A Comparison of two navigational aids for hypertext

by

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I. AN INTRODUCTION TO USER DISORIENTATION AND NAVIGATION IN HYPERTEXT

Hypertext is a new form of communication that has been under development since the early 1960s (Nielsen, Hypertext 41). It is commonly defined as a group of independent text segments called nodes that are connected by links. A link is an associative connection that is maintained by the computer. These links allow the reader to access a node from any other node, which eliminates the single sequential order that is commonly found in most printed texts. Because the reader is given a choice of paths through the text, hypertext documents are non-sequential in nature (Nielsen, Hypertext 1). This non-sequential reading order is probably one of the most important characteristics of hypertext and is simultaneously both an advantage and a disadvantage.

A non-sequential reading order is an advantage because it allows technical information to be accessed in a way that meets the needs of the audience (Younggren 78). Thus, the same document can provide background information to novices in the form of "pop up windows" while giving more advanced users the ability to skip the information entirely if they so desire (Brown and Russell 163).

On the other hand, a non-sequential reading order is a disadvantage because people often become disoriented when they try to find information within the document. This disorientation occurs when they cannot answer three questions:

1. Where should I go next?
2. How can I get back to....?
3. Where am I now? (Wright and Lickorish 97)
This problem with user disorientation was noticed early in hypertext research by Van Dam when he was working on the Hypertext Editing System (889), and he still considered it a serious problem in 1987. His concern about user disorientation was expressed in his keynote address at the Association for Computing Machinery's Hypertext '87 conference where he mentioned it as an area that needed further research (894). At the same time in the journal IEEE Computer, Conklin pointed out the "disorientation problem" as one of the two major issues that threaten to limit hypertext's usefulness (38).

While the emphasis on the importance of the disorientation problem has not changed much since 1987, some people have not completely supported this view. In 1988, Mark Bernstein asserted that in some situations, such as school assignments, disorientation is not an issue. This assertion was based on his assumption that school assignments are read by instructors who are so familiar with the material that they could not get lost. But Bernstein did acknowledge that user disorientation should be minimized in other situations, such as using technical manuals or other kinds of scientific or engineering applications of hypertext (Bernstein, Compass 35-6). In 1991, he went beyond this stance to call the concern about disorientation "misplaced," and he asserted that user disorientation "is indistinguishable from bad writing" (Bernstein, Deeply 42).

While Bernstein made this point in reference to hypertext in general, his argument doesn't completely take into consideration the stringent goals of technical documentation. These goals include helping the user to find information quickly and with a minimum of effort (Simpson and Casey 39). Because the purpose of these goals is to help people get their own work done by providing needed information, any problem that disturbs the transfer of knowledge to the
reader should not be taken lightly. Therefore, research into the creation of aids to user navigation and the application of these aids is an important part of hypertext documentation research.

**Navigation Aids**

In the course of conducting research into user disorientation, many different types of navigation aids have been invented. The complexity of these aids range from a simple backtrack mechanism to a complex integration of artificial intelligence with hypertext documents (Carlson 60). The following aids are the ones that are identified most frequently in the literature on hypertext. They are (1) backtrack, (2) history, (3) bookmark, (4) guided tour, (5) indexes, and (6) browsers. The backtrack, history, and bookmark aids are presented first because they are dynamic. The actual screens that these aids access can change each time the hypertext is used. The last three, on the other hand, are static. They are set up by the author of the hypertext and they will always provide access to the same screens every time the hypertext is used. Because this study examines browsers, they will be described more completely than the other types of navigational aids.

**Backtrack**

The backtrack facility allows the user to jump back to screens that have been previously visited. It greatly reduces any mental stress caused by navigation because users know that they can always invoke the backtrack command to return to an earlier screen. Nielsen considers this to be one of the most important of the navigation aids. In order to guarantee its usefulness, he
recommends that the backtrack should be consistently implemented so that it is always invoked in the same manner (Nielsen, Hypertext 129). Also, there should not be a limit on the number of times that a user can backtrack to the next earlier screen from the current screen. The optimum backtrack implementation would allow the user to retrace his or her path to the starting screen of the document. The final point about the backtrack facility is that it should always be available to the user (Nielsen, Hypertext 129). There should not be any part of the hypertext from which this aid is inaccessible.

History

A second way to help the user navigate is the history facility. Like the backtrack facility, it allows the user to return to nodes that have already been visited. But unlike the backtrack facility, which forces the user to retrace his or her path sequentially in the data, the history facility allows the user to pick which screen he or she wants to see again. There is no need to travel through other nodes to get to the desired node (Nielsen, Hypertext 129).

