DESIGN AND USE OF BROWSERS

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A human-centered approach for designing World-Wide Web browsers

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Because the World-Wide Web has features that are not found in traditional information systems, it has some unique problems pertaining to human use, such as the difficulty of searching for specific information. This paper describes human cognitive limitations pertinent to the design of Web browsers and provides a conceptual model for human information processing on the Web. It also compares user strategies and use of browser functions for two tasks that differ in the specificity of the information that is to be retrieved. General principles and specific recommendations for the design of Web browsers are derived from these considerations.

The Internet is an interconnected set of computer networks from around the world. By using standard protocols, transmission control protocol and internetwork Protocol (TCP/IP), and hardware connections between networks, the Internet has become a vast computer network consisting of many smaller networks with different types of computer hardware, operating systems, and network topologies. The World-Wide Web (WWW) is an information system on the Internet, started at CERN in 1990 (Berners-Lee, 1990). By combining hypertext with the Internet, the WWW has provided a unique opportunity for the application of hypertext. With the emergence of such successful browsers as Mosaic and Netscape, which possess friendly user interfaces and support multimedia, the WWW has become the most active part of the Internet.

Unique Features of the WWW

As a distributed computer system using client-server structure, the WWW shares features with traditional dis-

tributed information systems, but the WWW has many unique features that cannot be found in the traditional systems. These features fall into the following three categories.

Information sources. A traditional information system is developed with an explicit purpose in mind by only one author or authoring group. In contrast, on the WWW, information comes from a variety of authors who have diverse purposes. This diversity ensures that the method of information retrieval on the WWW cannot be unified, as in the traditional information system.

Database. The WWW is exceedingly large compared with a traditional information system, making an exhaustive search of it impossible (Reaux & Carroll, 1997). A traditional information system is relatively static, except for small changes that are made in maintaining and updating the system. In contrast, the WWW is a dynamic database that grows and changes continually. Whereas a traditional information system is only applicable to restricted domains, the WWW has many domains with no distinct boundaries separating them. Perhaps the most important difference between the WWW and a traditional information system is its nonhierarchical structure. Any attempts to build a hierarchical index system can only give users a way to find a certain domain while losing a lot of relations among objects.

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Users. A traditional information system has a relatively homogeneous and limited user population, and training on the system often is possible. The purpose of using such a system is definite and straightforward. However, the WWW has diverse users with a variety of backgrounds, which makes training difficult. The users have different purposes and need different tools to accomplish their search goals.

WWW Browsers

Because of these unique features of the WWW, the results of research on traditional information systems and small, single-authored hypertext systems cannot be applied to the WWW directly. Consideration must be given to the tasks performed by users of the WWW and to the strategies used to accomplish those tasks. Of greatest concern is the browser, which is software running on the client end of the WWW that is used to locate and retrieve information on the Web.

A browser has two basic functions, one being a navigation tool and the other a document browser. Current browsers already have a lot of other functions, such as Mail and News, and these additional functions will be expanded in the years to come. However, because of the nature of the Internet as an information system, navigation and document browsing will always be the main functions. By providing navigation tools and supporting HTML (hypertext markup language) formatting tags, which then can be used by Web-site designers, the design of the browser can play an important role in improving users' processing of information on the WWW.

Still in its infancy period, WWW browser design has been driven primarily by the improvement of technology and complaints of users. Problems of using browsers have been reported in several surveys (Georgia Tech Research Corporation, 1995; Lightner, Bose, & Salvendy, 1996). These problems are due in part to a lack of concern with human factors, consideration of which should help to improve the design of WWW browsers. In the present article, we describe cognitive limitations and examine browsing strategies. General principles for browser design and specific recommendations are derived from consideration of these human factors.

COGNITIVE LIMITATIONS

The amount of information that humans can process at any given time is limited. This fact can be characterized in terms of limited short-term, or working, memory capacity; limited attention capacity; and decision making based on too much or too little information.

