

Multitasking Bar: Prototype and Evaluation of Introducing the Task Concept into a Browser

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ABSTRACT

This paper clarifies two common patterns of multitasking on the Web, namely Multiple Tasks (MT) and Multiple Session Task (MST). To support both of these, the task concept needs to be introduced into a browser. An online pilot survey has revealed which attributes of the task concept are most significant to Web users and as a result a simple prototype, the Multitasking Bar (MB), is proposed based on these findings. The MB copes with the multitasking needs of both MT and MST in the browser by providing functions for task related Web page management and task schedule management. A two-session controlled experiment has been conducted to evaluate the MB and to compare user performance and experience when multitasking on the Web with and without support for MT and MST. Results show that support for both MST and MT significantly improves user task performance efficiency and greatly enhances the user experience when multitasking on the Web.

Author Keywords

Browser, Tasks, Multitasking, Revisitation, Multiple Sessions Task

ACM Classification Keywords

H.5.2 [Information Interfaces and Presentation]: User Interfaces — user centered design, prototyping, evaluation/methodology; H5.m. [Information interfaces and presentation]: Miscellaneous.

General Terms

Design, Experimentation, Human Factors, Measurement, Performance

INTRODUCTION

Currently with the ubiquity of the Internet, we are doing more and more of our jobs online [16,40,20], with the most important workplace for these jobs being the browser. On the other hand, humans are naturally multitasking beings, often either doing several tasks simultaneously and alternatively, or executing a single task through several working sessions. For instance, there are several reports in the literature that a great many managerial tasks can be characterized by their

brevity, variety and fragmentation [19,31,32]. This leads to simultaneously executed activities, interruptions and resumption of tasks both on and off the Web [30]. Meanwhile, a diary study of knowledge workers has identified an average of 50 task shifts per person during a typical working week [18], and a log study has identified an average of 3.74 e-mail or IM-driven task shifts per hour, taking between 8 and 10 minutes on average for the person to return to the interrupted task [21].

Cognitive psychologists have studied many aspects of multitasking or task switching, providing several definitions of multitasking [15,33]. Just et al. and Rubinstein et al. stated that multitasking is the ability of humans to handle simultaneously the demands of multiple tasks through task switching [24,36], and that it allows people to cope with ever increasing complex environments by handling multiple tasks through task switching [14,26]. We follow these definitions in this paper and concentrate especially on tasks that depend on Web resources, typically Web pages. When users multitask while working on the Web, they switch among several tasks running simultaneously, often suspending and then resuming their task(s). In doing so, they tend to follow one of two common patterns, which we define as Multi-Tasks (MT) and Multi-Session-Task (MST). In this paper, Multi-Tasks (MT) is defined as the pattern of executing a set of tasks simultaneously, where the execution often depends on bundles of Web pages. MST on the other hand, is the pattern of executing a single task spanning multiple Web sessions (as in MacKay's definition [27]). For example, whilst shopping on an e-commerce web site, and doing other task(s) on the Web at the same time, i.e., planning the itinerary of a vacation, constitutes MT. Furthermore, the shopping task is classed as an MST if it spans more than one Web session; in other words, if at some point the browser is closed and the shopping task temporarily suspended, and then later resumed in a new instance of the browser.

These patterns of MT and MST in Web use are very common, and have frequently been reported in the literature. In 2002, Spink et al. found that multitasking information seeking and searching is common human behavior as many IR system users conduct information seeking and searching on related or unrelated topics [38]. The study by Sellen et al. of knowledge workers' Web use [37] reported that 40% of the "information gathering" activities they observed were not completed in a single sitting, often due to external

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interruptions. MacKay and Watters found that users with tabbed browsing typically worked on several tasks during a single web session [28]. Morris et al. presented evidence that users often conduct multi-session tasks, such as Web investigations, and they also found that “such tasks are not adequately supported by current tools” [34].

In summary, there is significant evidence that both MT and MST are typical patterns of Web use, and should be well supported by browsers. This means that there should be some effective functions within the browser to help users manage tasks whilst multitasking on the Web, including functions for managing bunches of Web pages for corresponding tasks both simultaneously and across Web sessions, and functions for managing a task’s status and schedule. For example, in the aforementioned shopping example, while shopping online a user may browse several related web pages simultaneously. Some pages may be commodity pages from the actual e-commerce site, while others may be web pages from other sites about these commodities, such as user comments, background information, and reviews. In this situation, all these web pages comprise a bundle of resources forming the context for the user’s shopping task. Consequently, this resource bundle should be able to be saved, found, and restored as a whole whenever needed. Furthermore, when work is done on more than one task, the browser should provide better support than it does at present. It should intuitively make sense of and present the user with tasks to help switch quickly and easily between them. It also should manage the status of the tasks, to remind the user when these tasks must be completed, and what their current status is. In short, what is needed is support for (multi)task resource (Web pages) management and (multi)task schedule management in a browser.

Unfortunately however, contemporary browsers do not provide these kinds of functions, at least, not very well. In almost all widely-used browsers, there is neither the concept nor awareness of a task or task session, making it difficult to detect or explicitly define a task, manage its status, and hence save or resume work on it accordingly [34]. To resolve this issue, users have resorted to various workarounds, such as opening several browser windows or tabs simultaneously for different tasks [25], bookmarking all related Web pages for a task as a group, and even writing the URLs of the relevant Web pages for a task on paper [17,22] to enable continuing the task between sessions. Besides these workarounds, the most effective approaches hitherto lie in various research prototypes and browser extensions and plugins (for details, see the RELATED WORK section).