Bookmarks

Because hypertext users may become apprehensive about losing themselves in the document, Mark Bernstein has suggested that a bookmark might help alleviate that fear (Bookmark, 39). The bookmark facility allows the hypertext's readers to save a node to a list if they think that they will need to return to that node later (Nielsen, Hypertext 130). The resulting list would look much like a history list. The difference is that the contents of the bookmark list are totally under the control of the hypertext user. This control can be a problem
because users may not always immediately realize that the contents of a node is relevant and therefore fail to put it on the bookmark list. As a result, they may have difficulty finding the node again later (Nielsen, Hypertext 130).

Guided tours

A fourth navigation aid, the guided tour, is very helpful in giving new users of a hypertext document an overview of its contents. The guided tour is a string of nodes that has been linked together into a predetermined path through the hypertext (Nielsen 128). Usually they are created because the author thinks that they would be beneficial to the readers.

Guided tours have three advantages. The first advantage is that a single hypertext can contain many guided tours. For example, a hypertext on the history of the space program could contain one guided tour that shows the development of the rockets used by NASA, a second guided tour that shows the development of the manned space program, and a third guided tour that explains the unmanned space program. The second advantage of the guided tour is that they break large hypertext documents into easily digestible chunks of information so that the reader is not as likely to be overwhelmed by the mass of information contained in these hypertexts. The third advantage is that users are not locked into following the guided tour to its end. They are free to leave the tour and start navigating the network at any point if they find a compelling subtopic (Nielsen, Hypertext 128).

There is one problem with guided tours. They contradict the basic philosophy of hypertext by organizing this information into a preset reading sequence (Nielsen, Hypertext 128). But this is not a serious disadvantage if the
hypertext provides other methods of navigation and allows the guided tour to be optional.

Indexes

Indexes are very similar to their paper counterparts. They present an alphabetized list of keywords that are associated with each topic in the hypertext. The user can click on one of these words and the hypertext will take the user to the node associated with it (Shneiderman and Kearsley 12). While indexes have the advantage of enabling users to look up information by using specific terms, they are limited to the terms that the author used to index the hypertext (Shneiderman and Kearsley 12).

Browsers

Browsers are maps of the information area of the hypertext document. They have been referred to by a number of other names, such as “overview diagrams” (Nielsen, Hypertext 130), “graphs” (Frisse 881), and “bracket diagrams” (Martin 41). They show a complete overview of the organization of the document to the user. The advantage of browsers is that they help users orient themselves within the document by showing the topics that it contains. As a result, users can know their own location and understand their own movements better (Nielsen, Hypertext 131). Also, these browsers can be created in a number of styles.
Graphic browsers

One style, the graphic browser, portrays the nodes and links as an organizational diagram (see Appendix A: Example Graphic Browser Screens). The nodes are portrayed as circles or squares and the links are shown as lines or arrows extending from one node to another. A problem with the graphic browser is that its appearance becomes excessively complex when the information space is large. As a result, the lines showing the links between the nodes quickly become a mass of tangled spaghetti (Conklin 39). In response to this problem, researchers have suggested suppressing the display of some nodes and allow only landmark nodes to be shown on the graph (Bernstein, Compass 39-9). A landmark node is defined as a special node that is accessible from many other nodes (Nielsen, Art 298).

One way that the node suppression idea can be implemented is the "fisheye view" graphic browser. In this view, the network of the hypertext is shown in detail for the nodes that are near to the current node. Then as the nodes get farther away from the current node, less detail about the network is displayed (Nielsen, Hypertext 131). A second way to suppress some nodes is to use browsers that have multiple levels. The lower level would be comprised of many maps that show a small local region in detail while the upper level would show the overall structure of the document. In this scheme, many of the links found in the lower levels would not be represented in the upper level (Nielsen, Art 300). Because both strategies for creating graphic browsers require manual link editing, generating browsers without a good knowledge of the contents of the hypertext is not possible (Bernstein, Compass 32).
Table-of-contents browsers

The other style of browser, the Table-Of-Contents (TOC), resembles a book's table-of-contents (see Appendix B: Example Table-Of-Contents Browser Screens). It does not suffer from the problem of excessive complexity as much as the graphic browser because it does not explicitly show all of the links between the different nodes in the document. This is an advantage for large texts that would cause a graphic browser to be very complex. But omitting links is not an advantage for small texts because their structure is simple enough to be displayed easily. It also would be easier to create automatically such a browser because it would only have to show topic headings and not the associative links between the topics.

Theory of Navigation

While identifying some of possible aids for navigation is an important part of investigating solutions to the disorientation problem, their proper use must be understood. Also, any meaningful inquiry into determining their proper usage must have a basis in theory. Otherwise, research efforts become haphazard in their approach to the problem that is being addressed. One important place to look for a theoretical basis for using navigation aids is in the psychological research that has examined how people navigate both physical and textual environments. Once the psychological research is understood, it can then be applied to addressing the navigation problem.
Schemas

Everybody in the world use schemas and cognitive maps to represent their environment. These schemas tell us what to expect about our environment and the objects found in it (McKnight, Dillon, Richardson 67). One example is the schema for cities. A woman entering Chicago for the first time would expect to find government buildings and museums because they are contained in her schema for cities. But she would have no way of knowing how many government buildings or museums are in Chicago or how to get to them. This shows the limitation of schemas. They help us to know what kinds of things to expect in an environment, but they do not have any information about any particular instance of that environment (McKnight, Dillon, Richardson 68). In order to find the museums, the woman would have to have additional detailed knowledge about the city of Chicago.

