INFORMATION RETRIEVAL USING A HYPERTEXT-BASED HELP SYSTEM

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ABSTRACT

Hypertext offers users a simple, flexible way to navigate through electronic information systems but at the potential risk of becoming lost in the network of interconnected pieces of information. A study was conducted on information retrieval using a commercial hypertext-based help system. It was found that the predominant search strategy was "browsing" (characterized by scanning tables of contents and paging through topics), rather than employing the indexes ("analytical search"). Although subjects did not become lost, individuals with better spatial visualization ability, as measured by a standardized test, were faster at retrieving information and returned to the top of the information hierarchy less often than those with poorer spatial visualization ability. These results support previous studies that have found a strong preference by users to browse in hypertext systems and extend those findings to a new domain (help), a different type of user interface, and a different information architecture. In addition, the results demonstrate the importance of spatial visualization ability for efficient navigation and information retrieval in a hierarchical hypertext system.

KEY WORDS: hypertext, help systems, information retrieval, individual differences, visualization.

INTRODUCTION

During the past decade, the development of hypertext technology and graphical user interfaces has brought about significant changes in the construction and use of electronic information systems (see [3] for a major review of hypertext). Unlike traditional information retrieval systems in which users access information from large databases using boolean operations on keyword strings, users of hypertext systems navigate through the information database by following "links" from one piece of information to the next. Such an architecture encourages users to find information by "browsing", i.e. following a likely path from one node to another until they reach their objective. However, in the absence of visual cues, this method of search can easily lead users to become disoriented ("lost in hyperspace").

While hypertext technology holds tremendous potential for augmenting human intellect [5] as well as potential problems of disorientation, few empirical studies have actually examined the skills and strategies that users employ to locate information in hypertext systems. Studies that have been done emphasize the reliance on informal browsing search techniques, especially for novice information searchers [9, 10, 11, 15]. As distinguished from analytical strategies which require formulation of specific, well-structured queries and systematic, iterative search for information, browsing involves the generation of broad query terms and scanning much larger sets of information in a relatively unstructured fashion.

Although users appear to have a strong tendency to browse hypertext information systems, it is very easy for them to become disoriented when applying this search strategy, especially in the absence of explicit visual cues to the organization of information. One way users may compensate for the lack of locational cues is by formulating their own internal model of the information architecture. In a study on individual differences, [7] demonstrated significant correlations between spatial skills (spatial memory, visualization) and efficiency in locating items to be changed in a screen-based editor. In addition, an informal study on searching a hierarchical menu system [13] found a significant negative correlation between spatial visualization ability, as measured by a standardized test (VZ-2, paper folding test, [4]), and the number of times a subject restarted a search from the beginning of a hierarchy of menus. Subjects with high spatial visualization ability were much more likely to simply back up one level in the hierarchy and continue searching rather than to restart from the top of the hierarchy. The VZ-2 test is thought to measure a person's "ability to manipulate or transform the image of spatial patterns into other arrangements"[4, pg 173]. It is also thought to be related to spatial orientation ability, which is the "ability to perceive spatial patterns or to maintain orientation with respect to objects in space"[4, pg 149].

Thus, there exists some evidence that spatial ability is important in both searching and in maintaining orientation when using screen-based applications. However, no study has yet demonstrated a systematic relation between spatial visualization ability and efficiency of locating information in a hypertext-based system.

The present study examined the skills and strategies users employ to retrieve information within the context of answering questions using the Help Viewer, a hypertext-based help application that comes bundled with the Sun386i family of workstations. This paper focuses on the results of two aspects of the study:

- Search strategies. Of particular interest was whether users would show a preference for browsing similar to that reported in previous studies. The present hypertext system is in a new domain (help), employs a different user interface, and has a different information architecture from those used in previous studies. In addition, some of the questions were deliberately designed to be easier to answer using more analytical techniques.
- Visualization. It was hypothesized that the ability to perceive and manipulate spatial patterns should reduce disorientation and lead to more efficient navigation and information retrieval in a hierarchical hypertext system. Based on previous work [7, 13] it was expected that people with stronger visualization skills would be more efficient at finding information.