We believe that if we explicitly introduce the task concept into a browser and allow the browser to manage the task status and related Web pages for both MT and MST, it will promote user performance efficiency and enhance user experiences when multitasking on the Web. Our study attempts to answer two research questions:

How will the introduction of the task concept into a browser impact a user’s multitasking performance efficiency on the Web?

How will this introduction impact a user’s experience while multitasking on the Web?

In the rest of this paper, we first review related works on multitasking in a browser. We then introduce the pilot survey used to investigate how users expect to cope with multitasking in a browser. Next, we describe the design and implementation details of our prototype, the Multitasking Bar (MB). Thereafter, we report on the user study conducted to test the impact of introducing the task concept into a browser by comparing user performance efficiency and experience when multitasking on the Web with and without support for MT or MST in the browser. Next, we analyze data collected from our user study to ascertain research results and implications. Finally, we conclude by discussing the contributions of this paper and suggesting possible future work.

RELATED WORK

Various studies have been conducted to investigate the multitasking features and patterns in current browsers. Jhaveri and R ih a argued that the weakness of a browser’s support for MST is inherited from the weakness of revisitation support in a browser [22]. Keelar et al. provided a taxonomy of Web tasks and argued that task oriented revisiting functionality should be provided in a user’s Web interactions [25]. Moreover, MacKay and Watters revealed the importance of better task session resumption support in a browser through a field study that investigated users’ interactions with the Web on MST. They also identified three main features needed by browser tools to support MST [28]. However, all these studies typically focused on MST and hardly considered MT.

Previous studies also proposed approaches to enhance MST in a browser. Jhaveri and R ih a proposed Session Highlights to support MST in web-based research tasks [22], in which a research task is visualized as a workspace and each related Web page is represented as a thumbnail. Spink et al. proposed an approach for interactive information retrieval contextually within a multitasking framework [39]. Morris et al. built a search-centric task management tool named SearchBar as a plugin for Internet Explorer [34]. By using search queries as a fundamental organizational metaphor, the SearchBar groups a user’s browsing history into topic-centric tasks, and provides a quick task context resumption function. MacKay and Watters developed 3 prototypes to enhance a browser’s support for MST [29]. These prototypes can store and resume a bundle of web pages as a task context across Web sessions, and can switch between saved tasks by selecting the task in a dropdown list.

However, all these approaches concentrated solely on MST, and ignored MT. They investigated how to save and resume a task across Web sessions, and not how to present multiple tasks running simultaneously in a browser in such a way as to

make sense to the user. Moreover, with the exception of MacKay and Watters' study, the other studies did not even incorporate the task concept, which means that in these approaches users are not able to explicitly define and track a task on its necessary attributes, such as end date (deadline), status, etc. Furthermore, in these approaches tasks differ in that they are specific to different application domains in the different approaches. Each of these studies, except for MacKay and Watters', can only support multitasking for a particular kind of Web tasks, and not for generic Web tasks. In addition, except for MacKay and Watters' approach, none of them considered task schedule management.

Besides these publications, there are also many plug-ins, extensions and even built-in functions for browsers that can be used to support MST and MT partially. Save Session [1] and Session Manager [2] for Firefox and TabSaver for Internet Explorer [3] can save a current Web session and restore it at the next startup of the browser. In fact, in Firefox 2.0+, Internet Explorer 7.0+, Safari 0.9+, and Opera 4.0+, this is a built-in feature of the browser. However, although this feature can support MST in two adjacent sessions (instances) of the browser, it cannot support either defining task related Web pages explicitly or resuming a task to a state before several browser running sessions. Another function that can be used to support MT is tab grouping, which is provided by some Firefox extensions such as Multi Row Bookmarks Toolbar [4], Group/Sort Tabs [5], Tab Kit [6], and TabGroups Manager [7], etc. Nevertheless, none of these have the explicit task concept built in. Therefore, once again they cannot resume tasks across more than one Web session and do not support task schedule management. Moreover, we have not found any literature on the impact of these extensions on the user's performance or experience when multitasking on the Web, and most of the time the improvement in user efficiency and enhancement of user experience are just taken for granted.

In summary, previous studies and tools seldom introduce the concept of a task into a browser directly and explicitly, and provide little in the way of task schedule management. Furthermore, the impact of incorporating the task concept in a browser has not been studied thoroughly. To extend these studies we have implemented a simple prototype, the Multitasking Bar (MB), which explicitly incorporates the task concept in a browser and supports both MT and MST.

PILOT SURVEY

Before introducing the task concept into a browser for multitasking, we need to answer the question of what attributes the task concept should have in a multitasking-enabled browser or, in other words, what attributes of a task are most significant to users multitasking on the Web? Unfortunately, although some previous studies explored multitasking features of Web tasks, they typically concentrated on task types, task resumption times or task dwelling times, and browser functions to support multitasking [18,25,28]. They did not answer the questions we have posed here.