Cognitive maps

A fully formed cognitive map, on the other hand, provides the detailed knowledge needed in the above example. It is considered to be a person’s mental representation of the layout of a specific physical environment (McKnight, Dillon, Richardson 68). Because cognitive maps are formed from previous experience with a particular environment, they will go through a period of development where they are incomplete. The development occurs in three stages. The first stage is characterized by a knowledge of landmarks. The second stage is marked by a knowledge of routes or route knowledge, in the environment. The third and final stage of cognitive map development is reached when the person has acquired survey knowledge of the environment (McKnight, Dillon, Richardson 69).
The difference between route knowledge and survey knowledge is that route knowledge is not as comprehensive as survey knowledge. A person with route knowledge knows how to travel from A to B. But he won't necessarily know the best route from A to B. A person with survey knowledge would know what would be the best route (McKnight, Dillon, Richardson 69). While these models about schemas and maps are derived from research on navigation in physical surroundings, they provide a useful perspective on navigation within texts.

Schemas and maps in text navigation

According to McKnight, Dillon, and Richardson, readers form schemas about documents from their past experiences with them. These schemas tell what the contents of a particular text should be and how they should be organized. When people read a new text, they will orient themselves by using textual items such as indexes, table of contents, and headings as landmarks (McKnight, Dillon, Richardson 72). So readers of texts develop schema that enable them to gain landmark knowledge of books. Researchers have not seen a need for investigating the acquisition of route or survey knowledge of paper documents because most documents are quickly available and users do not retrieve information from them by following a route (McKnight, Dillon, Richardson 73). But for hypertext documents, studying route or survey knowledge acquisition makes more sense because the user will travel between a number of screens to find information.

In terms of navigation within online documents or hypertext documents, learning the organization and structure is difficult because these documents lack many context cues that are available for readers of paper text. As a result, the readers are forced to rely more on textual landmarks such as headings. Research
into this area has found that people who use non-hypertext online documents seem to learn landmark knowledge first and route knowledge second (McKnight, Dillon, Richardson 78). This phenomenon was also found in two studies by Canter et. al. In the first study, Canter et. al. found that novice users preferred to use a search strategy that took advantage of landmarks in the online text. In the second study, they found that users were more successful in navigating the text by using a search strategy that took advantage of signposting (Canter et al. 256). Later studies have tried to extend these findings to hypertext documents. These studies found that subjects seem to develop landmark knowledge of hypertext documents but more studies measuring route or survey knowledge are needed (McKnight, Dillon, Richardson 79).

Context

Providing an adequate amount of context to readers of hypertext documents is much more difficult than for paper documents. The main reason is that hypertext documents often lack the context cues that paper documents have. Different types of texts, such as books and newspapers, have many different visual cues that help to establish reader expectations (McKnight, Dillon, and Richardson 70) (Nielsen, Art 299). For example, books and newspapers have characteristic differences in their physical appearance. Books tend to be bound while newspapers tend to be unbound. Books have smaller page sizes than newspapers and both types of documents tend to have unlike layouts. But when information is put online, all of these physical context cues are lost. Nielsen addressed this problem by considering two different kinds of context: context-in-the-large, and context-in-the-small.
Context-in-the-large is the overall sense of location that a user of a document feels (Nielsen, Art 304). Users with a good sense of context-in-the-large know their location within the information space and the way to the information that they need. In other words, they may be said to have route or survey knowledge of a document. Context-in-the-small is the knowledge of how the information on the screen is related to the surrounding text (Nielsen, Art 304). This is a problem for users who are navigating hypertexts in which the nodes are larger than the available screen size. The users end up scrolling back to other sections of the text in order to better understand what is currently on the screen. Another place in the document where a reader can have a problem with context-in-the-small is with understanding how a link point relates to the information in the destination node. This can be alleviated by placing links within the text such that the text will naturally supply context for the link point (Shneiderman and Koved 312).

Schemas, cognitive maps and context

For users of hypertext documents to have a good sense of context, they need to be able to develop a cognitive map of the document. Using a schema that matches the type of text is a good starting point. But the unique organizational structures of hypertext may not lend themselves to this. In the case of hypertext, schemas may not be useful because hypertext documents tend to use unique organizational structures (McKnight, Dillon, Richardson 76). Any schema that could be applied to all hypertexts would be too general to be useful in developing a cognitive map. Such a schema would allow people to expect independent nodes of information and links that allow travel between nodes (McKnight, Dillon,
Richardson 76). So in fact, the multiple structures possible with hypertext will make the user's development of a schema for the text more complicated.