Sun386I™ Help Viewer

The Sun386i Help Viewer is a hypertext-based, online help application designed to provide novice users with quick and easy access to information about the Sun386i and its accompanying application software. (A more complete description of this system can be found in [6]).

Information Architecture. The information about the Sun386i is organized around a set of eight handbooks. Each handbook contains a number of topics and a table of contents listing those topics. In addition there is a Top Level table of contents that lists the handbook titles and a Master index.

Handbooks share a common structure:

1. A handbook table of contents listing each of the handbook's topics and its index.
2. A "basics" topic that introduces the application including basic conceptual information and a labeled diagram of its user interface.
3. A series of procedural topics designed to help the user quickly accomplish new tasks application.
4. An index of concepts, objects, and procedures discussed in the handbook.

Marchionini and Shneiderman [12] distinguished between two major components of an electronic information search system; the data base and the human-computer interface. This distinction is useful in describing the Help Viewer in more detail.

Data Base. The fundamental element of the Help Viewer data base is a page or frame of information. The Help Viewer employs hypertext technology to interconnect frames in a number of ways. Pages of topics are linked together sequentially and can thus be traversed in order the way one pages through a printed book. In addition, the final page of each topic contains a link to the beginning of the next topic in the handbook, further supporting the ability to sequentially peruse the contents of a handbook. Each page in a topic section has links to the Top Level table of contents and to the handbook table of contents for that topic. By convention, links in Help Viewer are denoted by underlined words or phrases.

Topics and handbooks are organized into a hierarchical information architecture. The Top Level table of contents has embedded links to each handbook table of contents and the Master index. The handbook tables of contents contain embedded links to the initial page of each of the topics and to the index for the handbook. Indexes contain embedded links to the section and page on which the referenced information is presented.

Human-Computer Interface. The Help Viewer human-computer interface is a window-based, point-and-click, graphical user interface that allows users to move between pages or topics in the data base by a variety of means: double-clicking on underlined hypertext links, clicking on hypertext paging buttons, pressing paging keys on the keyboard, selecting an options from the pop-up menu (for paging, following links or access to the history list). The graphic design mimics a printed book. The information is presented a page at a time. The layout maintains the conventions of 2 column display, graphical elements, and illustrations found in printed documentation.

METHODS

Subjects.

The study was conducted at Northeastern University in Boston with twelve volunteers ranging from experienced system administrators through novices who had never used a mouse. None of the subjects had previous experience using a Sun386i or the Help Viewer although three of them used other types of Sun workstations frequently or daily.

Procedure.

Subjects were asked to assume the role of a Help Desk administrator who receives requests for information from computer users via electronic mail and to find the answers to these questions using the Help Viewer. When subjects opened electronic mail, they found six messages containing requests for information. They were instructed to locate the answer to each question in the Help Viewer and to respond with the handbook, section and page on which the answer could be found.

Before reading the mail messages, subjects were given a brief introduction to the Help System. This consisted of: working through an introductory tutorial included with the Help Viewer, a brief verbal description of its organization, and, approximately 10-15 minutes perusing the Help Viewer to learn more about its features, the desktop environment, and electronic mail.

Data Collection.

Software Monitoring. Automatic recording of all user interactions with the Help Viewer was accomplished by inserting monitoring software into key places in the Help Viewer source code. The recording software classified and time-tagged each event and wrote these data along with other contextual information to an external data file. After the experiment was completed, the data files were processed by a separate reduction program which parsed the raw data stream, allowing reconstruction of the manner of selection and sequence of Help Viewer frames as well as mechanical errors that subjects made when interacting with the user interface.

Videotape Recording. All experimental sessions were videotaped in their entirety. Subjects were encouraged to "think aloud" while they were working. Although the videotapes were not analyzed in detail, they served as a source of verification for the software monitor data.