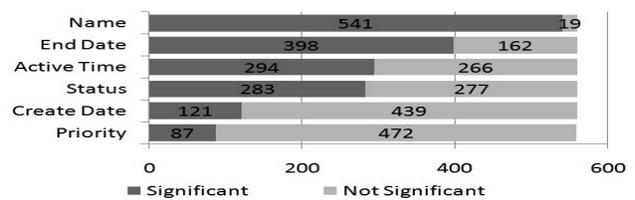


Figure 1. Distribution on significance of task attributes.

For this reason, we conducted an online survey at SurveyGizmo [8] about multitasking on the Web between April 10 and May 10, 2009. We received 582 valid responses with 82% of the respondents being male. Age of the respondents ranged from 18 – 57 years old (*median*=28). The respondents had varied occupations, including teachers, software developers, librarians, salespersons, assistants and secretaries, marketing specialists, managers, and students. All respondents identified themselves as either average (31%) or expert (69%) web users; none were novice users. Our survey asked 32 questions about a variety of Web use habits, including their usage of the browser, and their experience with multitasking (having experience of MT or not, having experience of MST or not), etc.

Many of these questions are beyond the scope of this paper and thus here, we only report on the most relevant questions. It should also be noted that the data presented in this section are self-reported, and thus we have used these results as design guidelines only, since we cannot verify their absolute accuracy.

In the survey, respondents reported having experience of MT (92%) and MST (94%), and when multitasking on the Web, on average they often had 2 – 8 tasks ($\mu=3.46$, $\sigma=1.56$) ongoing simultaneously. The most important question in the survey is Question 19, which relates to the significance of 6 attributes¹ of the task concept which we considered to be candidates for incorporation in a browser in our research prototype. The results are shown in Figure 1. Of the 582 respondents, 560 (96%, having either MT or MST experience) answered the question², and more than half of these identified Name (93%), End Date (71%), Status (53%) and Active Time (51%) as significant.

We also recruited 48 participants who are Firefox users familiar with tabs for our subsequent user study (the limit of this sample population is discussed in DISCUSSION).

SYSTEM DESIGN AND IMPLEMENTATION

We designed a simple prototype, the Multitasking Bar (MB), to evaluate the impact of introducing the task concept into a browser. It was implemented using the open source Firefox

¹ Here we selected the 6 attributes from task attributes which appear in almost all well-known task management tools, such as Microsoft Project [10], Microsoft Outlook [11], iGTD [12], Todolist [13], etc. Other attributes such as remind method, remind time, assign to, report to, etc. were discarded based on the results of a pilot survey of this pilot survey in which most of the 20 respondents marked these attributes as irrelevant to multitasking on the Web.

² This question was not posed to respondents who identified themselves as Web users without multitasking experience.

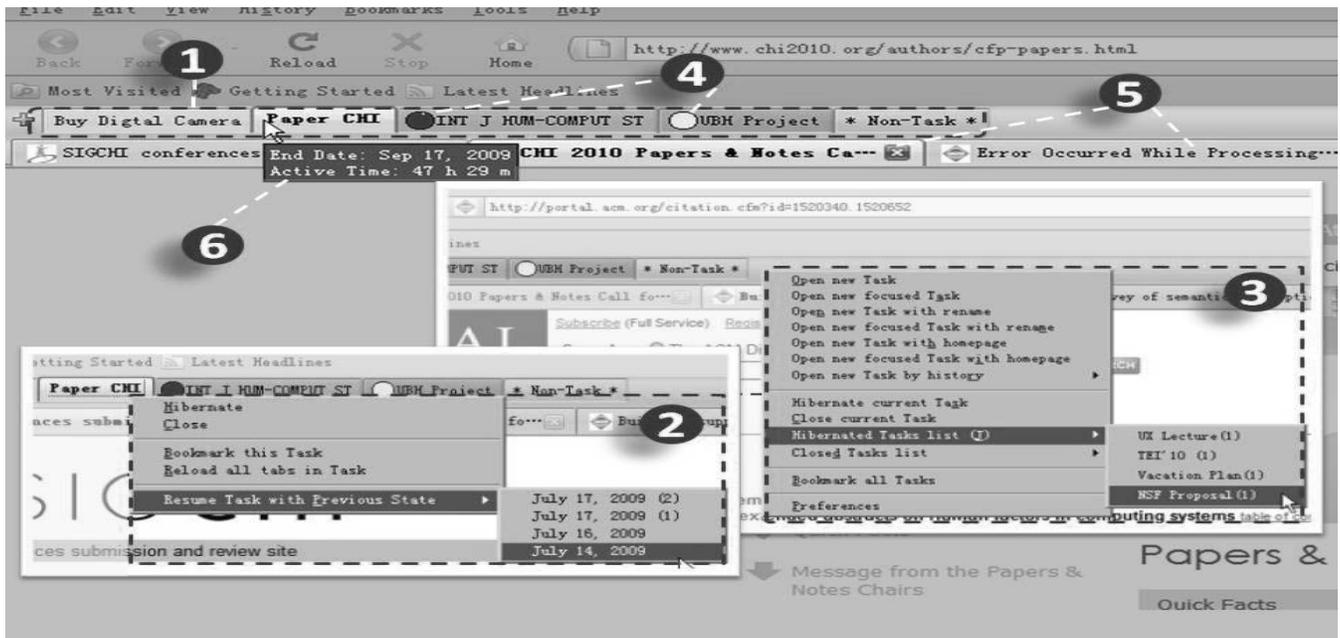


Figure 2. Screenshots of the MB. 1 – Multitasking Bar, 2 – Context Menu of Task Tab, 3 – Context Menu of Multitasking Bar, 4 – Status Icon, 5 – Tabs of Web pages of Current Task, 6 – Tooltip of Task Tab.

extensions Tab Kit [6], TabGroups Manager [7], and Tlogger [9]. Three screenshots of the MB are shown in Figure 2.

