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## Abstract

World Wide Web navigation is a recurrent task where more than half of the pages accessed are revisits, so effective use of navigation histories can be powerful tools for navigation support. However, the history mechanisms that are available through current commercial Web browsers have not fulfilled their potential for user support. In particular, contemporary browsers lack proper integration between short term (within a navigation session) and long term (between navigation sessions) support. We have developed a Memory Extender Mechanism for Online Searching (MEMOS) tool to provide both intra- and inter-sessional support. Users can utilize the intra-sessional history tool to navigate among pages within a particular session, or save all or part of a navigation session for future inter-sessional use. Empirical studies have shown that the intra-sessional MEMOS tool was perceived to be more useful than popular browser history mechanisms, but its benefit was most obvious for inter-sessional support. Using sessions previously saved through the MEMOS tool to tackle search questions was significantly faster and more accurate than trying to use standard re-discovery methods.

## 1. Introduction

With most information retrieval systems, after any given search the documents can be classified in four categories: a) retrieved and relevant (useful); b) retrieved and not relevant (useless); c) not retrieved and relevant; and d) not retrieved and not relevant. Literature on information retrieval has long recognized that as systems become larger and the breadths of many index terms becomes excessive, the inquirer finds it increasingly difficult to retrieve relevant documents (Blair 1990). This problem is further magnified in large hypertext or hypermedia information structures, such as the World Wide Web. The network representation of these environments can be much more complex than linear or hierarchical representations. Without a doubt, the World Wide Web is the largest, most complex, most rapidly expanding and most commonly used hypermedia system.

The World Wide Web has the ability to present vast amounts of diverse, complex, multimedia information that is richly interconnected and cross-referenced through hypermedia links. Unfortunately, when navigating through such large hypermedia structures, users may encounter several problems. It is easy to become entangled in a large and complex web of decentralized, unstructured, and potentially unreliable information. Web users can become disoriented when overloaded with massive amounts of information, much of which may be irrelevant. This disorientation, or tendency to lose one's sense of location and direction, is often a consequence of searching through large nonlinear documents (hypermedia). In addition, there is no effective screening mechanism, such as peer review, to guarantee the accuracy and quality of Web information. Peer reviews and other measures of value and "correctness" gained from traditional media are difficult to apply to a medium that is highly dynamic and, by its nature, always incomplete.

Searching for relevant information by using exact key words or phrases through Web search engines is difficult since people tend to use a tremendous variety of words to express the same concept, and the same word can be used in an unpredictable variety of contexts. In addition, only a small fraction of the results from a search engine query may be relevant to the user's purposes, and the most valuable information may not even be accessed by the user due to the large number of

pages retrieved in a search. While more general browsing strategies may have the advantage of potentially finding information which might not otherwise be found through specific searching, these strategies can result in the "art museum problem" (Foss 1989), where the user may spend a great deal of time in unrelated browsing while learning very little. Clearly, users of such systems require excellent support from navigation tools to search these large information spaces efficiently and effectively.

Nielsen (1990b) suggests that interaction histories can be used to help users understand and recognize their present location within complex hypermedia structures. Tauscher (1996) agrees that improved history mechanisms can help to minimize Web navigation problems by : a) making it easier to locate information, b) reducing the number of pages being visited overall, c) informing users where they have been and where they are, and d) improving total response time by allowing the user to jump directly to a desired page. Since more than half of all accessed pages are re-visits (Tauscher 1996), history mechanisms can be powerful navigation aids in the Web environment.

## 2. Web History Tools

Most Web browsers incorporate some history support within navigation sessions (intra-sessional) and between navigation sessions (inter-sessional). Existing Web browser history mechanisms and a new tool we developed to provide both intra- and inter-sessional support are presented below.

### 2.1 Intra-Sessional History Mechanisms

Traditional intra-sessional history mechanisms include Backtracking and History Lists. A backtrack is a simple concept where a user clicks on a button and returns to the previous page. Nielsen (1990a) points out that a problem arises when the user backtracks more than once and when the user visits certain pages more than once. Current Web browsers interpret a user's history of accessed URLs (page addresses) as a push-down stack. Therefore, the history stack is not a true trace of the user's navigation pattern. Depending on how pages are accessed, stacks may lose important information or contain unnecessary duplication. Users may be surprised when pages

stored in the history list do not follow their conceptual navigation model, which is a representation of which pages the user has visited and their order of access. A user's conceptual navigation model is important in providing predictive power to help reduce disorientation in complex information structures.

Until recently, most history lists provided by Web browsers were strictly for intra-sessional support. However, Microsoft Internet Explorer 4.0 and Netscape 4.0 have incorporated an inter-sessional dimension to their history lists. Explorer 4.0 organizes user histories in folders for previous days and weeks, but does not allow rearrangement or regrouping of sites. Netscape 4.0's History Window lists the Web pages visited during the last specified number of days. Users may view, sort, and search the list by title, location (URL), first visited, last visited, expiration, and visit count fields. However, like Internet Explorer, users may not edit or modify any of the information, and sites cannot be rearranged or grouped into meaningful topics. Although these mechanisms attempt to provide some inter-sessional support, the lists can quickly become very long and unmanageable. List length can be kept under control by decreasing the browser's history expiration option, but this is no help for users who find themselves searching for information that was accessed weeks before, not days before. In addition, these mechanisms do not properly differentiate between different users. One computer and browser may be shared by many users, such as a typical household. History lists tend to keep track of all pages visited by the browser, and the lists can quickly become very long and complicated due to excessive irrelevant site visits for any particular user.

Intra-sessional overview diagrams have also been presented as possible browser extensions (Navigation View Builder : Mukherjea 1995; WebMap : Dömel 1994; MosaicG: Ayers and Stasko 1995). Overview diagrams are an effective means of conveying information about the structure of the information space. Although overview diagrams can serve as excellent navigation aids, for large systems they become complex and introduce navigation problems of their own (Nielsen 1990a). Within the context of the Web, Smith and Wilson (1993) identify some problems with graphical browsing: large number of nodes; large number of links; frequent changes to the network;

insufficient visual differentiation among nodes and/or links; and users who are not visually oriented. With limited screen space, graphical navigation tools can only show a very small portion of the hyperspace structure at one time. Nielsen (1990a) refers to this inability to view large amounts of information at any one time due to the small size of computer displays as a context-in-the-small problem. Readability becomes a central concern, and creating an aesthetic layout of a complex structure is extremely difficult. Therefore, the vast and unstructured nature of the Web makes it very difficult to effectively implement overview diagrams.