Test Questions

During the test phase of the study subjects searched for the answers to the following six questions:

1. Help! I just deleted a mail message by mistake. Where can I find out how to get it back?
2. I need to find all my files that were modified after August 8, 1988. I want to use Organizer but I need some information on doing the search. Where should I look?
3. When I use many of the applications, I find that the window is too small. Can I change the size of the window so that it is the height of the screen? Where is the information that tells me how to do that?
4. When I login, I want the desktop display to automatically come up in the configuration that I want. Where can I find information on configuring and saving the desktop?
5. I often get mail messages which I need to forward to my group. Sometimes I want to forward the messages as is, sometimes I want to add some of my own notes and other times I need to include a message from someone else. Where can I read up on how to do this?
6. When I bring up Organizer, I see a number of icons displayed in the files window. Where can I find out what kinds of files these icons represent?

The questions were designed in an attempt to elicit both browsing and analytical search strategies. Questions 1, 3, and 6 were intended to evoke analytical strategies and questions 2, 4, and 5 were intended to evoke browsing strategies. A working hypothesis was that the more specific questions, and those not represented in a handbook's table of contents, should elicit analytical search strategies while the more general questions should encourage the user to employ browsing strategies. All questions had a single, correct answer.

At the end of the session, subjects were administered the Educational Testing Service factor-referenced cognitive test of visualization, VZ-2, paper folding test [4]. In this test, subjects are asked to match a 2-D representation of an folded square piece of paper with a hole punched in it with one of five alternatives showing the location of the hole when the paper is unfolded.

The experimental session concluded with a questionnaire. It took between 1 hour and 1 hour 45 minutes for a subject to complete an entire session.

RESULTS AND DISCUSSION

All the subjects in the study were able to find the answers to the questions presented to them. Discussion of the results focuses on the search strategies people used (browsing versus analytical) and the effect of visualization ability on the efficiency of information retrieval.

Search Strategies

For the purposes of this study, the browsing strategy was defined as scanning the tables of contents and paging through relevant topics to find the answers to the questions. The analytical strategy was defined as using the indexes to look up specific query terms and following the links to the appropriate topic and page.

Browsing versus Analytical Strategy. Although the questions were designed to elicit both browsing and analytical strategies, most users preferred to browse. Even though all questions could have been readily answered by referring to the Master index or a handbook index, on average, subjects visited an index on less than two (1.92) of the six questions and were actually successful in locating the answer by referring to an index on an average of 1.6 out of the six questions. In fact, despite efforts to the contrary in designing the questions, two users were successful in exclusively using the browsing strategy to answer all of the questions. Table 1 lists, for each question, the number of subjects who found the answer by browsing and analytical search. The data in Table 1 understate the fact that, in many instances, subjects went to an index only after failing to find the answer by first searching the tables of contents and topics sections. Figure 1, depicts the conditional probability that subjects would find the answer to a question by browsing or analytical search as a function of the number of attempts to locate the information using either of these strategies. As shown in Figure 1, the initial probability that a user would find the answer using the browsing strategy was quite high (0.75) but declined dramatically as the number of (unsuccessful) attempts increased.

Table 1. Frequency of how answers were found as a function of the question type.

Question Type	Question #	Table of Contents	Index
	2	10	2
Browsing	4	8	4
	5	11	1
	1	12	0
Analytical	3	7	5
	6	5	7
		53	19

Search Strategy and Solution Time. Solution time was defined as the total time required for a subject to locate the answers to all six questions. Although it might be supposed that high search efficiency (i.e. short solution times) would be associated with the analytical search strategy, in this study, highly efficient users employed both the browsing and analytical strategies. Of the four most efficient information searchers, two did not use the indexes at all while the others employed the indexes on two of the six questions. Part of the reason why search strategy did not have a significant affect on search efficiency may be because the structure of information in the Help Viewer does not penalize subjects for employing the browsing strategy. The information hierarchy in the Help Viewer database is relatively shallow and the topics are rarely more than several pages long. With this type of information architecture, it is possible for an efficient searcher to locate information using the browsing strategy in approximately the same number of steps as using the analytical strategy.