The MB supports both MT and MST. It groups Web pages for a task into a bundle and presents a task as a tab in the Multitasking Bar (1 in Figure 2). It manages the status of tasks, and can store, resume, rollback, and close related Web pages as a whole. It also collects user interactions with the browser for our user study, and can be configured with different function sets for different users³. Since the MB was designed to evaluate the impact of incorporating the task concept in a browser, we made it as simple as possible. That is, we excluded values that may be added by additional functions rather than essential advantages brought about by introducing the task concept into a browser.

Task Concept

The task concept in the MB only has four attributes, namely name, status, end date, and active time, which were significant to most of the respondents in our PILOT SURVEY. It is worth mentioning here that none of these attributes, except name, have generally been incorporated in a browser in previous studies; MacKay and Watters [27,28,29] used end date, but without status and active time.

In the MB, the name of a task is either defined by the user or automatically generated by the MB by using the title of the first Web page (excluding the search engine web pages) opened in the task. The MB represents a task as a Task Tab in the Multitasking Bar, and its name and status are shown as label and status icons, respectively (1 in Figure 2). Users can also optionally define the end date of a task, from which the accumulated active time of the task will automatically be calculated by the MB and shown in the tooltip of the tab for

the task (6 in Figure 2). Furthermore, according to its end date, at any time a task may be in one of the four states, namely IN PROCESS, APPROACHING END DATE, DELAYED, and CLOSED. If a task is approaching its deadline it will be shown with an APPROACHING END DATE status with the icon ☺ on its tab, and if it has already missed its end date it will be shown with a DELAYED status using icon ☹.

Tasks have states, especially a MST. At different times, the related Web pages for a task may be different. This feature has often been neglected by previous studies all of which assumed the user only wanted to resume a task to the state at its last running. But in fact, users occasionally need to roll a task back to a state other than that at the last running. The MB supports this feature; a user can roll back a task to any previous state stored, by selecting it from a drop down list in the context menu of the task tab (see 2 in Figure 2).

Tasks have structure. A large task often consists of a few smaller tasks, and sometimes the relationships between these child tasks can be complex. There may be certain business rules in these relationships, or these child tasks may even comprise complicated business processes or workflows. This complexity is beyond the scope of this study and we merely leave the management of the task structure to the user.

Sometimes tasks may be reused, especially the routine tasks recognized by Kellar et al. [25]. Although the MB has no dedicated function to reuse a task and does not even distinguish tasks running once from tasks running many times, it implicitly supports this feature. This means that a user can ‘reuse’ a task by rolling it back to a preferred stored state.

³ We used 3 different MB configurations for 3 groups in our user study; see USER STUDY for the details.

Grouping Strategy

There are several strategies for grouping Web pages to a related task in previous studies [22,29,34]. To make this as simple as possible, the MB follows and extends the strategy of Mackay and Watters [29], that is, first grouping any newly opened Web page into the current active task unless the user explicitly defines it as a new task, and then permitting the user to move any Web page to another task or even to drop it to the special “Non-Task” task. Here the “Non-Task” task is a dummy task in the MB which represents any casual Web surfing without a specific goal. Hence it collects Web pages that do not belong to any real task. It is always shown at the end of the Multitasking Bar as a task tab with a grey background (on the far right of 1 in Figure 2).

User Scenario

A typical scenario for using the MB follows. In the beginning a user starts a task by optionally giving it a name and end date. Any newly opened Web page is then collected unless the user moves it to another task or drops it to the “Non-Task”. Users can store the state of a task at any time. When the browser is about to close, the MB automatically stores the states of all tasks active in the browser. Hence afterwards the user can resume from a stored state. Users can also easily switch between tasks running simultaneously in the browser, and can suspend, resume, or close any of them as desired. The MB also highlights the status, end date, and accumulated active time of the tasks, making the user aware of her task schedule painlessly.

Data Collection

The MB can collect user interactions with the browser and itself, including any opening, closing, leaving, or returning to a Web page, and creating, renaming, storing, and resuming a task, as well as moving and dropping a Web page from a task. The MB also takes and stores screenshots when any new task is defined or any new tab is opened. This data can be used to calculate the time a user has spent on a particular task, and to compare the different usage patterns of users.

Configuration

After installation, the MB can be configured with or without MT and/or MST support. When the MT functions are disabled, the plus button on the Multitasking Bar disappears and there is only one real task available in the browser. When both MT and MST are disabled, the Multitasking Bar disappears and the MB acts only as a user browser interaction data collector.

USER STUDY

Our study goal is to evaluate the impact of incorporating the task concept in a browser on a user’s performance efficiency and experience when multitasking on the Web. We conducted a two session experiment on July 6 and July 13, 2009. Our experimental method was inspired by the method of Morris et al. [34], and we extended it to cope with our study goal. In the experiment we simulated a manager – secretary working scenario, in which participants acted as secretaries and were instructed by their managers, us the experimenters, to complete several tasks. They were

required to do several tasks spanning the two sessions and their interactions with the browser and other useful data were collected for analysis.