### 2.2 Inter-Sessional History Mechanisms

Inter-sessional mechanisms used by most Web browsers include already-visited cues and bookmarking. Already-visited cues are only helpful when the relevant page containing these cues is re-accessed. Bookmarks differ from history lists in that the user must explicitly specify that a page address is to be bookmarked when it is the current document displayed within the browser, whereas history lists are updated automatically. Although bookmarking can be a very useful tool, people may not recognize the relevance or importance of a particular site until later, when its connection with something of interest suddenly becomes apparent (Nielsen 1990a). At this point the relevant URL address may already be lost from the history stack.

Bookmarking lists tend to be smaller and more manageable than inter-sessional history lists. However, users tend to add large numbers of URLs in their bookmark lists due to the difficulty of finding locations on the Web (Nielsen 1990a). Most browsers also offer hierarchical organization options with their bookmarks, which enables users to browse through their personal site repositories more easily. However, as the number of bookmarks increases, this manual URL classification and organization can become difficult and tedious to maintain. Users may need to classify a large set of URLs at once when merging bookmark hierarchies, consolidating search engine results, or simply integrating URLs that have not been classified at bookmark creation. Classifying bookmarks at this time may prove to be difficult due to list length, duplication, and uninformative page titles.

## 2.3 MEMOS: An Intra- and Inter-Sessional Tool

Tauscher (1996) presents some design guidelines for Web browser history lists derived from Greenberg's (1993) fundamental design requirements for reuse facilities. Based on these guidelines, we developed a history tool called the Memory Extender Mechanism for Online Searching (MEMOS) for Netscape Navigator 3.0, using a combination of JavaScript (Netscape Communications 1997) and Java (Sun Microsystems Inc 1997). The MEMOS tool is able to show much more information than the corresponding browser history lists. MEMOS maintains a recency history list, showing the most recently accessed sites at the top of the list, and a frequency history list, showing the most frequently accessed sites at the top of the list. MEMOS provides memory support within a session and between sessions by providing both intra and inter-sessional navigation information. Users can utilize the intra-sessional history tool to navigate among pages within a particular session, or save and edit all or part of a navigation session for future inter-sessional use. Interdisciplinary links between the user computer interface and information access domains were considered during the design of the MEMOS tool. For example information access moderators, such as human memory properties, restrict how much information can be absorbed at one time, and ability to recall previously viewed information. MEMOS was designed to minimize the negative consequences of information overload, and encourage retrieval through recognition rather than the more cognitively demanding free or cued recall task. Some of the main features of the MEMOS tool are outlined below, followed by a snapshot of MEMOS during a navigation session in Figure 1. These features are organized by Tauscher's (1996) guidelines, which are paraphrased in bold.

**MEMOS maintains a record of URLs visited, and allows users to use recognition to recall previous URLs from this record**. Since the majority of Web page accesses are revisits, the primary requirement of any history list tool is to allow the user to view and select items from their list. MEMOS history items appear in descending order of recency since users have a natural tendency to scan lists from the top down.

**It is more efficient and less demanding, in terms of physical and cognitive activity, for users to recall URLs from MEMOS than to navigate to them via other methods.** If a history

tool makes it more difficult to revisit pages than other navigation mechanisms, it will not be used. Physical activity may include clicking a hyperlink or button, opening a menu, selecting a menu item, or issuing a keyboard command. Cognitive activity may include recalling a URL, scanning a history list to recognize a page title, retracing one's steps to a previous URL, or recalling how to navigate to a particular page from the current one. The MEMOS window occupies approximately half the screen, thereby allowing the user to view page changes in the main Netscape window. The user can therefore employ a "trial-and-error" approach if he/she is unsure of the desired page's title or URL by clicking on sample entries in the MEMOS list. This reduces the cognitive burdens of recall and recognition.

**Pruning duplicates increases the probability that MEMOS will contain the required URL.** Lists may double or triple in size without increasing coverage if duplicates are included. Although by pruning duplicates MEMOS does not preserve true temporal order, this does not increase the difficulty of locating an item on the list.

**Alternative strategies are supported by MEMOS.** Current Web browsers employ a stacking algorithm to collect history information. A recency ordered list with no duplicates will fare better since it does not lose information as the stacking-based approach does, and it more closely resembles the user's navigation mental model. When pruning duplicates in a recency ordered list, the URLs may be saved in the original position of the history list or in its last position. The "last position" approach performs better, since just revisited URLs will stay at the top of the list and local context is maintained. MEMOS saves URLs in their last positions.

History lists may also be frequency ordered, where the most revisited page appears at the top of the list and the least visited at the bottom. Frequency ordering is not a good representation of the user's navigation mental model, but it enables easy access to popular sites. Since users may have preferences for different history representations, and preferences may change over time, MEMOS supports these alternative methods. Access counts are given in brackets beside each entry in the frequency list. The user may jump to any item in either the recency or frequency list (only one item

from either list can be selected at one time).

**History items have a meaningful representation.** Title tags of pages may be absent or nondescriptive (e.g. "Introduction", "Table of Contents"). In these cases, URLs may convey more information. MEMOS allows the user to choose to view either of these page descriptors.

**MEMOS allows end-user customization of history data.** Users may change page title descriptions within the history list to give them personalized meaning by clicking on the "Edit" button. A change in one list (recency or frequency) will automatically be reflected in the corresponding site in the other list.

**Saving and clearing of history data.** Recency and frequency lists may be cleared at any time by selecting the "Clear" button. This is useful when users change or modify searching topics. An inter-sessional dimension is added to MEMOS that allows the user to save a navigation session by clicking the "Save" button. The user enters a session name under which the session will be saved and may also include a session description or comments. Unwanted Web subspaces may be removed from the list, and pages may be organized into a three level user-defined hierarchy. Once saved, the session is added to the user's session file for future navigation support. Each user has his/her unique session file, so irrelevant information from multiple computer users is not shown. A sample session file is shown in Figure 2. This interface follows the familiar Windows "File Manager" format with folders and indentation indicating a grouping of lower level sites or hierarchies. Hierarchical abstraction used in this history tool extends previous research by Archer et al. (1996).