The remainder of this section presents two annotated transcripts to illustrate the search strategies. Each line lists the document name, the page number and the number of seconds the user spent viewing the document. The document names are fairly self-explanatory; Top_level is the Top Level table of contents and any document name with _Handbook appended is a handbook table of contents. Below each transcript are descriptive comments made on the basis of personal observations and videotape recordings.

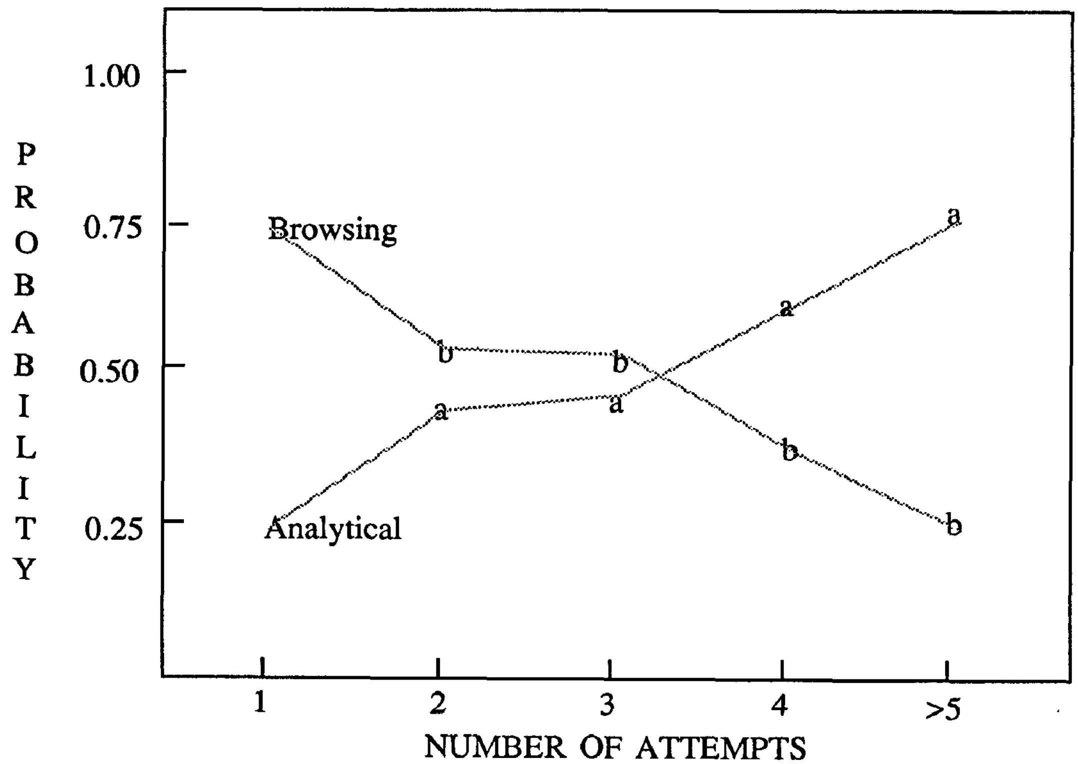

Figure 1: Conditional probability of successful strategy as a function of the number of attempts

Browsing. Figure 2 is an example of a subject employing the browsing strategy to find the answer to Question 6. This subject scans the tables of contents and pages through topics to find the answer.

Browsing the Index. Interestingly, when inexperienced information searchers went to the indexes (usually after several attempts to use the tables of contents), they were sometimes observed browsing through the section titles on the right side of the frame looking for the title of a topic that would match the information they were looking for rather than trying to find a term on the left side of the frame that related to the question they were trying to answer. In several instances, subjects 'accidentally' found the answer to a question by browsing through the indexes.