Demographics

We recruited 48 participants (15 female). They ranged in age from 19 to 43 years (*median*=24.5), and had a variety of occupations, including 25 students majoring in computer science, 3 students majoring in economics, 6 students majoring in psychology, 2 student majoring in management, 3 teachers, a librarian, 4 insurance salespersons, and 4 marketing specialists. Participants were given vouchers for food or beverages from the cafeteria as a gratuity.

Methodology

We used a between subjects design for our user study, with 16 participants each in one of 3 different groups. Participants in Group 1 (G1) were controlled like ordinary Web users without explicit multitasking support, while participants in Group 2 (G2), similar to users of previous approaches discussed in RELATED WORK, had MST support provided by the MB. Finally, participants in Group 3 (G3) had full support for MT and MST provided by the MB. We conducted the experiment in two separate sessions at our lab. Sessions lasted 110 minutes each including an additional questionnaire, and were scheduled one week apart.

We created the same Web working environment for each participant in both sessions, including a computer with a 19” screen with the following software installed: Windows XP Professional, Firefox with MB, Microsoft Instant Messenger (MIM), and Windows Office 2003. We instructed the participants that they could use any available tools to assist them in their tasks, including pen and paper (provided).

On June 29, a week before the beginning of the first session, we held a 20 minute training session of the MB for the participants in G2 and G3 according to their different configurations (with or without MT support) and asked them to practice using the MB during the following week. They reported their tasks created in MB in their practices, G2 ($\mu=4.47$, $\sigma=.79$), G3 ($\mu=4.02$, $\sigma=.47$).

First Session

In the first session, all participants were required to complete 5 tasks⁴, and the manager (experimenter) launched these tasks one by one at 10 minute intervals by sending MIM group messages and delivering the required documents to all participants. All these tasks had been completed by the researchers in a pilot study to estimate the time needed for each task. The results showed that about 142 minutes were required to complete all tasks, which means that the participants were not likely to finish all of these tasks in a single experiment session. It is worth emphasizing here that although we asked participants to resume and complete these tasks in the second session, we did not inform them of this until the start of the second session.

⁴ According to our pilot study, participants had 3.46 tasks on average and a maximum of 5.21 tasks. Therefore we designed 5 tasks for our experiment, 2 of which (tasks 2, 5) were simple and could be done quickly.

For each task, we asked the participants each to submit a Microsoft Word document containing the results of their work. They did this based on a semi-complete Word file issued by the experimenter at the beginning of the task, and were asked to fill in all blanks in the file, i.e., street name of a particular place, date of a specific event, etc., and to complete several unfinished paragraphs.

Task 1 was the same as task 1 in Morris et al.'s methods [34]. The manager requested that the assistants complete the itinerary for his upcoming business trip to Prague no later than July 14 (none of the participants had ever visited Prague). He told participants his itinerary requirements, such as the dates of travel, his desire to visit three famous historic sites and see three theatre productions, etc. and asked the participants to finalize his itinerary no later than the following week.

Task 2 was an easy job, and the same as task 2 in Morris et al.'s methods [34]. Participants were required to find a restaurant for the manager in Chicago where he could take a client for lunch. They were asked to finish this task immediately in no more than 10 minutes, and were asked to fill in the blanks of restaurant name, address, telephone, 5 recommended cuisines, reasons for recommendations, etc. When the time was up, the experimenter instructed all unfinished participants to stop working on the task.

In task 3, we required participants to finish a semi-complete report on a 2008 summary of the environmental industry in the United States (none of the participants were engaged in the environmental industry at the time). Participants were required to fill in the blanks of the Industry Gross Product, leading equipment manufacturers of advanced waste disposal, smog mitigation and water purification, etc., and to finish two paragraphs about technology and investment trends, with each paragraph having at least 500 words.

Task 4 was another long-term task whose deadline was July 11. Participants were asked to complete a semi-complete speech script for the manager's speech at an environmental forum. The report contained 20 blanks, such as the name of the chairman of the forum, city of the event, etc., and two uncompleted paragraphs about environmentalism and ecologicalism, both requiring more than 500 words.

Task 5 was also easy. Participants were required to write a recommendation for a digital camera the manager wished to purchase that met certain resolution and zoom requirements.

At the end of the session, the experimenter instructed all participants to stop working, and then asked them to complete an online questionnaire soliciting demographic information, information about their browsing habits, and multitasking strategies employed by them, and feedback on the MB tool (G2 and G3). Specifically, they were required to state how many minutes they had spent on each task, and for the unfinished tasks how many minutes they would need to complete them.

After each participant left, the experimenter saved all states by storing the Firefox's profile of the participant and any documents created in the session in a zip file, and collecting paper notes left on the desk in a file folder marked with the participant's name.

Second Session

When the participants returned for the second session, one week later on July 13⁵, the setup was the same as in the first week, and Firefox had retained any settings they had accrued during the first session (bookmarks, history, MB entries, etc.), plus 280 history visitation records and 4 bookmarks intentionally added to each participant's profile⁶ to populate it as if it had been used by the participant during the week. All their paper notes were on the desk as they had left them. However, we replaced the in-process result documents for their tasks with the unprocessed blank template files originally issued by the experimenter.