**<INSERT FIGURE 1 ABOUT HERE>**

**Figure 1 : MEMOS Intra-Sessional History Tool**

**<INSERT FIGURE 2 ABOUT HERE>**

**Figure 2 : MEMOS Saved Session File**

## 3. Experimental Studies

### *3.1 Hypotheses*

The objective of our experiments was to test the intra- and inter-sessional efficiency and perceived effectiveness of the MEMOS tool against standard Netscape 3.0 history mechanisms under various user strategies (browsing, searching, and searching with a time constraint). The following hypotheses were tested. Hypotheses 1-4 relate to the intra-sessional measures, hypotheses 5-7 relate to inter-sessional measures, and hypotheses 8 and 9 were used to evaluate the hierarchical organization of navigation data for future use.

*Hypothesis 1 (Intra-sessional Efficiency).* The use of the intra-sessional MEMOS tool will lead to more efficient searching.

*Hypothesis 2 (Intra-sessional Perceived Ease of Use).* The intra-sessional MEMOS tool will be perceived as being an easier to use navigation aid than the corresponding Netscape 3.0 history mechanisms (Go List, History Window).

*Hypothesis 3 (Intra-sessional Perceived Usefulness).* The intra-sessional MEMOS tool will be perceived as being a more useful navigation aid than the corresponding Netscape 3.0 history mechanisms (Go List, History Window).

*Hypothesis 4 (Intra-sessional User Strategies).* The intra-sessional MEMOS tool will be used more often in user browsing strategies than in user searching strategies.

*Hypothesis 5 (Inter-sessional Efficiency).* The use of the inter-sessional MEMOS tool will lead to more efficient searching strategies.

*Hypothesis 6 (Inter-sessional Perceived Ease of Use).* The inter-sessional MEMOS tool will be perceived as being an easier to use navigation aid than the corresponding Netscape 3.0 history mechanism (Bookmarking).

*Hypothesis 7 (Inter-sessional Perceived Usefulness).* The inter-sessional MEMOS tool will be perceived as being a more useful navigation aid than the corresponding Netscape 3.0 history mechanism (Bookmarking).

*Hypothesis 8 (Hierarchical Organization Perceived Ease of Use).* The ability to organize a saved session in a user-defined hierarchy will be perceived as being easy to use.

*Hypothesis 9 (Hierarchical Organization Perceived Usefulness)*. The ability to organize a saved session in a user-defined hierarchy will be perceived as being useful.

Hypotheses 1, 2, 3, and 4 focussed on the short-term intra-sessional use of the MEMOS tool. It was expected that the MEMOS tool would perform better than the standard Netscape 3.0 history mechanisms for both efficiency (navigation time, number of pages visited) and perceived effectiveness (divided into two hypotheses for perceived ease of use and perceived usefulness). The results of an initial pilot study supported Hypothesis 2 and 3 since MEMOS was ranked as being the best tool in the majority of effectiveness measures. This pilot study also supported Hypotheses 4 since the use of the MEMOS tool was more evident in the browsing sessions than either of the searching with or without time constraint sessions.

Hypotheses 5, 6 and 7 focussed on the long-term inter-sessional use of the MEMOS tool. It was expected that the efficiency (searching time, number of pages visited) of search strategies would improve when users utilized their previously saved sessions. It was also expected that the MEMOS tool would be perceived as being more effective (divided into two hypotheses for perceived ease of use and perceived usefulness) than Netscape's bookmarking mechanism. The results of our initial pilot study supported both these hypotheses.

Hypothesis 8 and 9 were based on past information abstraction research. Abstraction is a powerful tool for managing complexity where a hierarchical organization is used to classify different chunks of information according to their similarities or successive detail (Ossher, 1987). The potential to reduce complexity with hierarchical organization is particularly evident when data are largely qualitative (Archer et al. 1996). User comments made during our pilot study on the effectiveness of user-defined hierarchies were positive and encouraging.

### *3.2 Experimental Tasks*

Subjects performed various browsing and searching tasks during two experimental sessions, spaced approximately one week apart. During this study, searching was defined as a closed task

with a specific objective, whereas browsing was an open task with a general objective, considered more exploratory, vague, and non-specific than searching. We followed the general purpose, goal-directed browsing classification outlined by Cove and Walsh (1988) and Salomon (1990), where a general goal governs the consulting of sources, and users can reformulate goals in the course of browsing. During searching tasks, subjects were asked to find answers to very specific questions, where a time constraint of 5 minutes was imposed on half of the search questions. During browsing tasks, subjects were given a general topic to explore, without any time constraint.

During this experiment, information resources for browsing and searching tasks were limited to Web pages. Web pages on two general topics (health/fitness and British Columbia travel) were downloaded to a local server. Local storage of pages dramatically reduced Web page retrieval times, thereby allowing this variable to be controlled with minimal variance. The AltaVista Personal® search engine (Digital Equipment Corp. 1997) was installed on the local server to allow keyword searching within the specified set of pages. This search engine's appearance and behaviour was identical to its popular Web counterpart, AltaVista Search® (http://altavista.digital.com), and a sufficient number of pages (approximately 6,000) were downloaded to give the experimental setting a real "online feel".

### *3.3 Experimental Design*

During the first session of our experiments, a three-by-two unbalanced analysis of variance design with repeated measures was used. The two factors were: user strategy (browsing, searching, and searching with time constraint levels) and MEMOS availability (navigation with MEMOS and navigation without MEMOS levels). The standard Netscape 3.0 history mechanisms were available to the user regardless of MEMOS availability. All subjects were asked to perform a browsing session with MEMOS and a browsing session without MEMOS. After each browsing session, a search question was asked which used the same factor level for Factor B (with MEMOS or without MEMOS) but different topic (health/fitness or British Columbia travel) than the previous browsing task. Half of the subjects searched without a time constraint while MEMOS was available, and with a time constraint while MEMOS was not available. The second half of the subjects searched with

a time constraint while MEMOS was available, and without a time constraint while MEMOS was not available. Since subjects were not performing all three user strategy tasks for both levels of the MEMOS availability factor, this was an unbalanced design. This design was chosen to keep the experimental sessions within an average of one hour per subject.