It has also been found that when people approach an online or hypertext document for the first time, they try to apply schemas from similar experiences to the present situation, even if the application of the schema resulted in navigation strategies that do not make efficient use of the navigation aids in the document. For example, a study by Marchionini and Shneiderman found that students used an index facility in a hypertext document instead of using embedded menus, even though embedded menus provided a more efficient means of navigation (Marchionini and Shneiderman 75). Marchionini and Shneiderman attribute this finding to the level of expertise of the users. In other words, the subjects chose to reduce their cognitive load by using strategies that are modeled on existing paper based strategies (Marchionini and Shneiderman 76).

**Metaphors for navigation**

Metaphors provide a way for users to quickly create a schema for learning a new environment by borrowing from a known environment (Simpson & Casey 52). They are often used for aiding novices' comprehension (McKnight, Dillon, Richardson 81). The two most common metaphors for navigation are the concept of traveling through information and "book emulation" (McKnight, Dillon, Richardson 82). In the navigation metaphor the text is seen as a space that must be traversed. Researchers tend to use this metaphor most frequently both for theoretical speculations and as the basis for their studies (McKnight, Dillon, Richardson 83).
Using the spatial metaphor provides a new viewpoint that might produce some important insights into describing user navigation of hypertext. For example, Canter, Rivers and Storrs examined the navigation patterns of database users to see if they could create a quantitative index that described user navigation (94). This index involved such measures as “Loopiness,” and “Pathiness” in the users' navigational patterns (Canter, Rivers, and Storrs 95). Another group of researchers, Hammond and Allinson, investigated the idea of the guided tour as a navigation aid (Hammond and Allinson, Travels 270). They saw the guided tour as being well suited for use with the spatial metaphor. Other navigation aids that are well suited for use with the spatial metaphor are the backtrack facility, the history facility, and the browser.

The second metaphor, "book emulation," is considered to be useful for novice users because it uses navigation knowledge derived from experience with books. This experience can be best utilized by using navigation aids like the bookmark facility and indexes that have foundations within the "book emulation" metaphor. In fact, the authors using this metaphor can go as far as actually showing an image of the book on the screen (McKnight, Dillon, Richardson 82). Not all researchers are enthusiastic about the book metaphor. Nielsen thinks that using such a metaphor will limit the conceptual model to the users of the document. Also, he felt that its use is limited to "walk-up-and-use situations" where there is not an opportunity to learn new skills (Nielsen, Art 300). Because of objections such as these, the "book emulation" metaphor probably is less widely used than the navigation metaphor.

One final point should be made about these two metaphors. There is no reason that hypertext authors can't mix metaphors with respect to navigation
aids. For example, the browser aid may work well with the navigation metaphor, but its use is not restricted to those documents that make use of that metaphor. It would work just as well with documents that use the "book metaphor."

Studies of Navigation Effectiveness

Because researchers of navigation effectiveness have taken several approaches, their studies tend to make three kinds of comparisons: (1) paper documents versus hypertext documents, (2) one kind of navigation aid versus another kind of navigation aid, and (3) one implementation of a navigation aid versus another implementation of the same navigation aid. One problem with these studies is that their results tend to be contradictory.

Paper vs. hypertext

The comparisons between paper and hypertext documents used technical information as the subject matter. In Rubens' study, he took a software manual and converted it into hypertext. The subjects were asked to perform tasks that required them to integrate information from different screens. Rubens found that converting the manual into hypertext without adjusting it into a suitable format produced documents that were harder to use than their paper counterparts (Rubens 38). The performance difference was expressed in longer search times and less accurate responses to questions. One reason for the hypertext's weaker performance was found in the lack of cohesive devices such as indirect references to previous material that were present in the paper document (Rubens 39). While they work for linear material where the access is instantaneous, these devices only increase the amount of link traversals.
A second study by Egan et. al. found almost opposite results from Rubens' study. These researchers put a statistics manual into a computer environment in which the users had access to the data through indexing and a fisheye table of contents (Egan et. al. 205). The indexing and the fisheye table of contents were used for navigation throughout the superbook document. They found that the computer version of his manual was superior to the paper version of the manual in terms of speed and accuracy of answering the questions in the study (Egan et al. 209). They also found that the indexing facility provided less help for the users when they were provided synonyms than when they had the actual words used by the author. As a result, they concluded that knowledge of the structure of the document was less necessary than the knowledge of the words used by the author (Egan et. al. 209).