We informed the participants that they would continue in their role as secretary to the manager and that the computer was in the exact state they had left it the previous week, except that a computer virus had destroyed their work result files. Then we instructed all participants to report on the progress on their tasks giving task name, end date, status, time they had spent, and time still needed to complete the task. Each of them was asked to submit a report within 10 minutes. It is worth mentioning here that we did not tell them how many tasks there were or what they were; instead, we told them that if they couldn't remember, they could ask the experimenter for help, but not the other participants. Ten minutes later, we gave participants the correct information about their tasks' status according to the records from the first session and instructed them to carry on with the tasks. At the end of the second session, the experimenter distributed another questionnaire similar to session 1, and specifically with respect to the question on how much time participants had spent on each task, including both completed and uncompleted tasks.

Data gathered

Data gathered during the study included notes and observations from four experimenters who observed each session, questionnaires completed after each session, the participants' task result documents from each of the two sessions, the transcripts of the instant messages, any other digital or paper notes made by participants, and the participants' Firefox profiles at the end of each session including history, bookmarks, and user browser interaction data collected by the MB.

RESULTS

During the two sessions⁷, the MB clearly impacted users' multitasking on the Web. The MB was used by participants

⁵ Two participants (one in G1, and another in G3) deviated from this one-week gap between sessions, returning after 8 and 10 days, respectively.

⁶ According to our survey, participants view 38 Web pages per day on average, and create a bookmark every two days.

⁷ We use a t-Test for normally distributed data, and a Mann-Whitney U Test and Wilcoxon Test for non-normally distributed data in between groups in

	G1		G2		G3		G1:G2	G1:G3	G2:G3
	μ	σ	μ	σ	μ	σ			
Window and Tab Interactions							t-Test		
Window Actions	9.87	2.78	9.9	2.51	8.23	2.31	0.98	0.07	0.06
Tab Actions	88.61	20.85	74.54	15.64	60.82	17.73	0.03	0.01	0.03
Task Tab (MB) Actions	n/a	n/a	n/a	n/a	23.99	4.64	n/a	n/a	0.01
Revisitation									
History List	7.41	1.86	0.36	1.03	0.24	0.1	0.01	0.01	0.03
Task Resume	n/a	n/a	n/a	n/a	6.47	0.4	n/a	n/a	0.02
Followed Links	40.53	7.52	31.73	7.16	32.08	5.98	0.01	0.01	0.88
Navigation									
Search Engine	36.96	8.23	24.14	5.7	20.7	7.48	0.01	0.01	0.15
Look in page (find)	6.07	3.34	5.94	2.18	5.14	2.47	0.90	0.36	0.33
Copy/Paste Actions	43.68	4.24	30.28	3.57	31.27	5.25	0.01	0.01	0.54

Table 1. Group Statistics of Interactions with Browser (when p-value of t-Test is less than .05, the null hypothesis is rejected)

in G2 (times of using MB functions, $\mu=23.99$, $\sigma=4.14$) (11% in all browsing actions) and G3 ($\mu=16.07$, $\sigma=4.64$) (10%).

Throughout the experiment, they used the MB to create tasks G2 ($\mu=5.48$, $\sigma=.59$), G3 ($\mu=5.02$, $\sigma=.46$), and then to hibernate and resume these G2 ($\mu=6.47$, $\sigma=2.77$), G3 ($\mu=4.15$, $\sigma=0.40$). Analyses of the MB log data also show that the introduction of the task concept by the MB changed the participants' browsing behavior (Table 1). MB users in G2 ($\mu=37.20$, $\sigma=11.14$) and G3 ($\mu=30.59$, $\sigma=14.44$) opened fewer web pages than those without it, G1 ($\mu=48.73$, $\sigma=19.13$), ($p_{21}<.04$, $p_{31}<.01$), and they performed fewer navigation actions. The MB also changed participants' revisitation strategies. Participants with the MB used fewer history tools provided by the browser than those without it (Table 1). However, all groups had few bookmarks because they were not aware that their tasks would be continued in the second session (number of bookmarks for G1, G2 and G3 are 2, 0 and 1, respectively). Moreover, the MB changed the way participants used tabs. From Table 1 we can see that MB users used fewer tabs than the others.

Multitasking Performance Efficiency

The MB improved participants' multitasking performance. Except for one user in G2 who failed to finish task 4, all other MB users (97%) accomplished all their tasks in the experiment. Yet, among the participants not using the MB, 3 users (18%) had 4 tasks unfinished at the end of session 2. There are differences between the groups' mean times for accomplishing all five tasks in our experiment. Firstly, MB users accomplished the tasks in less time than the others; participants of G2 ($\mu=156.81$, $\sigma=16.80$) and G3 ($\mu=144.94$, $\sigma=12.69$) used less time than those of G1 ($\mu=172.44$, $\sigma=22.71$), ($p_{21}<.04$, $p_{31}<.01$) to accomplish the tasks⁸. Secondly, participants with both MT and MST (G3) support worked more efficiently than participants with only MST

same session analysis and in same group between sessions analysis respectively. Likert scale responses are on a scale of 1 to 5, where 1 = strongly disagree and 5 = strongly agree.