Subjects were asked to return a week later to perform four specific searching tasks. A one-factor balanced analysis of variance design with repeated measures was adopted for this part of the experiment, where the applicability of MEMOS was the factor. Two search questions were based on previously saved MEMOS sessions, and were not immediately obvious or directly attainable from the pages that were saved during the first session. The subjects were required to search approximately two levels deep from a specified saved page (URL link) in order to obtain the answer. This means that approximately two hyperlinks had to be selected from a saved page to reach the desired pages. Search questions that were not based on previously saved MEMOS sessions were based on pages that the subject viewed during a previous browsing or searching session but had not saved with the MEMOS tool. These questions were tested independently to ensure no bias towards or against the use of the MEMOS tool.

### *3.4 Subjects*

During the full study, a total of 24 subjects performed appropriate browsing and searching tasks during their first and second sessions. Subjects were business students from undergraduate and graduate programs. Participation in the experiments was voluntary, and subjects were paid a flat $10 for their time and effort. Subjects estimated that their average level of Web experience was 5.8 on a 7-point scale. Twenty-five percent had used the Web for less than a few months, and 54% had more than one year of Web experience. Two general topics were used throughout the experiments: health/fitness and British Columbia. Subjects estimated that their average level of familiarity (prior to their first session) was 4.5 for health/fitness, and 3.0 for British Columbia, on a 7-point scale (where 1 is not at all familiar and 7 is very familiar with the topic).

During the first session, a brief (approximately 5-10 minutes) Web-based tutorial was provided to familiarize the subjects with traditional Netscape 3.0 history mechanisms as well as the new MEMOS tool. This tutorial was followed by a 10 minute demonstration of these mechanisms. Subjects performed a quick navigation session were they tried each of the history mechanisms under the guidance of the experimenter. Features of each tool were reiterated by the experimenter during this demonstration.

**4. Data Analysis**

Hypotheses 1, 4, and 5 were tested by analyzing data collected during the sessions. Recommended techniques for analyzing unbalanced designs (Appelbaum and Cramer 1974), using a regression approach to ANOVA (Neter et al 1985) were followed where applicable in the analysis of these hypotheses. Hypotheses 1 and 7 evaluated the efficiency of the MEMOS tool (for intra- and inter-sessional support), and hypothesis 4 examined intra-sessional user strategies.

Hypotheses 2, 3, 6, 7, 8, and 9 were tested by analyzing data collected from questionnaires (questionnaire questions are summarized in Table 2). Questionnaires were carefully constructed using measures for perceived ease of use and usefulness, which research has shown to be robust and to exhibit internal consistency, replication reliability, and test-retest reliability (Davis 1989; Adams et al. 1992; Hendrickson et al. 1993; Subramanian 1995). For the perceived ease of use and perceived usefulness constructs used in this study, the Cronbach alphas were .804 and .829 respectively. This reliability defends the use of these literature-supported constructs. Hypotheses 2, 3, 6, and 7 examined the perceived ease of use and usefulness for the MEMOS tool (for intra- and inter-sessional support) compared to corresponding Netscape 3.0 history mechanisms. For these hypotheses, each question was tested using the Wilcoxon Matched-Pairs Signed Rank test. Hypotheses 8 and 9 evaluated the hierarchical option of the MEMOS tool, where questionnaire questions were tested using the one-sample one-tailed Wilcoxon test. A summary table of hypothesis results is shown in Table 1.

**<INSERT TABLE 1 ABOUT HERE>**

**Table 1 : Hypotheses Summary Results**

*MEMOS Efficiency (Hypotheses 1, 5)*

In terms of efficiency, we hypothesized that the MEMOS tool would lead to more efficient searching for both the intra- and inter-sessional navigation scenarios. Our findings indicated that the intra-sessional potential for this tool was not realized due to its relative lack of use. Using MEMOS to navigate within a particular session did not improve searching efficiency (number of pages revisited: $p>0.05$; search time: $p>0.05$). Spearman Rank coefficients showed there was no significant correlation between search time and topic familiarity ($r_s= -0.12$, $p>0.05$), browsing time and topic familiarity ($r_s= 0.12$, $p>0.05$), or previous Web experience and searching time ($r_s= 0.12$, $p>0.05$) or browsing time ($r_s= 0.02$, $p>0.05$).

Analysis of inter-sessional efficiency characterized Session 2 questions by the method used for finding their answers (shown in Figure 3). From the 96 questions asked (24 subjects x 4 questions), 35 were answered using the MEMOS tool when the question was based on previously saved sessions. Thirteen questions that were based on saved session were not answered with the help of MEMOS. From the questions that were not based on MEMOS, three managed to find a correct answer through a previously saved session. These cases were considered chance and unintentional results, and were not included in the analysis. Therefore, search questions were analyzed according to the following three categories :

- Question based on MEMOS, and MEMOS used to find answer (Based/Used)
- Question based on MEMOS, and MEMOS not used to find answer (Based/Not Used)
- Question not based on MEMOS (Not Based)

**<INSERT FIGURE 3 ABOUT HERE>**

**Figure 3: Break-down of Second Session Search Answers**

A one-factor analysis of variance was performed to analyze the time spent for these three search categories. The results where significant ($F=12.89$, $p<.001$). Using the Tukey-Cramer method (Neter et al. 1985), paired comparisons indicated that the differences between the

Based/Used (average time of 2:04 minutes) and Based/Not Used (average time of 5:19 minutes) and between Based/Used and Not Based (average time of 5:03 minutes) was significant. There was no difference in searching time when MEMOS was not used, whether the question was based on a saved session or not. A similar analysis was performed for the total number of pages visited during search tasks. As with search time, these results illustrated a significant difference between the Based/Used and Based/Not Used and between Based/Used and Not Based. Therefore, the use of MEMOS, when answers could be found through a session file, resulted in faster search times with fewer pages visited. Interestingly, effectiveness (ability to find a correct answer) was also found to be significantly improved ($F=31.96$, $p<0.001$) when using a saved session for searching.