One distinction that is generally accepted in the research on human memory is that between short- and long-term memory (Cowan, 1995; Hitch, 1987; but see Nairne, 1992). Short-term memory has both capacity limits and time limits. The capacity is limited to seven plus or minus two meaningful items (see, e.g., Miller, 1956), and these items will be lost within a time interval of several seconds if rehearsal is prevented (see, e.g., Peterson

& Peterson, 1959). The load placed on short-term memory by a task can be defined roughly as the amount of information that needs to be kept in mind. Although long-term memory is of virtually unlimited capacity, the likelihood of retrieval of pertinent information is dependent on the types of processing performed when the material is initially presented and the retrieval cues that are provided subsequently (Cowan, 1995). Memory limitations are less for experts in a domain than for novices, in part because experts develop efficient encoding and retrieval strategies (Chase & Ericsson, 1982).

Our ability to attend to information in the environment is also limited, and the orientation of attention will determine how well we perceive, remember, and act on that information (Proctor & Van Zandt, 1994). Given the limited attention span, it is important to attract attention to those types of information that are critical in decision making. Among others, the following factors are of consequence. First, a salient physical property will tend to draw attention. For example, a word can be made distinct by being printed in a different color or font from the rest of the words or by use of underline, boldface, or italics. Second, the familiarity or semantic properties of the information can influence the likelihood that attention will be attracted to it. For example, in the case of visual information, a highly familiar face can attract attention, as can the sound of a person's name. Third, in terms of the modalities in which the information is presented, auditory information can usually attract attention better than visual information. Fourth, the human system responds more to changing stimuli than to static stimuli. For instance, blinking letters on a screen full of normal letters, and the appearance of a sound in a silent environment all attract attention because the stimuli involve changes in the background environment.

The quality and quantity of the information provided to the decision maker are crucial to the kind of decision that can be made. If an overwhelmingly large quantity of information is imposed upon the decision maker, less than optimal heuristics are usually used to eliminate certain information quickly to reduce the amount of information to a manageable size. Alternatively, if not enough information is given to the decision maker, then a decision based on incomplete information can also be far from optimal. In such situations, decision makers can use such strategies as trial-and-error or making random decisions.

Cognitive continuum theory (K. R. Hammond, Hamm, Grassia, & Pearson, 1987) distinguishes decisions on a continuum from highly intuitive to highly analytical. K. R. Hammond (1993) summarized 10 task characteristics that can influence decision makers to be more analytical. Several of these characteristics are applicable to the design of WWW browsers: increasing the number of cues, weighting cues unequally in the environmental model, measuring cues objectively instead of subjectively, and having an organizing principle available.

The information flow is very fast on the WWW because of the amount of available information and the speed

of obtaining information. This places heavy demands on the user's short-term memory. Every hypertext link vies for the user's attention, which makes decisions about path selection difficult, especially for time-critical tasks. Many usability problems of current WWW browsers are due to a lack of consideration of the cognitive limitations of short-term memory, attention, and decision making.

BROWSING ON HYPERTEXT SYSTEMS AND THE WWW

Hypertext, on which the WWW is based, offers a novel approach to learning and information retrieval. Many researchers (e.g., Canter, Rivers, & Storrs, 1985; Carmel, Crawford, & Chen, 1992; Cove & Walsh, 1988) have attempted to classify the user strategies on hypertext systems. All classifications distinguish user strategies in terms of several categories, from well-structured search to serendipitous wandering. The central point is that various user strategies are employed for a variety of purposes when users retrieve information from hypertext documents. Regarding the WWW, surveys conducted by the Georgia Tech Research Corporation (1995) show a diverse picture of primary use of browsers: browsing (79.0%), entertainment (63.6%), work (51.8%), shopping (11.1%), and other (10.8%). The overlap of the percentages suggests not only that users may come to the WWW with different purposes but also that they may have more than one purpose in mind. As with browsing of hypertext systems, different strategies are probably adopted to suit the different purposes. A good browser should provide diverse tools to meet all of the users' needs arising from their goals and strategies.