⁸ According to the average time spent by experimenters in the pilot study on every section (blanks, paragraphs to be completed) of each result document, we estimated a proportionate completion time for the unfinished tasks of participants based on the result document they submitted at the end of the experiment and the time they spent on it.

support (G2) ($p<.04$). Moreover, the decrease in mean task time consumed brought about by MT is 11.87 minutes, which is close to the decrease of 15.63 minutes brought about by MST.

Meanwhile, MB users performed fewer other browsing actions. Table 1 shows that participants in G2 and G3 used search engines significantly fewer times and copied and pasted fewer times than those in G1. This fact plus the fact mentioned previously that MB users accessed fewer web pages indicate that the MB helped its users find the required Web resources quickly and accurately. Equally important, the MB was also helpful in "Keeping found things found" [23], since the participants in G2 and G3 also performed fewer revisitation actions (Table 1).

We also found that to accomplish the tasks in the experiment, participants in G2 ($\mu=15.17$, $\sigma=1.92$) and G3 ($\mu=12.76$, $\sigma=2.18$) switched fewer times between tasks than those in G1 ($\mu=17.86$, $\sigma=2.39$), ($p_{21}<.01$, $p_{31}<.01$, $p_{23}<.01$). Once again, participants with MT support in G3 performed better.

Moreover, we found that MB users in G2 ($\mu=66\%$, $\sigma=8\%$) and G3 ($\mu=69\%$, $\sigma<6\%$) revisited most of the web pages they had used in the first session, whereas only 43% ($\sigma=9\%$) of the web pages visited in the first session were revisited by participants in G1 ($p_{21}<.02$, $p_{31}<.01$).

Finally, the MB improved the user's performance on resuming tasks across Web sessions. In session 2 of our experiment, all participants in G2 and G3 successfully resumed all their tasks left unfinished in session 1. But only 4 participants (25%) in G1 could achieve this without experimenter's help. Other participants in G1 failed to resume their tasks for various reasons. 6 of them (38%) could not remember how many tasks there were in the experiment, while 4 (25%) forgot at least one of their unfinished tasks. It is astonishing to note that 2 in G1 (13%) even forget that they had finished Task 2 in the first session and tried to do it again in session 2.

User Experience

Participants reported favorably about their experience using the MB; they felt that it was easy to multitask on the Web

Question	G1	G2	G3	G1: G2	G1:G3	G2:G3
Easy to work on multiple tasks simultaneously.	2	2.5	4	$z=2.11, p<.04$	$z=4.82, p<.01$	$z=4.41, p<.01$
Easy to remember tasks unfinished in session 1. ²	1.5	4	4.5	$z=4.82, p<.01$	$z=4.78, p<.01$	$z=2.75, p<.01$
Easy to re-find information used in session 1. ²	2	4	4.5	$z=4.78, p<.01$	$z=4.82, p<.01$	$z=2.58, p<.01$
Easy to remember the end date and progress of each of unfinished tasks. ²	1	4	4	$z=4.82, p<.01$	$z=4.81, p<.01$	$z=0.53, p>.05$

Table 2. Experimental group's median Likert-scale ratings of MB tools in two sessions (questions for all groups, ² Session 2 only).

Question	G2	G3
MB is useful, and I want to install it in my browser.	$z=1.80, p>.07$	
	4.5	5
Easy to learn how to use MB.	5	5
Easy to remember usage of MB.	$z=1.70, p>.08$	
	4.5	4.5
MB was confusing to me.	1	1
MB helped me work on multiple tasks simultaneously.	$z=4.56, p<.01$	
	2.5	4.5
Easy to create a task.	$z=.44, p>.7$	
	4	4
Difficult to remember how to create a new task.	$z=.43, p>.60$	
	3.5	3.5
MB took up too much space in browser.	$z=.15, p>.80$	
	3.5	3.5
Multiple task tab feature helpful.	n/a	4.5
Hibernate/Resume helpful.	5	5
Automatic naming task helpful.	5	5
MB helped me remember what I did last week. ²	5	5
MB was useful for my tasks. ¹	3	3.5
	$z=4.67, p<.01$	$z=4.67, p<.01$
MB was useful for my tasks. ²	5	5
Schedule management helpful. ¹	3	3
	$z=4.06, p<.01$	$z=4.48, p<.01$
Schedule management helpful. ²	4	4.5

Table 3. Experimental groups median Likert-scale ratings of MB tools in two sessions.* (¹ Session 1, ² Session 2)

* When there was no significant difference between data from sessions 1 and 2, we used the two data sets as one sample and between groups U-test results were presented, otherwise we additionally presented Wilcoxon Test results between sessions.

with the MB's help. Table 3 shows the participants' Likert-scale rating for the usability of the MB and their user experience when multitasking on the Web after both the first and second sessions.

A participant in G3 said in her questionnaire that the MB released her from the cognitive burden of remembering the status and resources of tasks both within and across Web sessions and made working on multiple tasks pleasant and efficient. An interesting observation is that, although participants using the MB rated it as only moderately useful during the first session, when they were able to use the MB to resume their tasks, the usability rating increased greatly for the second session. Likewise, MB users with MT support agreed significantly more with the statement that the MB is helpful when working on multiple tasks simultaneously.

The usability rating for schedule management of the MB increased dramatically after session 2. A conversation between a participant in G2 and an experimenter during session 2 explains this change. She said, "I admit that I downgraded the schedule management feature of MB in Session 1. You know, although technically saying the end date and active time is critical when having several tasks, nobody really realizes it and bothers themselves to track these data until these data are required."