Another study that indirectly contradicted Rubens' findings was performed by Barfield, Haselkorn, and Wheatbrook. They compared a HyperCard stack version and a paper version of the HyperCard user manual. In their study, they asked subjects to perform simple and complex tasks using the information within the manuals. They found that while subjects using the paper manual were able to find the information for simple tasks faster than with the online hypertext, the people using the hypertext were able to complete their tasks more quickly when the tasks became complex (Barfield, Haselkorn, and Wheatbrook). This finding is in line with Horton's recommendation for not using hypertext for simple information retrieval (Horton, 308).

As can be seen from the examination of the previous studies, there is no clear consensus concerning paper versus online comparisons. Each study in some way contradicts the other. The subjects performed worse on complex tasks for
Rubens but not for Barfield, Haselkorn, and Wheatbrook. Also, Egan et al.'s subjects were able to perform better on simple retrieval tasks than Barfield, Haselkorn, and Wheatbrook's subjects. These contradictions may be attributed to differences in the documents writing and use of navigation aids and not to the online vs. paper variable. Therefore, perhaps a change in the focus of inquiry should change from comparisons of the paper and hypertext formats to comparisons of navigation aids might be more fruitful.

Comparisons between different kinds of aids

Hammond and Allinson provide most of the work that has been done in comparing the usefulness of different navigation aids. Their studies evaluate aids that use the navigation metaphor instead of the book metaphor. The aids that they have examined are a tour facility, an index facility, and a map facility. Their first investigation was a descriptive study in which they examined the navigation behaviors of their subjects in a large hypertext document (350 screens). They found that out of their group of 42 subjects, 91% of their subjects used the tour facility, 79% of their subjects used the index facility, and 74% of their subjects used the map. As can be seen by these percentages, most of the students used all three of the aids (Hammond and Allinson, Travels 272).

After they had examined the data from the first study, they performed an experimental study in which these three aids were compared (Hammond and Allinson, Extending 297). One important difference between the two is that the second study's hypertext document contained only 39 screens. This is a much smaller hypertext document than the 350 screens of the first study. As a result, the students are probably not as likely to get lost in it. Hammond and Allinson
found that when each navigation aid was provided alone, the tour facility was responsible for the highest percentage of screen traversals (49%) followed by the map (31%) and the index (23%) (Hammond and Allinson, Extending 297). When all of the navigation aids were provided to the subjects, then the usage of each aid was determined by the type of task that the user had to accomplish. The tour was used the most for the exploratory task, while the map and index were used the most for the directed task (Hammond and Allinson, Extending 298). All of their subjects had an equal accuracy rate regardless of the navigation aid that they used (Hammond and Allinson, Extending 300). They concluded that the type of task does affect the use of navigation aids, and that tours help the most with exploratory tasks while the map and index help the most with directed tasks (Hammond and Allinson, Extending 302).

Overall, there is a strong level of agreement between the two studies. Both have indicated that when the users are exploring the document, they will use tours the most. The disagreement lies in the different ordering for the index and the map between the studies. This difference may be due to the different level of complexity between the two documents. The map may have been more confusing for the people in the first study who used the larger hypertext document than for the people in the second study who used a smaller document.

Implementations of the same aid

While studies like the one performed by Hammond and Allinson may help choose the best type of aid for a given situation, they do not provide any insight into how the stylistic differences between versions of the same aid will affect the
users ability to navigate. Even though there is a need for studies that examine the effectiveness of different versions of the same type of aid, few are being done.

Comparisons of structure

There hasn't been much work on establishing the role of structure on navigation. One study by Edwards and Hardman attempted to show that people do build cognitive maps of online documents. They took three groups of subjects and asked them to navigate a hypertext document. Each group had its own document with a slightly different structure, but the actual contents were identical. The structures that they compared were a hierarchy, a mixed hierarchy, and an index structure. The hierarchy organized the topics into subordinate and superordinate relationships (see Figure 1).

Figure 1. The hierarchy structure
The mixed hierarchy contained both the hierarchy and the index structure in the same text (see Figure 2). The index structure had all nodes linked to a central node without being linked to each other (Edwards and Hardman 108) (see Figure 3). They hypothesized that the subjects would find the structure of the hierarchy to be the easiest of the three to comprehend. Therefore, the people using this structure should have the highest level of performance and they should have the most accurate understanding of the text's structure. Edwards and Hardman also hypothesized that the subjects should find the mixed structure to be the most difficult to understand and that the subjects using it should do worse than the other groups (113-4).

Figure 2. The index structure
Edwards and Hardman found that their hypotheses were basically true. The people who were in the hierarchy condition showed the greatest improvement in their times. By the end of the study, they were performing better than the other groups (Edwards and Hardman 117). Also, the people who were in the hierarchy demonstrated the best understanding of the structure of the document (Edwards and Hardman 117-119). The power of hierarchical arrangements of information could be seen in how some people in the index condition built a map that followed the content hierarchy of the document instead of the link structure. From these results, they concluded that simple hierarchies do the best job of enabling people to make internal cognitive maps of documents and that mixed structures interfere with forming this map (Edwards and Hardman 123).
Comparisons of browsers

A second group of studies has concentrated on comparisons of hypertext browsers or closely related issues.