***MEMOS Perceived Ease of Use and Usefulness (Hypotheses 2, 3, 6, 7)***

Table 2 shows the inter-sessional and intra-sessional results from the perceived ease of use and usefulness statistical analysis. Three questions from the questionnaire given in the first session were used to examine MEMOS intra-sessional perceived ease of use. Respondents agreed that MEMOS provides more flexibility than the Go List, since it allowed the user to jump back from either a recency or frequency list, and offered additional editing, viewing, and saving options. Comments made by subjects also suggested that finding a desired page though the Go List was more confusing than using the MEMOS tool because of unnecessary duplication and loss of information. However, MEMOS was not shown to be significant on the overall ease of use question when compared to the Go List. Subjects remarked that they often forgot about the MEMOS tool during a navigation session since it was not fully integrated into the Netscape interface. Netscape's history mechanisms were accessed from buttons or menus located at the top of the Netscape window. However, MEMOS was accessed from the bottom of the screen (see Figure 4). Therefore activating the MEMOS window was more inconvenient than clicking on the Go Menu. Table 2 also shows that the MEMOS tool was very significantly preferred (at a 0.001 level) over the browser's History Window in all ease of use aspects. Like the Go List, the History Window did not offer much flexibility, and eliminated some information while duplicating other information. Accessing the History Window was a two-click process (clicking on the Window menu followed by clicking on the History item, as shown in Figure 4), and was more inconvenient than accessing MEMOS by a

single click at the bottom of the screen. It was impossible to integrate MEMOS into the Netscape toolbar since the Netscape 3.0 source code was not available during the development of this tool.

**<INSERT TABLE 2 ABOUT HERE>**

**MEMOS Perceived Ease of Use and Usefulness (H2, H3, H6, H7)**

**<INSERT FIGURE 4 ABOUT HERE>**

**Figure 4: Accessing Intra-Sessional History Mechanisms in the Netscape 3.0 Interface**

Results were also mixed for the intra-sessional MEMOS tool. MEMOS was more flexible ($p<0.001$) and less confusing ($p<0.05$) than Netscape's bookmarking mechanism, but saving session histories was generally more time consuming and required more mental and physical effort than typical bookmark saving. A strict comparison of the effort needed to establish bookmarks in a MEMOS format (all relevant pages bookmarked and organized in a separate hierarchy), would undoubtedly reveal more mental and physical effort for bookmark organization.

Usefulness was shown to be very significant among all intra- and inter-sessional dimensions ($p<0.01$). We could confidently conclude that MEMOS was perceived to be more useful than the corresponding Netscape 3.0 history mechanisms for both intra- and inter-sessional support. At the intra-sessional level, comments made by subjects stressed the advantages of MEMOS recency stacking (eliminated duplications and no loss of information), alternative viewing options (recency and frequency lists), and most importantly, the opportunity to save navigation sessions for future use. At the inter-sessional level, subjects generally agreed that Bookmarks were useful inter-session memory aids for sites that are frequently visited, such as favorite search engine or directory home pages. However, bookmarks failed to give proper support for less popular sites. Subjects agreed that it was virtually impossible to bookmark all potentially relevant pages, since the bookmark list would soon become unmanageable and often the relevance of a site was not evident until later. Bookmarking also allows duplicates, which may lead to confusion when using bookmarks for later retrieval. MEMOS allowed users to save entire navigation sessions under a session name, with user-

defined hierarchies. Subjects remarked that this new method of saving references to Web pages allowed for large numbers of references to be stored without becoming overwhelmed by volume.

***Hierarchical Organization Perceived Ease of Use and Usefulness (Hypotheses 8, 9)***

Table 3 shows that all perceived ease of use and usefulness measures for the hierarchical organizational option of the MEMOS tool were shown to be very significant ($p<0.001$). The creation of a user-defined hierarchy can require some effort and time, however, once a logical hierarchy is set up, it is significantly easier to use, because it breaks lists into manageable chunks.

**<INSERT TABLE 3 ABOUT HERE>**

**Table 3 : Hierarchical Organization Perceived Ease of Use and Usefulness (H8, H9)**

***Intra-Sessional User Strategies (Hypothesis 4)***

Hypothesis 4 examined the use of the MEMOS tool under different user strategies. Results from a one-factor analysis of variance showed a significant difference ($F=4.34$, $p<0.05$) in MEMOS use during browsing and searching tasks. During browsing, when no specific goals were given, subjects tended to delve more deeply into sites through internal link traversal. A typical browsing session would begin with a search engine query with general keywords, from which the search result page was quickly examined. A site located near the top of the search result page would be selected and, given that this page had links to other pages, the subjects would typically spend some time browsing through the site with internal navigation buttons/links. In order to return to a desired previous page, subjects had to click the "Back" button several times or jump directly to the page using a history list mechanism (Go List, History Window, or MEMOS). In most cases, the "Back" button was used instead of the more efficient history lists. When questioned about this behaviour, the common response among subjects who had previous experience with history list mechanisms was that these mechanisms were ignored/forgotten due to poor prior experience with Netscape's Go List and History Window. These subjects had found that it was easier to click the "Back" button several times than to look through a confusing list of duplicates and missing information. Subjects who had not used history list mechanisms previously tended to default to their usual "Back" button

use. They commented that they "simply forgot history lists were there". Therefore backtracking with the "Back" button was the standard means of retrieving a previously accessed page.

Searching tended to be characterized by shorter trails than browsing. When the answer to a given question did not seem immediately obvious within a site, subjects tended to return to the search result page to examine another avenue. A one-factor analysis of variance was performed to analyze the proportion of re-visited pages (number of pages re-visited during a task / total number of pages visited during a task) for the three levels of browsing, searching with a time constraint, and searching without a time constraint. The proportion of re-visited pages was significantly higher ($F=33.15$ $p<0.001$) for the browsing session than either searching sessions. This result supports the observation of longer navigation trails during browsing, therefore requiring more backtracking to return to a desired previous page.

**5. Findings and Conclusions**

In the World Wide Web environment, effective use of navigation histories can be powerful tools for navigation support. Web navigation is a recurrent task where more than half of the pages accessed are revisits (Tauscher 1996), so history information can be a valuable tool to help users navigate the immense and complex Web environment. However, the history mechanisms available in current commercial browsers do not fulfil their potential for user support. In particular, history list mechanisms, such as Netscape's Go List or History Window, have negatively influenced user perceptions of their utility. We have developed an advanced history mechanism, MEMOS, which overcomes many of the shortcomings of corresponding browser tools. The intra-sessional component of the MEMOS tool is more flexible and powerful than corresponding Go Lists or History Windows, and is meant to replace these mechanisms. The intra-sessional component of the MEMOS tool effectively allows the Web user to retrieve previously visited sites. It is meant to complement existing bookmarking tools, which are best suited to access sites that visited very frequently. The implication for the hypertext/hypermedia designer is that attention must not only be paid to supporting the user in finding new information, but also in retrieving previously accessed information. Navigation tools should allow users to quickly and easily locate information accessed

during the current session, as well as information examined in previous sessions.

