mechanism
		New	Within	
Auto-Complete	120 0.9%	67.5%	32.5%	85.7%
Back Button	2545 18.9%	1.1%	98.9%	100%
Back Menu	21 0.2%	0.0%	100%	33.3%
Bookmarks	356 2.6%	84.6%	15.4%	71.4%
Forward Button	88 0.7%	0.0%	100%	66.7%
Forward Menu	0	—	—	—
Google Toolbar	171 1.3%	63.2%	36.8%	76.2%
History	0	—	—	—
Home Button	13 0.1%	69.2%	30.8%	33.3%
Hyperlinks	5625 41.7%	1.7%	98.3%	100%
New Window	707 5.2%	12.7%	87.3%	90.5%
Reload Button	12 0.1%	25.0%	75.0%	28.6%
Select URL	53 0.4%	64.2%	35.8%	19.0%
Typed-in URL	601 4.5%	65.1%	34.9%	100%
Other	3186 23.6%	1.5%	98.5%	100%

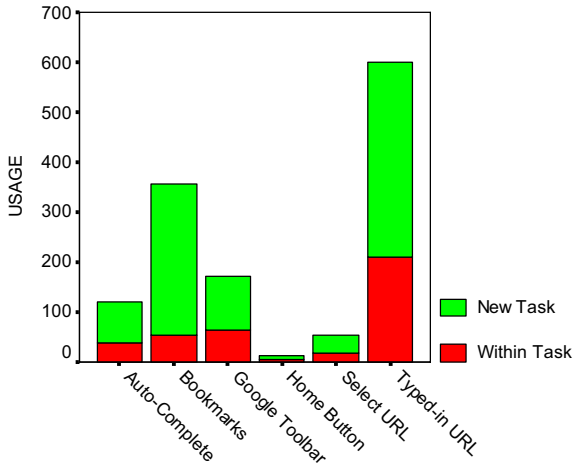

Figure 2. The breakdown of use for NTS navigation mechanisms.

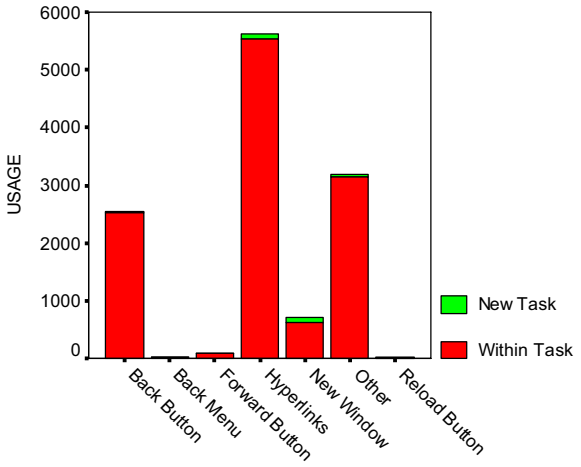

Figure 3. The breakdown of use for WTS navigation mechanisms.

to as Within Task Session (WTS) navigation mechanisms, were used almost exclusively for navigation within a task session. A breakdown of the session navigation type (NTS and WTS) is shown for each navigation mechanism in Table 1.

4.2.1 New Task Session (NTS) Navigation

Web browser navigation methods categorized as NTS navigation mechanisms consisted of those commonly used to initiate a new task session: auto-complete, bookmarks, the Google toolbar, the home button, selecting a URL from the address bar drop-down menu, and typed-in URLs. The bar chart in Figure 2 shows the breakdown of usage for these navigation mechanisms.

Task sessions were initiated by one of these mechanisms in 77.7% of all tasks. The overall use of these mechanisms to initiate new tasks ranged from 64.2% (select URL) to 84.6% (bookmarks). The use of NTS navigation mechanisms was not consistent across participants; the only NTS mechanism used by all participants was typed-in URLs.

The NTS navigation mechanisms, when not used to initiate a new task session, were typically used within a session to either branch off to new websites (e.g., moving from one news website to another during a Browsing task) or to return to a previously visited page (e.g., returning to Google within a Fact Finding task).

4.2.2 Within Task Session (WTS) Navigation

Web browser navigation methods characterized as WTS navigation mechanisms consisted of the back and forward buttons and menus; hyperlinks; new windows; the reload button; and other navigation. These mechanisms were used almost exclusively for navigation within a task session and accounted for 96.8% of all WTS navigation. The usage of each navigation mechanisms, for WTS navigation, ranged from 75% (reload button) to 98.9% (back button). We observed usage of the three main navigation mechanisms (hyperlinks, back button, other) by all participants, which is not surprising given that hyperlinks are a fundamental aspect of hypertext. The bar chart in Figure 3 shows the breakdown of usage for these navigation mechanisms.

Table 2. Proportion of NTS navigation mechanisms used to initiate a new task session for each task type.