The most popular metaphor in the hypertext system is that of navigation, or travel (N. Hammond & Allison, 1987). Such a spatial metaphor (Kim & Hirtle, 1995) has worked well for the small and well-controlled hypertext system, but it does not work well for a huge and loosely organized hypertext system such as the WWW. Talking about the position of users and the map of the system does not make sense on the WWW. Thus the concepts of selective information processing and decision making seem more important than the navigation metaphor in the design of Web browsers. This means that browsers should provide more tools for supporting users' decision making under high information processing load rather than only indicating users' positions in the system and giving directions to various locations.

Consideration of some of the types of problems encountered in browsing hypertext systems supports this contention. Foss (1989) proposed a classification of browsing problems based on the research on small, closed, hypertext systems. One group, usually called "disorientation" or "lost-in-hypertext" problems, arises from unfamiliarity with the structure and conceptual organization of the document network. These problems are not very common on the WWW, according to user surveys

(Georgia Tech Research Corporation, 1995). That users report few lost-in-hypertext problems is consistent with our contention that the navigation metaphor is not applicable to the WWW. A second group of problems, designated as "embedded digression problems," refers to undesired consequences of pursuing multiple paths and digressions, such as losing one's place, forgetting to return to the main task from a digression, and so on. These problems are caused by the high cognitive demands imposed by hypertext and are closely related to the limitations in attention, short-term memory, and decision making described earlier. A third group, the "art museum problems," refers to a lack of memory for details of any particular part of the information that has been viewed. These problems are a consequence of the limited short-term memory capacity and the considerable attention required to perform the more integrative, elaborative types of processing necessary for long-term retention. The embedded digression and art museum problem types are likely more significant in the WWW than in small, closed hypertext systems because of the volume of information on the WWW and its relative lack of structure.

Various tools were proposed to remedy the hypertext-system problems, and some of them are used in current Web browsers—for example, the Back command, which brings the user back to the previous node, the History list, which shows the path leading to the current node, and Bookmark, with which the user lists the addresses of the nodes that are thought to be important. Because of the differences between the WWW and small, closed, single-authored hypertext systems such as HyperCard, other tools developed for systems of the latter type cannot be applied on the Web. For example, Map, which shows all the nodes that the user visited and the links among them, is inapplicable.

The principles and methods used in the design of small hypertext systems can be converted smoothly to the design of WWW home pages. Several models have been proposed for the design of hypermedia (Isakowitz, Stohr, & Balasubramanian, 1995; Schwabe & Rossi, 1995). Thüning, Mannemann, and Haake (1995) analyzed the cognitive aspects of hypermedia design and provided some design principles based on cognitive issues. But all these principles are for the design of Web sites, not for the design of Web browsers.

As the client-end software of the WWW, browsers play a unique role in users' information processing. Functions provided by browsers, such as general navigation tools and HTML formatting tag support, cannot be replaced by other elements. For example, if Netscape Navigator and Microsoft Internet Explorer did not support Frame tags in HTML, it would be difficult to display index information in the browser window while the contents are scrolling down. Given the central role of browsers on the WWW, Chignell and Waterworth (1997) have treated the development of a more effective model of browsing as an ergonomic problem that needs to be solved.

A CONCEPTUAL MODEL

Figure 1 shows the most important factors involved in users' information processing on the WWW. At the bottom of the figure are the cognitive aspects of users' information processing. High cognitive workload influences users' browsing; the continual flow of information provides a challenge to users' memory and attention capacities. Search purposes, relevant contents from Web sites, relationships among Web sites, and some feedback from the browser need to be kept in memory. Useful information may be lost within a short period of time if rehearsal is not possible. On the other hand, important information may be missed or may be unretrievable from long-term memory at a later time because it is not attended to. As a huge hypertext system, the WWW provides too many choices to the users. With the increasing freedom to choose among more Web sites, more search engines, and more functions of Web browsers, users need to make many decisions during browsing. Better decisions will obviously improve the quality of users' information processing.