In many instances, subjects were unfamiliar with even the basic concepts and terminology and were thus unable to formulate the query terms necessary to make effective use of the indexes. Their general tack seemed to be to try to recognize in the title of a section a restatement of the information they were trying to find.

Analytical Search. The analytical strategy was used in certain limited circumstances, typically because the user was previously unsuccessful in applying the browsing strategy or because the question was phrased in such a way that the table of contents could not be used to find the answer. Use of the indexes was most frequent in subjects who were members of the computer system support staff and thus were accustomed to searching for specific information about computer systems by using UNIX man pages and manual indexes.

Question 6: When I bring up Organizer, I see a number of icons displayed in the files window. Where can I find out what kinds of files these icons represent?

Time (secs)	Page	Document
24	1	Top_Level
39	1	Organizer_Handbook[1]
8	1	Displaying_a_File_System_Map
14	1	Organizer_Handbook
6	1	Displaying_a_File_System_Map
6	1	Organizer_Handbook
48	1	Changing_Display_Window_Properties[2,3]
8	2	Changing_Display_Window_Properties
8	3	Changing_Display_Window_Properties
6	4	Changing_Display_Window_Properties
7	5	Changing_Display_Window_Properties
5	4	Changing_Display_Window_Properties
29	1	Organizer_Handbook
14	1	Organizer_Basics
5	2	Organizer_Basics
19	3	Organizer_Basics

Subject 7

Comments:

- [1]The subject spent a good deal of time examining the tables of contents (i.e. handbooks). She spent 24 seconds on the Top Level, 39 seconds on the first viewing of the Organizer Handbook table of contents and subsequently spent another 29 seconds viewing the handbook table of contents later in the sequence. This is characteristic of a user scanning the tables of contents for a section title which matches the information for which he or she is searching.
- [2]The subject paged through topics of interest. She was browsing for clues to direct her to the answer. This is evident by the fact that she was paging through the sections instead of making a quick entry and exit to a topic. Note that she finally found the answer after paging through Organizer_Basics.
- [3]This user had a great deal of difficulty recovering from a misdirected search. Notice how long she spent looking at the first page of the section entitled Changing Window Display Properties. It was unclear that this section contained the answer to the question, but lacking a viable alternative, she persisted in paging through the section looking for a lead.

Figure 2: Browsing Strategy

Figure 3 is an example of the analytical strategy used by a technician who had more than five years experience with computers. In this example he found the correct answer, "Moving and Resizing Windows, page 2" immediately after going to the index.

Question-induced search strategy. As expected, the tendency to use the indexes was also found to be associated with the type of question. Users were most likely to resort to the analytical strategy when the question was stated in such a way that the tables of contents would not be particularly helpful in locating the answer. As is evident in Table 1, Questions 3 and 6 were the questions that were most frequently answered by referring to the indexes. This was consistent with the fact that these questions were designed to elicit the analytical search strategy. An example of this was Question 6 concerning the file icons in the Organizer. The term 'icon' does not appear in any of the tables of contents. As a result, seven of twelve subjects in this study found the answer to Question 6 by using an index.

Not all attempts to design questions which would elicit the analytical search strategy were successful. Question 1 was designed to elicit the analytical search strategy but, as seen in Table 1, all subjects were successful in answering this question using the browsing strategy.

Visualization

Table 2 presents the correlations between individual differences in visualization ability, computer expertise, and mechanical errors and various performance measures. It was predicted that there should be a significant correlation between visualization ability and search efficiency (i.e. solution time). This prediction was confirmed. As can be seen in Table 2, there was a highly significant negative correlation between visualization and total time needed to answer the six questions indicating that the higher the visualization score, the less time was needed to locate the answers to the six questions. Figure 4 presents a scatterplot of the solution times as a function of visualization for the twelve subjects. The shorter solution times were not due to the fact that subjects with high visualization scores made fewer mechanical errors in using the system (the correlation between visualization ability and error rate was not significant), nor was it that subjects with high visualization scores simply accessed fewer documents (the correlation between visualization ability and number of documents accessed was not significant).