Previously saved sessions are a small subset of Web pages that can be used for future information access. They are likely to be re-used, since the user has already shown an interest in them. In large information spaces, such as the Web, tools that create smaller, more manageable information subsets, can reduce the negative consequences associated with information overload. Reducing information overload can then result in more efficient (faster) and effective (accurate) information retrieval.

We have found that the application of information abstraction through user-defined hierarchies is a preferred means of saving navigation sessions for future use. In the highly cluttered, confusing, and unstructured environment of large hypermedia systems, such as the Web, designers must try to apply tools such as information abstraction to improve the searching and organization of information. A benefit of hierarchical directories is that they can add structure to a subset of information from an otherwise unstructured environment, through the application of information abstraction. This is becoming increasingly important as the Web and the number of its users continue to grow at a phenomenal rate. Researchers need to investigate other interface mechanism tools that will add structure to the unstructured Web environment and help to decompose its vast information space into manageable and useful sub-spaces.

**Acknowledgement**

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**References**


Adams, D.A., Nelson, R.R., Todd, P.A. (1992). "Perceived Usefulness, Ease of Use, and Usage of Information Technology: A Replication". *MIS Quarterly*, June, 227-247.

Appelbaum, M.I., Cramer, E.M. (1974) "Some Problems in the Nonorthogonal Analysis of Variance". *Psychol. Bull.*, 81, 335-343.

Archer, N.P., Head, M.M., Yuan, Y. (1996). "Patterns in Information Search for Decision Making: The Effects of Information Abstraction". *International Journal of Human Computer Studies*, 45, 599-616.

Ayers, E.Z., Stasko, J.T., (1995). "Using Graphic History in Browsing the World Wide Web". in *Proceedings of the Fourth International World Wide Web Conference*, Boston, MA, <http://www.w3.org/pub/Conferences/WWW4/Papers2/270/>.

Cove, J.F., Walsh, B.C. (1988). "Online Text Retrieval Via Browsing," *Information Processing and Management*, 24 (1), 31-37.

Blair, D.C., (1990). *Language and Representation in Information Retrieval*, Elsevier Science Publishers.

Davis, F.D. (1989). "Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology". *MIS Quarterly*, September, 319-318.

Dömel, P. (1994). "Webmap - A Graphical Hypertext Navigation Tool". in *Proceedings of the Second International WWW Conference*, Chicago, IL, <http://www.ncsa.uiuc.edu/SDG/IT94/Proceedings/Searching/doemel/www-fall94.html>.

Foss, C.L. (1989). "Tools for Reading and Browsing Hypertext". *Information Processing and Management*, 25, 4 (1989), 407-418.

Greenberg, S. (1993). "Supporting Command Reuse: Empirical Foundations and Principles". *International Journal of Man-Machine Studies*, 39, 391-425.

Hendrickson, A.R., Massey, P.D., Cronan, T.P. (1993). "On the Test-Retest Reliability of Perceived Usefulness and Perceived Ease of Use Scales," *MIS Quarterly*, June, 227-230.

Mukherjea, S. (1995). "Visualizing the Information Space of Hypermedia Systems". <http://www.cc.gatech.edu/gvu/people/Phd/sougata/Nvb.html>.

Neter, J., Wasserman, W., Kutner, M.H. (1985). *Applied Linear Statistical Models (2nd ed.)*, Irwin.

Nielsen, J. (1990a). *Multimedia and Hypertext: The Internet and Beyond*, Boston, MA.: AP Professional.

Nielsen, J. (1990b). "The Art of Navigating Through Hypertext". *Communications of the ACM*, 33(3), 296-310.

Ossher, H.L. (1987). "A Mechanism for Specifying the Structure of Large, Layered Systems". in Bruce Shriver & Peter Wegner (Eds.), *Research Directions In Object-Oriented Programming,* Cambridge, MA: MIT Press, 219-252.

Salomon, G. (1990). "Designing Casual-Use Hypertext - The CHI 89 Information Booth". *CHI '90 Proceedings: Computer-Human Interface*, 451.

Smith, P.A., Wilson, J.R. (1993). "Navigation in Hypertext Through Virtual Environments". *Applied Ergonomics*, 24 (4), 271-278.

Subramanian, G.H. (1995). "A Replication of Perceived Usefulness and Perceived Ease of Use Measurement." *Decision Sciences*, 25 (5/6), 863-874.

Tauscher, L.M. (1996). *Evaluating History Mechanisms: An Empirical Study of Reuse Patterns in World Wide Web Navigation*, Masters Thesis, Department of Computer Science, University of Calgary, Alberta, Canada.

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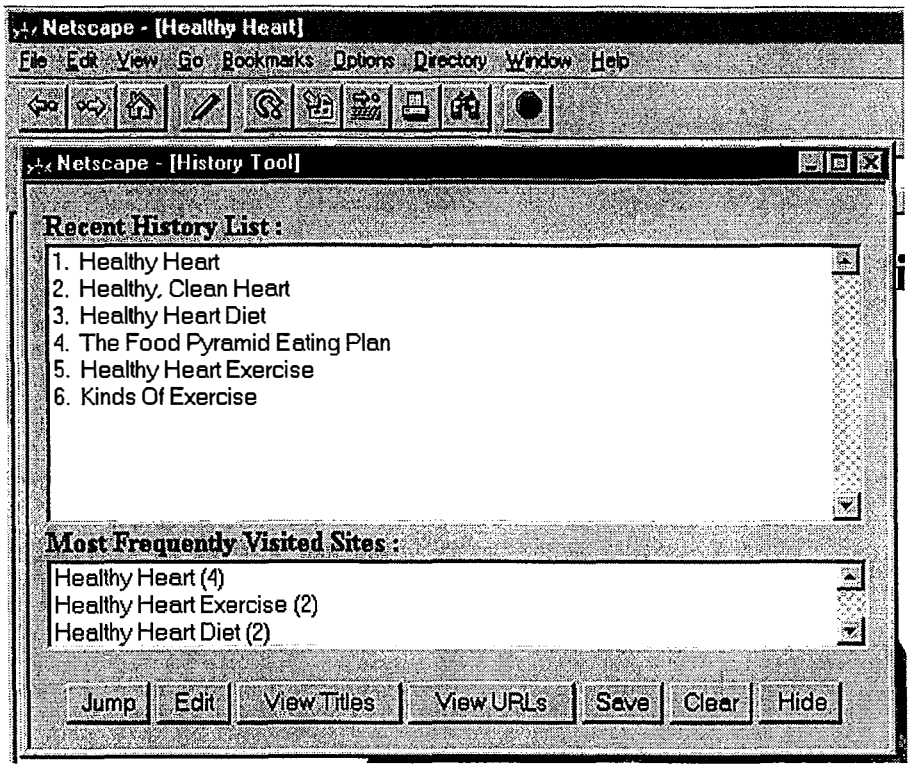