	FF	IG	BR	TR
Auto-Complete	6.9%	16.3%	6.3%	3.9%
Bookmarks	14.7%	11.9%	21.1%	35.9%
Google Toolbar	23.4%	25.6%	5.5%	.5%
Home Button	.5%	.0%	.8%	.9%
Select URL	1.4%	.0%	10.1%	1.3%
Typed-in URL	33.5%	26.3%	26.3%	34.8%
Non-NTS navigation mechanisms	19.6%	19.9%	29.9%	22.7%
Total	**100%**			

4.3 Task Type

We investigated whether the type of task played a role in the use of navigation mechanisms by examining the mechanisms used to initiate and navigate within Fact Finding (FF), Information Gathering (IG), Browsing (BR), and Transaction (TR) task sessions. Table 2 displays the proportions of navigation mechanisms used to initiate new task sessions.

With the exception of Transactions, the use of typed-in URLs was the most common method to initiate new tasks. Typed-in URLs were used to initiate 33.5% of Fact Finding tasks, 26.3% of Information Gathering tasks, 30.8% of Browsing tasks, and 34.8% of Transaction tasks. Bookmarks were the most commonly used navigation mechanism to initiate Transactions (35.9%), closely followed by typed-in URLs. For Browsing tasks, the second most common navigation mechanism was bookmarks (21.1%), followed by URLs selected from the drop-down address menu

Table 3. Proportion of WTS navigation mechanisms used to navigate within a task session for each task type.

	FF	IG	BR	TR
Back Button	20.6%	32.3%	20.2%	4.5%
Back Menu	.3%	.3%	.1%	.0%
Forward Button	.5%	1.4%	.4%	.1%
Hyperlinks	43.4%	44.9%	54.3%	40.2%
New Window	5.4%	3.4%	3.8%	7.9%
Other	24.8%	15.1%	15.3%	45.9%
Reload Button	.0%	.1%	.0%	.1%
Non-WTS navigation mechanisms	5.0%	2.5%	5.9%	1.3%
Total	**100%**			

(10.1%). The Google toolbar the second most common way to initiate both Fact Finding (23.4%) and Information Gathering (25.6%) tasks.

Table 3 displays the proportions of navigation mechanisms used to navigate within each type of task session. Navigation through interactions with the web page (i.e., hyperlinks, 'other', and new windows) was common across all tasks and was used to navigate within 73.6% of Fact Finding tasks, 63.4% of Information Gathering tasks, 73.4% of Browsing tasks, and 94% of Transaction tasks. Back button usage was highest (32.3%) within Information Gathering tasks and was greatly reduced within Transactions (4.5%).

4.4 Individual Differences

We investigated whether individual differences played a role in the use of NTS navigation mechanisms. Using a K-Means cluster analysis, participants were clustered based on their use of the most commonly used NTS navigation mechanisms while initiating a new task session. Figure 4 shows the four resulting clusters. The first three clusters (c1, c2, c3) consisted of 76.2% (16/21) of the participants and represented those who appeared to have a dominant method of navigation. The fourth cluster consisted of the participants (23.9% - 5/21) who did not display a dominant method of navigation.

The first cluster (c1) made up of 9 participants, consisted of the group of participants who primarily choose to directly type-in URLs to initiate a new task session. The use of typed-in URLs for initiating a new task ranged from 42.2% to 80.0% across members of the cluster. All participants in this group were also users of the auto-complete function for navigation.

The second cluster (c2) was made up of 5 participants and consisted of those who primarily used bookmarks to initiate a new task session. The use of bookmarks for initiating a new task ranged for 55.7% to 70.5% across members of this group. This cluster differed from the other three clusters in that *all* of the members reported they did not use a secondary computer, meaning that frequent users of bookmarks did not move between machines. Participants were also very habitual in how they used their bookmarks. From this group, 4/5 participants used a single method to access their bookmarks (either through the side window, drop-down menu or links toolbar). This trend was found across all participants; 80% (12/15) of bookmark users chose a single method to access their bookmarks.

The third and smallest cluster (c3) was made up of 2 participants and consisted of those whose dominant method of navigation was the Google toolbar. The use of the Google toolbar for initiating a new task was 50.0% and 71.8%, respectively, for the two members of this group.

The fourth cluster (c4) was made up of 5 participants and consisted of those who did not display a dominant method of navigation. Within this group, participants exhibited varied use of the navigation mechanisms.