Table 2: Correlation Matrix

	1	2	3	4	5	6
Independent Variables						
1. Visualization		.47	.31	-.75***	-.65**	-.33
2. Expertise			-.28	-.41	.10	.27
3. Error Rate				-.17	-.19	-.09
Dependent Variables						
4. Solution Time					-.47	.49*
5. Top Level Visits						.75***
6. Total Pages						

* p < .05
** p < .01
*** p < .005

Question 3: When I use many of the applications, I find that the window is too small. Can I change the size of the window so that it is the height of the screen? Where is the information that tells me how to do that?

Time (secs)	Page	Document
3	1	Top_Level
9	1	Master_Index:_A
24	1	Master_Index:_W
14	1	Moving_and_Resizing_Windows
7	2	Moving_and_Resizing_Windows

Subject 1

Comments:

- This subject spent very little time examining the Top Level table of contents, he moved to the index almost immediately. Once in the index, he quickly moved to 'W' for window. This is typical of the analytical strategy where the user has a specific query term for which he or she is searching.

Figure 3: Analytical strategy

There was, however, a significant negative correlation between visualization and the frequency of returning to the Top Level table of contents; that is, the better the person's visualization ability, the fewer number of times that person needed to return to the top of the information hierarchy. This result is consistent with the earlier finding of [13] and suggests that individuals with good visualization ability construct a better internal model of a hierarchical information architecture which enables them to return to an intermediate level rather than to the top of the information hierarchy.

Finally, visualization ability was not significantly correlated with general computer expertise implying that experience in using computers does not necessarily bring with it skill in locating information in a hypertext system. Indeed, some of the most efficient users were individuals with good visualization ability but were not experts in using computers. Experience with computers can, however, affect the kind of strategy that a person uses. As described in the previous section, more experienced information searchers, such as computer support personnel, were more likely to use the index to find the answers to the test questions than were subjects with less experience searching for information about computer systems.

The results are consistent with the notion that individuals with good spatial visualization skills are able to construct a better internal model of the information architecture of a hierarchical hypertext system which can help them compensate for the lack of explicit visual cues. The Help Viewer has no explicit cues to its information organization in the form of a graphical browser, although each page in a topics section does have a link to the Top Level table of contents and to the current handbook table of contents. The results suggest that these textual cues to the structure were not sufficient to eliminate search efficiency differences due to visualization ability. However, it may be that strong visualization ability will always result in more efficient search regardless of the support provided by the hypertext system. Further investigation is needed to tease out the role of visualization ability when explicit visual cues, especially a graphical browser, are present.