At the top of Figure 1 are the system aspects, including the WWW browser, the index/search system, and the Web sites, that will influence users' information processing. For example, most users today would feel inconvenienced if required to use a Web browser without the Bookmark function. The competition between Netscape Navigator and Microsoft Internet Explorer causes browsers to have more functions, support more tags and techniques, and be more user friendly. With the expansion of the WWW, index/search systems, such as Yahoo! and Lycos, become increasingly important in searching for information. Different user interfaces and different search algorithms used in index/search systems will have different effects on users' information processing strategies. The third aspect, Web-site design, is also very important. A well-designed Web site should be informative and easy to navigate. Although the only system aspect we consider in detail in this article is the WWW browser,

the design of index/search systems and of Web sites could be future research topics.

TASK TYPE AND SEARCH STRATEGIES ON THE WWW

Previous research illustrates that users adopt different strategies when using hypertext systems and that users come to the WWW with various purposes. To date, only uncontrolled log files have been used in analyzing user strategies on the WWW (Catledge & Pitkow, 1995; Tauscher & Greenberg, 1997). Moreover, there is little evidence pertinent to the questions of how strategies for information gathering on the WWW vary as a function of the users' purpose and whether these differences in strategy reflect the cognitive task demands. The WWW can be used for either of two major purposes: (1) to search for certain, particular items of information or (2) to acquire information about something interesting. We used two types of tasks in our experiment that reflect these distinct purposes. One task required retrieval from the WWW of specific items of information, whereas the other required retrieval of any items that seemed interesting to the user. We will call these tasks "specific search" and "nonspecific browsing," respectively. In everyday life, WWW users needing particular facts for work or school would likely conduct a "specific search." In contrast, those with an hour of free time to fill, and the curiosity and desire to learn about a broad range of interesting topics, would likely engage in "nonspecific browsing." Our intent was to determine whether different strategies (or processing modes) were adopted for the two task types and to examine whether the browser functions used in the tasks reflected the different cognitive task demands. The hypothesis was that users would show evidence of a more analytic, or "goal-directed," strategy when engaged in the specific search task and of a more intuitive, or "wandering," strategy when engaged in the nonspecific browsing task. These two strategies should place different loads on the user's cognitive ca-

Figure 1. The factors involved in users' information processing on the WWW.

pacities, resulting in different frequencies of using the browser functions.

Method

Ten graduate students majoring in engineering at Purdue University participated in the experiment. A preexperimental questionnaire indicated that all subjects were relatively experienced computer users. All currently used the computer at least several times a week, and all but 1 subject had 2 or more years of computer experience. All subjects currently were using Netscape Navigator, the browser used in this study, at least 1–2 h per week, and all but 1 subject had 50 or more hours experience with Netscape. The independent variable, task type (specific search and nonspecific browsing), was manipulated within subjects. Order was counter-balanced by having 5 subjects perform the specific search task first and 5 subjects perform the nonspecific browsing task first.

For both task types, the subjects used Netscape Navigator 2.0 to retrieve information from the WWW. Subjects were told to use the search engines with which they were most familiar. Nine of them chose Yahoo! whereas 1 used Infoseek. In the specific search task, subjects were asked to search for five items in the order provided by the experimenter and to put the URLs for these items into Bookmark. The five items were (1) the First Lady's biography; (2) home page of Canada's Air Force; (3) Human-Computer Interaction '97 International Conference; (4) Lee, Tsung-Dao's (physicist and Nobel prize winner) home page; and (5) the results of the 1996 Russian presidential election. These items were selected to be ones that were not directly retrievable through the search engine but required several steps to retrieve. In the nonspecific browsing task, subjects were asked to find items that they thought were interesting and to put the URLs for these items into Bookmark. Both tasks were time limited; subjects were required to stop the task after 10 min, regardless of whether it had been completed. The experimenter observed and recorded every location to which the subjects traveled.