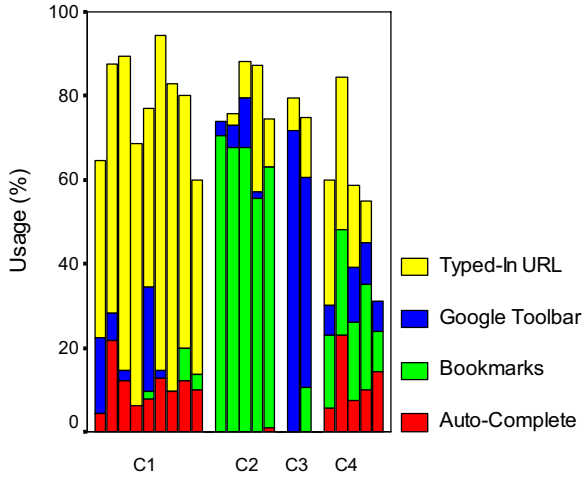

Figure 4. Participants were clustered according to their use of the four most frequently used navigation mechanisms for initiating a task session.

5 Discussion

Based on the data collected during the field study, we have identified three factors that play a role in the use of navigation mechanisms: task session, task type, and individual differences. Overall, we did not observe striking differences between the usage data we collected and that of previously studies. However, it does appear that the use the back button has decreased fairly substantially, from 41% in Catledge and Pitkow's [7] study to the 18.9% found in our study.

We have identified two classes of web browser navigation mechanisms: those used to start a new task session (NTS) and those used within a task session (WTS). Although the NTS navigation mechanisms were more commonly used for initiating a new task, they were also used for some within task navigation. We observed very strong evidence that the WTS navigation mechanisms were almost exclusively used for within task navigation.

This is an important finding for the designers and researchers of web browser navigation mechanisms. We must consider whether the usage of a navigation method is low simply because the type of mechanism exhibits lower relative usage (e.g., NTS vs. WTS) or because the mechanism has an inherent flaw that discourages its use. For instance, when we compare the overall use of bookmarks (2.6%) with that of the back menu (0.15%) it appears that both navigation mechanisms are used relatively infrequently. However, once we examine the navigation mechanisms in their context of use, we are able to gain a fuller understanding of their use. Within the context of a new task, bookmarks were the second most common method for initiating a new task and accounted for 25.3% of all new task navigation. Our participants commented that they used bookmarks because they were fast and easy to use. The back menu, a within task navigation mechanism, accounted for only 0.17% of all within task navigation. Participants reported they did not use this navigation method because it is easier to click the back button repeatedly and that it can be difficult to recognize the desired page from the list of pages in the drop-down menu. Three participants also reported they were not even aware of the functionality provided by this navigation mechanism. This example also illustrates how the ineffectiveness of one navigation mechanisms (back menu) may impact the usage of another mechanism (back button).

We observed the navigation mechanisms used by participants while engaging in Fact Finding, Information Gathering, Browsing, and Transaction tasks. The data collected suggests that the task at hand did influence the navigation methods used to initiate new tasks. Although some navigation mechanisms, such as typed-in URLs were frequently used among all tasks, participants tended to also choose methods of navigation that supported the characteristics of the task at hand. For instance, Fact Finding and Information Gathering tasks are often search-based, and this was reflected in the use of the Google toolbar, whose use was minimal among Browsing and Transactions. We recently reported [15] on the repetition rate of web tasks (i.e., tasks that were conducted

more than once by a participant during the study). Transactions, due to the large amount of email use, were the most often repeated tasks (95.2%), followed by Browsing (84.4%), Information Gathering (58.8%), and Fact Finding (55.5%). Tasks which were more often repeated exhibited a higher use of navigation mechanisms that support revisitation. Both Browsing and Transactions exhibited a higher use of bookmarks than the less often repeated tasks and we also observed the highest use of select-URLs during Browsing tasks.

We observed four main groups of users based on their choice of a dominant navigation mechanism for initiating new tasks. The first three groups consisted of those who consistently used typed-in URLs, bookmarks, and the Google toolbar. The fourth group consisted of those participants with no one dominant method of navigation. Malone [17] observed individual differences in how people organize their information and classified people as either filers or pilers. Filers organize their information in a logical structure while pilers do not adhere to any structured organization. Teevan, Alvarado, Ackerman, and Karger [26] observed a similar distinction between users when observing their web and email search behaviour. Although further study is required, the use of navigation mechanisms may be coupled with the way in which URLs and web information are stored and retrieved. For instance, bookmarks may be well suited for filers, while a searchable history may be more appropriate for pilers.

6 IMPLICATIONS

Based on our findings, we present implications for both the evaluation and future design of web browser navigation mechanisms.

6.1 Evaluation and Interpretation in Context

We have demonstrated that the use of current web browser navigation mechanisms must be interpreted in the context. When interpreting the effectiveness of navigation mechanisms, we cannot make direct comparisons between the usage of NTS and WTS navigation mechanisms. Similarly, when evaluating new navigation mechanisms, it is important to understand how the usage of a given mechanism may be influenced by the type of task in which a user is engaging. Therefore, researchers should give careful consideration to the types of tasks users are assigned to perform when evaluating new navigation mechanisms in a laboratory environment. It is also important to recognize that when evaluating NTS navigation mechanisms, users may not have as many opportunities to use these mechanisms when compared to WTS navigation mechanisms. Therefore, tasks and scenarios used in the evaluations should be designed to allow an appropriate amount of usage of the navigation mechanisms.