One study by Egido and Patterson is a verbal vs pictorial comparison for a hierarchical hypermedia browser. They hypothesized that a picture combined with a label should aid navigation within a pictorial database better than just pictures or labels alone (Egido and Patterson 127). They found that pictorial data does help the user navigate the database. When the pictures were used to illustrate labels, the subjects performed the best (Egido and Patterson 131). But the researchers raise the point that verbal descriptions of the labels might have been just as helpful to the user as the pictures (Egido and Patterson 132).

McKnight, Dillon, and Richardson have reported a series of studies that examined the effectiveness of a hierarchical list against an alphabetical list. Simpson found that a hierarchical list is more effective as a navigational aid than an alphabetical list. Also, she found that a graphical contents list provided more help than a text based list (McKnight, Dillon, and Richardson 80-1).

Questions Raised by Previous Work

When we examine the research that compares the different types of browsers, it seems that the graphic browser would be superior to a verbal style of browser such as the table-of-contents style. But a closer inspection raises a few questions about the studies. The first question revolves around the verbal list that Simpson was comparing the graphic browser against. Was the verbal list a hierarchical list or merely an alphabetical list? Also, how big was her document? According to McKnight, Dillon and Richardson she used a relatively small text
(82). Would her results be replicable with a map for a larger text that would have a more complex graphic browser?

Other questions revolve around the experience level of the subjects used in the study. Many researchers, like Edwards and Hardman or Barfield, Haselkorn, and Wheatbrook, put their subjects through a training period before starting the study. By giving them training, the researchers promoted the development of a schema for hypertext that prevented the participants from being novices. So are these results generalizable to people who haven't seen hypertext before? This is an important question because most people currently have very little experience with hypertext.

**Purpose of the Current Study**

The current study was developed in order to explore the effect that two different types of browsers have on novice users of hypertext. In this comparison of the table-of-contents (TOC) style of browser and the graphic style of browser, it is hypothesized that that the TOC style will be more effective in aiding novice users of hypertext for two reasons.

The first reason is that there would be a transfer of training effect with the TOC style of browser. The transfer of training effect occurs when people apply knowledge from one system to another system (Simpson & Casey 50). Because of their experience with this structure in print, the subjects would already have a schema for using a TOC type of browser. Thus, they would find the TOC type of browser easier to use.

The second reason is that the TOC style should do a better job of helping the user develop an accurate cognitive model of the reference text because it
shows the document's topical hierarchy more clearly. This clearer presentation of
the hierarchy was achieved by excluding all representation of the document's links
in the browser and by displaying the nodes' headings in a hierarchy. Support for
the position that the representation of links should be reduced in browsers comes
from Conklin and the study by Edwards and Hardman. Conklin reported that that
graphic browsers become complex when the hypertext document becomes very
large because of the large number of links that they display (Conklin 39). Also,
Edwards and Hardman's study showed that subject's performance declined when
a document's structure became too complex because of a large number of links
(117).

Variables used in the study

Variables must be selected that efficiently tests the following hypothesis:
for novice users who need to perform directed tasks, the TOC style of browser
makes navigation within a hypertext easier than a graphic style of browser. It is
important that the variables used to measure the subject's performance
accurately reflect the document's ease of use. After examining the literature and
considering the needs of this particular study, the following variables were chosen:

1. The number of screens visited for each question.
2. The total number of screens visited for the session.
3. The amount of time taken to find the answer to the question.
4. The amount of time taken to find the answer to all of the questions.
5. The number of times the browser was used.
6. The accuracy of the answers.
7. The screen id and name.
Each of these variables measures a slightly different aspect of the students' performance that is affected by the hypertext documents' ease of use. The first and second variables examine the ease with which information is accessed. The larger the number of screens, the more likely that the subjects had difficulty finding the information that they wanted. This interpretation of these variables is implicitly supported by Edwards and Hardman's assertion that those people with more complete maps of the information structure of the hypertext would search through a smaller number of screens than if their map was incomplete (113). Also, a large screen count is undesirable because most users are trying to find information with a minimum amount of effort. This is because most users of online reference documentation need to answer a specific question about commands or operating procedures (Horton 36). They don't want to browse through the manuals. Usually, they want the answer in the shortest amount of time so they can get back to other work (Simpson & Casey 38). Therefore, they will want to expend a minimum amount of effort to find the information, and searching through a large number of screens could be interpreted as an activity that requires a lot of effort.