**Figure 1**
**MEMOS Intra-Sessional History Tool**

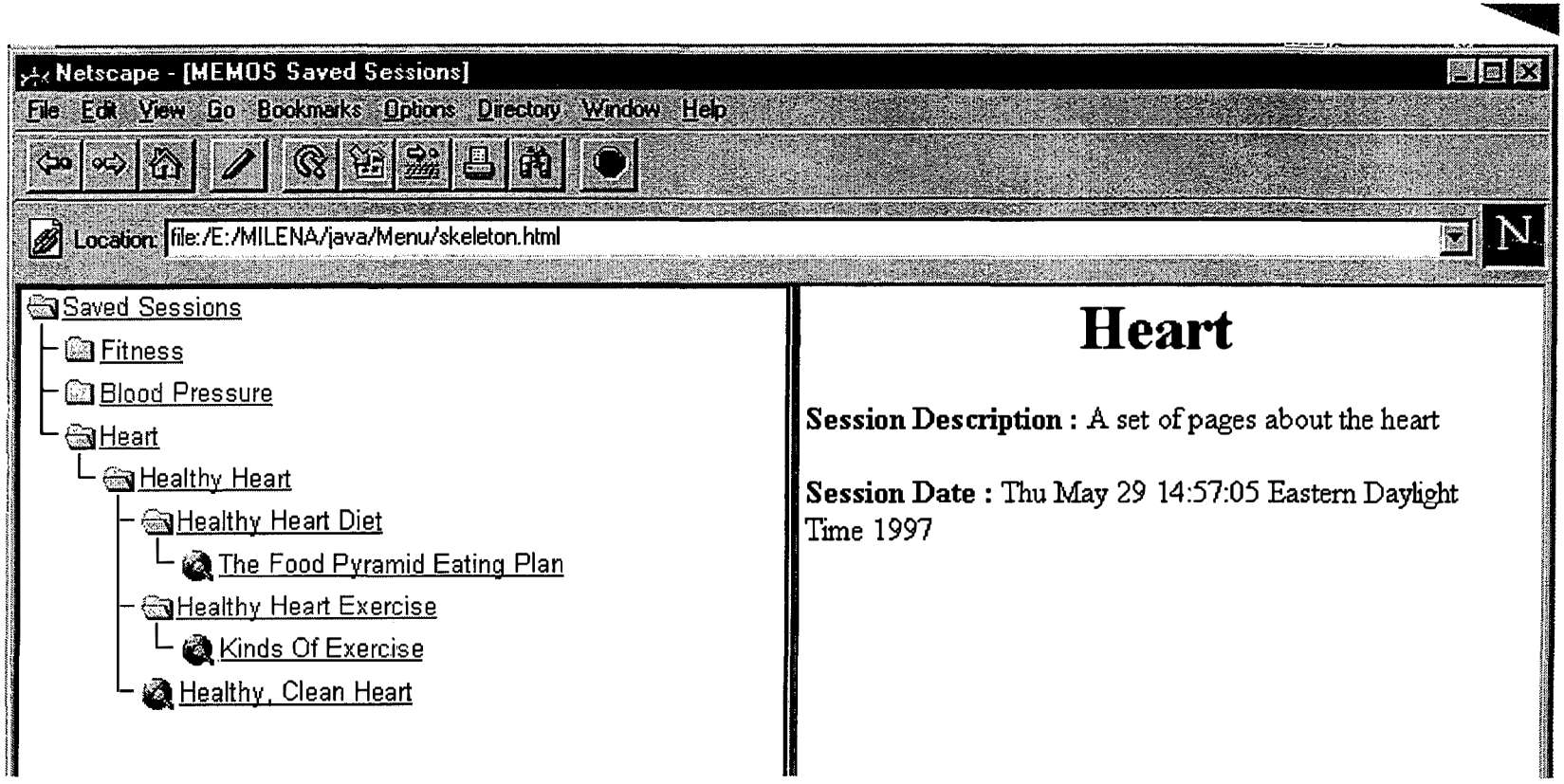


**Figure 2**
**MEMOS saved session file**

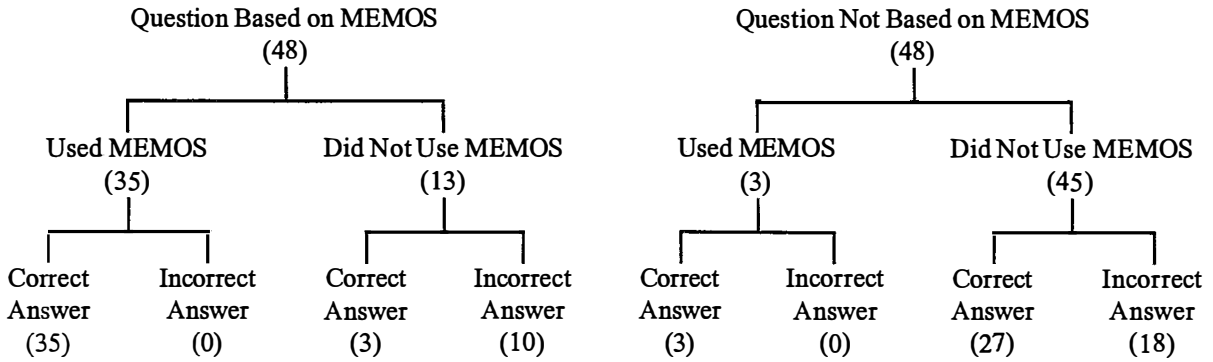


**Figure 3**
**Break-down of Second Session Search Answers**

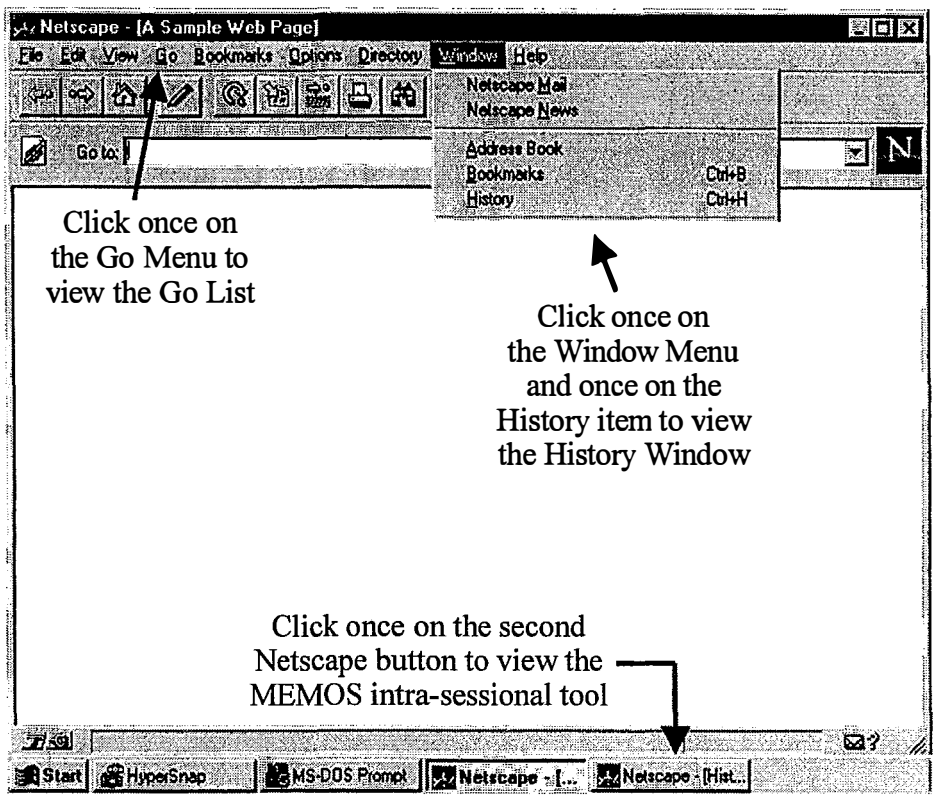


**Figure 4**
**Accessing Intra-Sessional History Mechanisms in the Netscape 3.0 Interface**

**Table 1**
**Hypotheses Summary Results**

| Hypothesis | MEMOS Result |
|---|---|
| H1 : Intra-sessional Efficiency | - no improved searching efficiency compared to standard intra-sessional history mechanisms |
| H2 : Intra-sessional Perceived Ease of Use | - significantly more flexible and less confusing than the Go List, but overall ease of use measure not significant<br>- significantly easier to use than History Window |
| H3 : Intra-sessional Perceived Usefulness | - significantly more useful than the Go List or History Window |
| H4 : Intra-sessional User Strategies | - significant use during searching, not browsing, tasks |
| H5 : Inter-sessional Efficiency | - significant improvement in searching efficiency over standard inter-sessional history mechanisms |
| H6 : Inter-sessional Perceived Ease of Use | - significantly more flexible and less confusing than Bookmarks, but overall ease of use measure not significant |
| H7 : Inter-sessional Perceived Usefulness | - significantly more useful than Bookmarks |
| H8 : Hierarchical Perceived Ease of Use | - hierarchical organization was significantly easy to use |
| H9 : Hierarchical Perceived Usefulness | - hierarchical organization was significantly useful |

**Table 2**
**MEMOS Perceived Ease of Use and Usefulness (H2, H3, H6, H7)**

| Question | Go List vs. MEMOS | | | | History Window vs. MEMOS | | | | Bookmarks vs. MEMOS | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Med. | p | sig. | Pref. | Med. | p | sig. | Pref. | Med. | p | sig. | Pref. |