6.2 Supporting Task Characteristics

We theorize that that web browser navigation mechanisms can provide more effective and efficient navigation by better supporting the underlying characteristics of the tasks in which users engage on the Web. We observed two principal underlying task characteristics during our study: search and revisitation [15]. Fact Finding and Information Gathering were primarily search-based tasks while Browsing and Transaction tasks often consisted of repeated visits to websites.

Standard web browser navigation mechanisms currently provide limited support for search-based tasks through search toolbars, such as the Google and Yahoo! Search toolbars. Search-based tasks (i.e., Fact Finding and Information Gathering) account for a considerable portion of most users' web usage. Therefore, next generation navigation mechanisms should provide support for more efficient navigation and interaction with search engines that can also be customized to users' specific interests.

While many NTS navigation mechanisms currently support revistation, their functionality is limited. We observed that participants revisited web pages in order to both re-find static information as well as to monitor dynamic information. Users' navigation needs may differ depending on the type of revistation and information being sought and next generation navigation mechanisms should aim to better support this behaviour. One example of a new navigation mechanism that supports a specific type of revisitation is landmarks [16], which supports re-finding static information by returning users to previously found text.

6.3 Supporting Individual Differences

We observed that individual differences seemed to impact the usage of web browser navigation mechanisms. Future navigation mechanisms should be designed with an understanding of the different individual differences that exist and provide variations of each mechanism to reflect these differences. For instance, menu-based bookmarks may only appeal to those users who prefer to file their information. For those web users who prefer to type most URLs, they may prefer a version of bookmarks that can be accessed through typed commands (or shortcuts), as opposed to menu interactions. Similarly, for those participants who exhibited heavy usage of the Google toolbar, they may prefer to use searchable bookmarks. This is also supported by our observations that dominant bookmark users accessed their bookmarks through a single method (either through the side window, drop-down menu or links toolbar).

The history mechanism has the potential to offer effective methods for website revistation. However, the history function is rarely used. Many of our participants reported they found it difficult to re-find a previously visited URL through the history mechanism and only used it as a last resort. A history mechanism that better supports multiple user preferences, such as filing, searching, and typed commands, may better appeal to a variety of web users.

7 STUDY LIMITATIONS

The set of participants who took part in this study consisted of students who were skilled and experienced web users. Although our sample population does not reflect the general public, the data collected was relatively consistent with previously reported usage data conducted within academic [7; 25] and office environments [18].

There were several trade-offs associated with the study design. A field study was chosen to obtain a relatively realistic view of the participants' habits and behaviours. This allowed us to observe participants working with their own tools and undertaking self-motivated tasks. However, requiring users to annotate their web usage and use a custom web browser presented pragmatic challenges. It was not feasible for participants to provide detailed descriptions of their web usage for extended periods of time. The size of the sample population was also limited in comparison to sever-side data collection studies. However, server-side data collection would not have allowed us to collect a similar dataset. As in previous research studying user behaviour [22; 23; 26], a rich qualitative analysis was still possible given the sample size.

The custom web browser and task annotation had the potential to reduce the naturalness for which we were striving. Through post-session questionnaires, we asked a series of Likert scale questions aimed at understanding how the methodological decisions we made impacted participants' behaviour. Participants were asked to provide their ratings using the following scale: "Not

at all", "A little", "Somewhat", "A lot", "A Great Deal". When asked if the *web browser* used in the study changed the way the usually work on the Web, the median participant response was "A little". The median response for whether *recording task information* changed the way they usually work on the web was again "A little". From this data, we surmise that the study requirements did not significantly impact participants' natural behaviour.

8 Conclusions and Future Work

Logging task data to examine the usage of navigation mechanisms is a largely unexplored area. In this study we have provided an analysis of such logged data in which we included information about the task associated with individual web sessions. This analysis identified three factors that influence the selection of navigation mechanisms by the users: task session, task type, and individual differences. These findings have implications for the evaluation and design of new and improved web browser navigation mechanisms.

Many participants did have a dominant, or preferred, navigation mechanism and we would like to better understand the qualities of the dominant mechanisms that make them preferable. In our future work, we would also like to further examine the individual differences that exist between users, in terms of their preferred navigation mechanisms and how strongly these differences influence their choice of navigation mechanisms. Ultimately we would like to capitalize upon the finding presented in this paper to design a suite of next generation web browser navigation mechanisms that better support the needs of web users.

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