The third and fourth variables, the amount of time needed to find the answers, takes a slightly different view of the amount of effort needed to find the information. The greater the amount of time needed to find the required information the greater the likelihood that they were lost. Rubens felt in his comparison of online documentation vs. paper that the shorter search time indicates a more efficient search (38). Other researchers have used the same
interpretation of this variable (Egan et al. 39) (Canter et al. 255) (Edwards and Hardman 113)

The fifth variable, the number of times the browser was used, is important in determining if the users took advantage of these aids. If Hammond & Allinson's logic is to be used for this variable, then the browser with the greatest use could be considered to be the most useful (298).

The sixth variable would help in determining if the users actually found the information that they needed. This variable is probably the most important of the performance variables because a technical document's ability to convey information accurately to a reader is critical to its effectiveness. While the sixth variable is affected by the type of browser used, it is also affected by other factors in the screen. Some of these include the style of writing, the readability of the text, and the passive screen based orientation factors. Potentially, these factors present a threat to the study by allowing confounding explanations, but they were controlled because only the browser was changed between the two hypertexts.

The seventh variable, the screen IDs and names, was recorded more as a way to double check the other variables and to determine the actual path that was taken by the users.

Expected results

If the TOC browser is superior at aiding the novice user in navigating a hypertext document, the following relationships between the two browsers would be expected to occur.
1. The students using the TOC style of browser should traverse fewer screens than the students using the graphic style of browser.

2. The students using the TOC browser should take less time to answer their questions than the students using the graphic style of browser.

3. The accuracy of the responses given by TOC browser groups should be greater than the accuracy of the responses given by graphic browser groups in answering their questions.

In summary, the purpose of this study was to compare two types of browsers. The study attempted to determine whether novice users of a hypertext software user manual found a TOC style of browser to be easier to use than a graphic style of browser when they were asked to perform directed tasks. The TOC was expected to be superior to the graphic style because of the transfer effect from print books and because the TOC style should be less confusing to read. In the upcoming chapters, the following points will be discussed: the methodology used to compare the two browsers, the data that was collected, and the ramifications of this data.
II. METHOD

Because the study attempts to determine whether novice users of a hypertext software user manual found a TOC style of browser to be easier to use than a graphic style of browser when they were asked to perform directed tasks, it used the quasi-experiment as the basic investigative method. The quasi-experiment was selected because it provides the researcher with the ability to establish cause and effect relationships between a treatment and its results. It differs from the true experiment in that the subjects are not randomly assigned to the main groups, the equality of the main groups are determined via a pretest, and the research design must account for threats to internal validity (Lauer & Asher 179).

The basic procedure for performing this study consisted of three steps. The first step was to develop the written materials for the study. These materials included two hypertext versions of the software documentation, the pre-test, and the questions for the directed task. The two versions of the documentation were developed from the printed manual of a Macintosh drawing program. These two hypertexts differed only in the type of browsers that they used. The second step was to ask two classes of upper level technical writing students to do the pretest and to perform a directed task using these hypertext documents. To do the pretest, the students had to answer a survey. Their answers to the questions were used to establish the experience level of the two classes. The directed task involved basic information retrieval. The students were asked to answer ten questions using information that they found in the hypertext documents. One half of each class was randomly assigned to one of the browsers so that there were two groups using the graphic browser and two groups using the TOC browser. As the
students worked on the directed task, the computer recorded their performance in terms of the variables that were described earlier. The third step was to analyze the data in order to evaluate the effectiveness of the browsers.

The following sections explain the basic procedure in greater detail. They discuss the experimental subjects, the materials used in the study, the data collection procedure, the data analysis methods used, and the threats to the study's validity.

**Subjects**

The subjects were members of two sections of an upper-level technical writing course. The sections were computer intensive, i.e., the students did all of their class work on the computer. They did their in-class assignments on the computer, their out of class assignments on the computer, and their class discussions on the computer. The number of students in each of the classes was 20 and 22 respectively. The subjects cannot be considered to be representative of the audience of the original drawing program documentation because students in this course tend to come primarily from the scientific and technical majors. In contrast, many users of this drawing program are not limited to these backgrounds: they come from non-technical areas as well. So the subject sample is limited by a lack of individuals that represent the non-technical, artistic user.

While many of the students didn't know that the course was computer intensive when they registered, others did know. This knowledge increased the likelihood that some of the subjects in the sample were self-selected and their presence was not the result of a random sampling of students taking this particular upper level technical writing course. The self-selection would occur
because some of the students would take the class because it was computer intensive, while others would leave the class because it was computer intensive.

The major criteria in selecting the subjects were the subjects' availability and their general experience with computers. I wanted novice hypertext users, not novice computer users. These two classes filled both criteria. Most of the students had worked with microcomputers before this class and everyone in the class had ten weeks of experience of using Macintosh computers before taking part in the study. Because they had previous computer experience, any difficulty that they experienced might be more attributable to their use of the hypertext and less to their experience with manipulating the computer itself.

Materials

The materials used in the study consisted of (1) the pretest, (2) the hypertext documents, (3) the task questions, (4) the procedural instructions and (5) the exit letter that provided the students with a way to find out what the study was about.