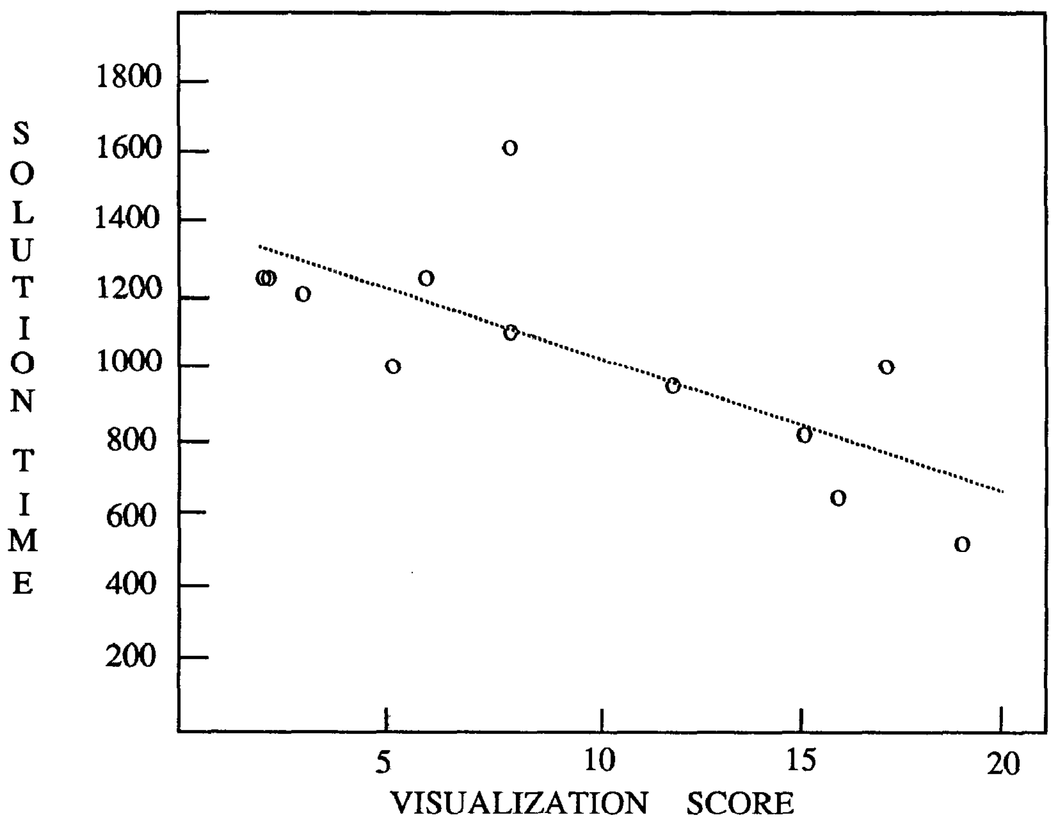

Figure 4: Scatterplot of solution time as a function of visualization score. Visualization scores ranged from 2 to 19 (with a mean of 9.5). Solution times ranged from 521 seconds to 1625 second (with a mean of 1068 seconds).

CONCLUSIONS

In the present study, users from a wide range of backgrounds and experience levels were able to quickly learn and effectively use the Help Viewer. In general, subjects reported that they found hypertext links easy to understand and convenient to use. Their success in locating the answers to the six questions was testament to this fact.

The results of this study support previous findings showing the predominance of a browsing strategy. They extend the earlier results by demonstrating a preference for browsing in a different domain (help), with a different user interface and information architecture. In the remainder of this section, some of the critical features which can affect choice and efficiency of strategy are discussed.

Penalties. Any discussion of browsing versus analytical strategy has to take into account whether the system is biased towards one strategy. In the Sun386i Help system there were was no difference in system response time, number of keystrokes, ease of following from one topic to another, or, user interface, between finding a topic through the table of contents (browsing) or through the index (analytical). Thus, there was no penalty associated with either strategy.

Individual Differences: Visualization. Search strategy is only one dimension of effective information retrieval; individual differences in visualization ability appear to play an equally important role. As demonstrated in this study, people with good visualization ability are much more efficient at finding information than are people with poor visualization ability. This suggests that good visualizers are better at constructing mental models of the information architecture and using those models to direct their navigation.

The information architecture of the Sun386i Help System is strongly hierarchical. There are also clearly marked cues to the information architecture in the form of hypertext links back to the table of contents of the current handbook or the Top Level table of contents. Moreover, the system is small. For the version of the software used in the study, there were a total of 342 displayed pages in eight handbooks. Given the significant advantage to people with good visualization skills in this simple system, it can be expected that poor visualizers are at a considerable disadvantage in larger systems unless there are clear, distinct cues to the information architecture.

Finally, it should be reiterated that the hypertext system used in this study employed an information architecture which was basically hierarchical. Apparently, spatial visualization ability is important for comprehending the information architecture of hierarchical hypertext systems. This may not be true for other types of information architectures. An important focus of subsequent research should be to understand the interaction between different information architectures and users' ability to efficiently navigate and retrieve information in hypertext systems employing those architectures.

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