| **Perceived Ease of Use :** | | | | | | | | | | | | |
| Flexible | 2.5 | .000 | *** | M | 3.5 | .000 | *** | M | 2.5 | .000 | *** | M |
| Confusing | -1.5 | .011 | * | M | -2 | .001 | *** | M | -1.0 | .012 | * | M |
| Easy to Use | 0.5 | .051 | ns | - | 2 | .000 | *** | M | 0.0 | .352 | ns | - |
| **Perceived Usefulness :** | | | | | | | | | | | | |
| Easy to find desired page | 2.0 | .000 | *** | M | 3.0 | .000 | *** | M | 2 | .001 | *** | M |
| Fast at finding desired page | 1.5 | .001 | *** | M | 2.0 | .000 | *** | M | 2 | .001 | *** | M |
| Effective for browsing | 2.5 | .000 | *** | M | 3.5 | .000 | *** | M | 2.5 | .000 | *** | M |
| Effective for searching | 2.5 | .000 | *** | M | 4.0 | .000 | *** | M | 2.5 | .000 | *** | M |
| Useful | 2.0 | .000 | *** | M | 3.5 | .000 | *** | M | 1.5 | .002 | ** | M |

Notes :

a) Wilcoxon Matched-Pairs Signed Rank test used for comparisons

b) Med. = estimated sample median, p=significance level, sig. = ns (not significant), * (.05 level), ** (.01 level), *** (.001 level), Pref. = significant preference over the history mechanism pair tested (M=MEMOS, G=Go List, H=History Window, B=Bookmarks)

**Table 3**
**Hierarchical Organization Perceived Ease of Use and Usefulness (H8, H9)**

| Question | Median | p | sig. |
|---|---|---|---|
| **Perceived Ease of Use:** | | | |
| Confusing | 2.5 | .000 | *** |
| Easy to Use | 5.5 | .000 | *** |
| **Perceived Usefulness:** | | | |
| Easy to find desired page | 6.0 | .000 | *** |
| Fast at finding desired page | 6.0 | .000 | *** |
| Effective | 6.0 | .000 | *** |
| Useful | 6.5 | .000 | *** |

Notes :

a) 1-tailed Wilcoxon Signed Rank test used

b) Median = estimated sample median, p=significance level, sig. = ns (not significant), * (.05 level), ** (.01 level), *** (.001 level)

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