The primary dependent variable was mean path length. The path length is defined as the number of steps that users took by continually choosing hyperlinks within the document or Back command. A step is defined as use of any browser function shown in Table 1. Any step taken by going to the index/search system, choosing a URL from Bookmark, Go, or History, or typing in the URL address was considered as the beginning of a new path. For example,

in the action sequence {search engine, hyperlink, hyperlink, back, hyperlink, type URL address}, the length of the path is 4—that is, the number of steps between using the search engine and typing the URL address. The mean path length is supposed to measure the user's search strategy. Marchionini (1995) analyzed the difference between analytical (i.e., goal-directed) and browsing (i.e., wandering) strategies. He concluded that the paths should be shorter and more numerous for a goal-directed strategy than for a wandering strategy. That is, users will change their paths more frequently when employing a goal-directed strategy than when using a wandering strategy, resulting in shorter path lengths. This is because, when engaged in goal-directed search, the user will initiate a new path if it does not seem that the current path will lead to the target information, whereas when "wandering," the user may be satisfied by many links along the path because they are potentially interesting. Catledge and Pitkow (1995) used a similar measure to characterize user strategies.

Results

All subjects performed each task for the full 10 min allowed. The mean number of items found and entered into Bookmark was 2.5 for the specific search task and 0.5 for the nonspecific browsing task [$F(1,9) = 9.47$, $MS_e = 2.11$, $p = .013$]. The small number of items retrieved in the latter task was likely in part a function of the relative ambiguity about what constitutes an "interesting" item. However, our primary concern was not with the number of items retrieved, but with the user behaviors in which subjects engaged while performing the tasks.

For mean path length, including the task sequence as a variable, the main effect of sequence was not significant [$F(1,8) = 2.59$, $MS_e = 6.578$, $p = .146$], nor was its interaction with task type [$F(1,8) = 2.99$, $MS_e = 5.702$, $p = .122$]. The main effect of task type was significant [$F(1,8) = 9.63$, $MS_e = 5.702$, $p = .015$]. Mean path length was 6.68 steps for the nonspecific browsing task but only 3.37 steps for the specific search task. This outcome supports the hypothesis that different user strategies are used for the two task types. Specifically, the

Table 1
Mean Number of Times That Each Function Was Used for the Specific Search and Nonspecific Browsing Tasks, With the Corresponding F ratio, p Value, and MS_e

Name	Type	Search Task	Browse Task	F Value	p Value	MS_e
H	Homepage	0.8	0.8	0.00	1.000	0.333
L	Link within the current page	17.7	17.9	0.01	.944	38.311
B	Back function	8.9	7.9	0.21	.655	23.444
G	Go function	0.4	0.66	0.20	.662	0.978
F	Forward function	0.4	0.1	3.86	.081	0.117
Error	System or network error	1.4	0.9	0.62	.453	2.028
Reload	Reload the current page	1.0	0.1	0.00	1.000	0.111
U	Input URL to open a page	2.9	0.9	4.19	.071	4.778
M	Bookmark function	2.9	0.5	7.58	.022	3.800
L(S)	Link to a search engine	3.5	0.5	8.62	.017	5.222
U(S)	Input keywords into a search engine	6.7	1.3	35.27	.0002	4.133
G(S)	Go to Net search	0.7	0.0	2.19	.173	1.117
H(S)	Homepage as a search engine	0.0	0.1	1.00	.343	0.050
Mail	Mail function	0.0	0.1	1.00	.343	0.050
Menu	Directory menu	0.0	0.4	2.25	.168	0.356
NewW	New browser in File menu	0.0	0.1	1.00	.343	0.050
Option	Option menu	0.0	0.1	1.00	.343	0.050
Stop	Stop the loading of the page	0.3	0.9	3.12	.111	0.578

shorter average path length for the specific search task than for the nonspecific browsing task is indicative of a more goal-directed strategy.