The MB helped participants track the time consumed on each task. When we asked participants to report their task status at the beginning of session 2, almost all participants in G2 (14, 88%) and G3 (15, 94%) accurately reported the name, current status (completed or not), and end date required by manager, but none of participants in G1 could do this. Moreover, when estimating the total time needed for all tasks, MB users in G2 ($\mu=17.42, \sigma=4.91$) and G3 ($\mu=18.20, \sigma=5.55$) deviated significantly less than the other group, G1 ($\mu=23.15, \sigma=7.79$), ($p_{21}<.02, p_{31}<.04, p_{23}>.06$) and thus they could make more accurate plans than the others.

Unlike what Morris et al. found in a user study on the SearchBar [34], we found that participants agreed moderately with the statement that the MB took too much space in the browser. The reason for this difference might be due to the fact that the SearchBar was shown in a left pane of the browser which consumes horizontal screen real estate, while the MB was shown in a toolbar of the browser which consumes more precious vertical screen real estate.

DISCUSSION

The results presented in the previous section confirm that the participants found the MB is easy to use. It introduces the task concept into a browser thereby improving a user's experience with multitasking. Users thought that the MB was easy to learn and to use, and they also thought that it decreased their cognitive burden and improved their performance when multitasking on the Web. Data collected in the experiment support this view. MB users opened fewer Web pages, performed fewer navigation actions, and made little use of traditional history tools, yet re-found required Web pages more easily. At the same time, they used less time to accomplish tasks, and were better aware of and had better control over their tasks. Moreover, they were able to switch between tasks and resume interrupted or suspended tasks more quickly. In addition, they could remember the deadline and current status of their tasks and were aware of the time consumed on these tasks with little effort.

We also observed that the user performance improvement brought by MT is as much as by MST. Users with MT support always showed better performance and experience in almost all kinds of data we collected, especially when multiple tasks were running simultaneously. It might be a little surprising that in our experiment the overall improvement in task time consumed brought about by MT is close to that brought about by MST. We could not compare MB against other prototypes in previous studies owing to their unavailability, but according to our comparison, users with support for both MT and MST showed significantly better performance and experience in tasking switching, tab using, navigating, and revisiting than users with support for only MST.

One of the main unexplored questions here is that of users' browsing pattern shifts when introducing the task concept into a browser. As observed in this experiment, the introduction greatly impacted users' usage of browsers. It is obvious that users will gradually cope with this impact and alter their browsing behavior in many aspects, such as their refinding and revisitation strategy, searching strategy, and even collaborative strategy. These pattern shifts are more likely to occur in long-term, real-world use than in the lab. Therefore, a long-term study is required to ascertain how users will eventually adapt to the task concept in browsers through exploring and trying out the new features, and finally integrating them with their own browser habits.

We also acknowledge the limitations of this study. Firstly, we used a selected sample population consisting mainly of university students with specific characteristics (using Firefox, having multitasking experience on the Web). This means that we cannot expect that our results will generalize to a more general population. Instead, the results of this study have provided insight into how the introduction of the task concept into browsers impacts skilled Firefox users' performance and experience when multitasking on the Web. Although it is very likely that these results also apply to skilled users of other browsers, further studies are needed. Secondly, although we decided to introduce the task concept into a browser with 4 attributes based on our survey results, there are possibly other attributes that can bring great benefit to users, the importance of which users cannot appreciate before actually experiencing them. We intend pursuing a study in this direction to compare different impact factors for all attributes of a task. Finally, although we have tried our best to simulate an ordinary multitasking scenario in our experiment, the "Hawthorne Effect" [35] may still exist, and a long-term study is needed to verify our results.

CONCLUSIONS AND FUTURE WORK

We have clarified two common patterns in multitasking on the Web, namely Multiple Tasks and Multiple Session Task. We found that unlike MST, MT has often been ignored in previous studies and implementations. Nevertheless we found that supporting MT in a browser is as effective as supporting MST for improving a user's performance and experience when multitasking on the Web.

We have presented results from a pilot survey of users' expectations of tasks in browsers and their task-related browsing habits. These show that the four attributes of a task, namely name, status, end date, and active time, are most significant to users when coping with tasks in a browser.

We have presented the Multitasking Bar, a novel tool to help users multitask on the Web. With its help, users can define task(s) and manage related Web pages, and also switch between, suspend and resume task(s) as required. It also helps users in schedule management and releases their cognitive burden by informing them of deadlines and time consumed on task(s) when needed.

We have presented a user study on the impact of introducing the task concept into a browser on users' performance and experience when multitasking on the Web. This evaluation is based on the MB. We found that with the MB's help, the performance and experience of users improved dramatically. The results provide answers to the two research questions posed in the introduction. Introducing the task concept into a browser definitely improves a user's performance and experience when multitasking on the Web. Therefore, it is worthwhile considering when designing and implementing browsers and tools.

Future work includes extending this study to ascertain the impact of introducing tasks into browsers for users who do not use tabs, which was neglected in this work, and a broader deployment of the MB to explore its impact over longer periods of time and within a larger user population. Future development of the MB will focus on a better visualization method, a more sophisticated task grouping algorithm, and tighter and more seamless integration with history and bookmark utilities of the browser.

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