Despite the shorter mean path length, the total number of steps was larger for the specific search task than for the nonspecific browsing task [$M_s = 46.6$ and 33.2 steps, respectively; $F(1,9) = 5.71$, $MS_e = 159$, $p = .041$]. The protocols of the information gathering were analyzed to compare use of browser functions for the two tasks. Table 1 contains the mean number of times that each function was performed for each task type. The functions are divided into three groups: (1) basic navigation and browsing functions (e.g., Back and Forward); (2) functions that initiate a new search path (e.g., linking to a search engine); and (3) other functions used exclusively, but infrequently, in the nonspecific browsing task (e.g., examining the Option menu), and the Stop function. Of greatest concern are the first two groups of functions. Group 1 functions ($M = 4.14$) were performed more often on average than were Group 2 functions [$M = 1.92$; $F(1,9) = 28.82$, $MS_e = 1.714$, $p < .001$], but function type interacted with task [$F(1,9) = 9.18$, $MS_e = 1.517$, $p = .014$].

Analysis of the Group 1 functions showed only a main effect of function [$F(6,54) = 72.80$, $MS_e = 12.342$, $p < .001$]: Subjects clicked on links within the current page and used the Back function much more often than any of the other Group 1 functions. The frequent use of the Back function indicates that many of the links followed by users in both the specific search and nonspecific browsing tasks were subsequently determined to be inappropriate. This is at least in part because the users must make their decisions on the basis of insufficient information, and it indicates a need for tools that support users' decisions and enable more efficient selection of links on which to click. Most important, the lack of a main effect of task type or a function $\times$ task type interaction ($F_s < 1.0$) indicates that the basic navigation and browsing functions were performed approximately equally often for the two task types.

Analysis of Group 2 functions showed not only a main effect of function [$F(4,36) = 6.65$, $MS_e = 5.127$, $p < .005$], but also a main effect of task type [$F(1,9) = 35.46$, $MS_e = 5.139$, $p < .001$] and an interaction of the two variables [$F(4,36) = 4.30$, $MS_e = 3.478$, $p < .01$]. All of the Group 2 functions were used more often for the specific search task than for the nonspecific browsing task, reflecting the fact that a new path was initiated more often when the user had a specific item in mind. The task main effect and the interaction primarily reflect that input of keywords into a search engine was used more often, and the Go command less often, than were the other functions, with these differences most pronounced in the specific search task. Preferring to use search engines and URL addresses in the specific search task likely reflects the user's need to reduce time and effort in decision making when engaged in goal-directed search. It seems that, when engaged in specific search, users do not want to be attracted by relatively extraneous infor-

mation that increases the demands on their limited processing capacity. Bookmark is used to provide an external memory aid that compensates for the greater short-term memory demands of the specific search task.

As noted above, the relatively extraneous Group 3 functions were used only for the nonspecific browsing task, suggesting that information gathering proceeds in a less straightforward manner when the user is not searching for particular information. Also, the Stop function tended to be used more often in the nonspecific browsing task, suggesting that subjects are less willing to wait for requested information when browsing. To summarize, subjects performed the specific search task in a more goal-directed manner than the nonspecific browsing task. They used the browser functions more often but performed fewer extraneous functions and initiated new paths more often, resulting in a shorter average path length. The longer average path length and less frequent use of search-related functions in the nonspecific browsing task suggest that acquisition of information is preferred over locating a specific piece of information when browsing in a "wandering" mode. These findings also imply that different tools are needed for different strategies.

RECOMMENDATIONS AND CONCLUSIONS

The reported experiment confirms that different task types will lead to different user strategies and that human cognitive limitations impact use of WWW browsers. When users are searching for specific information, they engage in a goal-directed search strategy that involves more extensive use of the functions that initiate new search paths than occurs during nondirected browsing. The particular functions used with increased frequency when users are searching for specific information are ones that minimize the greater cognitive demands associated with such searching. Not only should a browser support a wandering strategy of the type used when browsing, but it also should help the user to do efficient goal-directed search. The design objective for Web browsers should be one of assisting users to make decisions in path selection and to minimize the influence of irrelevant information. Furnishing tools for both goal-directed search strategies and wandering browsing strategies as optional specifications is important.

At least three general principles for Web browsers emerge from our evaluations of search strategies and of limitations in human information processing: (1) WWW browsers should have the capability to extend the limited capacity of humans to retain pertinent information in short-term memory and to help the user retrieve information from long-term memory; (2) WWW browsers should limit the information to a certain range that is relevant to users' goals, which will help users to process appropriate information more deeply; (3) WWW browsers should assist users in making decisions in path selection and shorten the path length by minimizing the influence of irrelevant information.

Seven specific recommendations to improve the design of WWW browsers that are consistent with the general principles are as follows:

Shopping list. The browser can provide a shopping list entry to allow users to enter the keywords that represent their goals. After this is done, when the user visits any page, words on the page that correspond to any item on the shopping list will be assigned a different font property, like a bright color.

Restrict sidetracking. Given the shopping list, users can specify the number of "irrelevant" pages (i.e., those that do not contain items from the shopping list) down the path before the browser pulls users back from that path to the point where they were still engaged in the goal-directed activities or remind them with a pop-up window.

Typed link. Because it is necessary to differentiate the numerous links according to how much the author wants them to attract attention from users, browsers should support such typed links by supporting different HTML tags for anchoring instead of leaving the responsibility to Web-site authors.

Preview information. Unnecessary jumping around between different nodes is a waste of the user's energy and time and the resources of the network. Therefore, a brief summary about the new node might help users to make more thoughtful decisions about jumping. Browsers should include HTML tags—for example, <preview> and </preview>—to allow Web-site authors to append the summary information for the links. The summary information could be displayed in a balloon help or on the status bar when the user's mouse is over that link.

User-controlled multiwindows. Compared to Frame and Target Window, provided by current browsers such as Netscape Navigator, user-controlled multiwindows provide the same functions but can be opened and closed by the users not the authors. Because the WWW has a diverse user population with different purposes, the intents of the author and users are not always the same. That is why frames and multiple windows receive many complaints from users.

Quick back. One of the characteristics of short-term memory is that information can be forgotten quickly if not used. In the WWW environment, users need to keep a lot of things in mind if they want to achieve their goals efficiently. If they find that the information in a page is not useful, they should be able to go back as quickly as possible. This will help the users to unburden their memory and move on to other things of interest. One of the ways in which Back can be executed quickly is to use a simple but distinct action, such as clicking on the right button of a mouse. The pop-up menus in current browsers are supposed to extend the use of the mouse and are not designed for this purpose.

Bookmark note. According to an October 1995 WWW user survey (Georgia Tech Research Corporation, 1995), 44% of WWW users have 11–50 items in their Bookmarks, 18% have 51–100 items, and 14% have over 100

Table 2
Design Recommendations for WWW Browsers and Their Relation to Human Cognitive Limitations

Recommendations	Cognitive Limitation		
	Memory	Attention	Decision Making
Shopping list	√	√	√
Restrict sidetracking			√
Typed link		√	√
Preview information			√
User-controlled multiwindows	√		
Quick back	√		
Bookmark note	√		

√ Limitation or control level is relevant to the recommendation.

items. Microsoft Internet Explorer allows the user to type in a name for the Bookmark instead of using the page title as the default. Expanding this capability to allow the user to add a brief note to each Bookmark would aid long-term retention of the the information. This tool would seem to be particularly valuable to nonspecific browsing, for which much of the interesting information that is acquired is liable to be forgotten.

Table 2 summarizes the above-mentioned design recommendations with respect to the associated human cognitive limitations. All recommendations should be provided as optional functions so that expert and novice users can choose to enable or disable these tools to meet their needs. The intention of the recommendations is not to force users to give up their freedom of wandering in the WWW space, but rather to help them navigate more efficiently toward their goals.

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