The pretest

The pretest was a survey designed to measure the two classes' equality in terms of the variables used to measure the student's ability to navigate the hypertext. This measurement was done by examining four aspects of the subjects' background: general demographic information, their previous experience with the Macintosh computer and the HyperCard authoring environment, their previous hypertext experience, and their previous experience with the software package that is described in the hypertexts (see Appendix C: The Pretest). By
asking about the students' prior computer experience, their basic computer skill level could be established. This was important because their skills with the basic system affected how quickly and easily they could traverse the hypertext as they looked for answers to the task questions. If they had an equal level of experience, then they should have manipulated the mechanics of the interface equally well. Thus their average speed in answering the questions should not have been affected by their mastery of the computer.

Along with measuring the equality of the two classes in terms of the performance measures, the pretest asked if the subject was a native English speaker. This question was used to determine if the presence of non-native English speakers would introduce error into the study. So the pre-test examines the most critical areas that might introduce systematic error into the study.

The hypertext documents

Except for their browsers, the two hypertexts that were developed from the drawing program's documentation were identical. Everything from the information contained in each hypertext to the basic layout of the screen, to the actual structure of the documents, to the documents' interaction with the user was identical. This identical structure was achieved through developing one document and then making a copy of it. The copy then had the second browser integrated into it. Since the only area where the two hypertexts weren't identical was in their browsers, any difference in the performance of their users probably could be attributed to these browsers.

The information contained within each of the hypertexts was an excerpt of a manual for a common drawing program. The drawing program manual was
selected for a number of reasons. First, it was already structured in a modular fashion: the manual was organized into small chunks of information that were independent of each other. This modularity of the information in the manual made it an excellent candidate for conversion to a hypertext format. The hypertexts that were created from this manual contained approximately 119 screens of information, which was organized into 70 nodes with an average node size of 1.7 screens.

The layout of the screens was designed to provide the user with as much contextual information as possible. For example, the top of the screen held both the topic and subtopic headings, so the user could always tell which topic he or she was reading (see Appendix D: Example Data Screens). Also, a number in the upper right corner of the screen indicated the number of screens of information that were in the current node. This information was important for the user since the number of screens in each node ranged from one to three. The multi-screen node design was used because of the relatively small amount of information that could be put into a single screen. The controls of the two hypertexts were identical. Both documents allowed for quitting, for accessing the browser, and for sequentially traversing screens within and between the nodes. Also, there was a minimum of five and a maximum of fourteen links on each screen.

The structure of the hypertext documents was a modified hierarchy. This structure was used because it most accurately reflected the organization of the original user manual, while allowing the user to jump directly to associated areas. These links complicated navigating through the document some, but they also provided readers with the ability to access other relevant portions of the text without having to traverse the hierarchy.
The task questions

The questions that the student were to answer were presented in a separate section of the hypertexts and the student's responses to these questions were recorded by the hypertexts. The questions were designed so that no one area of the hypertext would be visited more often than any other areas. Also, the task questions made direct references to the topic headings for each node (see Appendix E: The Directed Task Questions). The questions contained some word or phrase from the name of the screen that contained the answer to the question. This would increase the student's chances of recognizing the screen that he or she needed. To make the analysis of the students' answers easier, the answers to the questions were framed in a multiple choice format. Each question had a choice for skipping the question so the students could give up if they couldn't find or recognize the answer in the hypertext.

The procedural instructions

Because both the survey and the hypertext documents were on the computer, the procedural instructions were provided in paper format. The procedural instructions told the students how to find the hypertexts and how to use them (see Appendix F: The Procedural Instructions). The procedural instructions also gave the students an ID number, which was used to organize the data during the data collection and the analysis stages of the study. A final feature of the procedural instructions was that they had a help section which explained the different controls in the hypertext. Because only the most essential information was given in the procedural document, its length was limited to four
pages. It was important to make this document as clear and as complete as possible so that the users wouldn't have any trouble understanding their task.

The exit letter

The exit letter explained the purpose of the study and the variables that were examined (see Appendix G: The Exit Letter). This letter was placed in the students' class files on the computer after both classes had participated in the study. This prevented the people in one class from contaminating the next class by telling them about the letter's contents. Besides explaining the variables that the computer measured, the exit letter also revealed the answers to the questions.

Procedure

As part of the preparations for the study, the students were assigned an ID number. This number was used to identify the data set without revealing the real name of the student. After they were given this number, they were randomly assigned to one of the browser types. The assignment was done by creating two random lists of the ID numbers with a computer. One list was created for each class and was then divided in half. The first half of each list was assigned to the TOC style of browser and the second half of each list was assigned to the graphic style of browser.

When the students entered the lab, they were given the procedural instructions handout that told them how to answer the questions in the pretest and how to use the hypertexts. Before they were allowed to begin, they were read a prepared statement that provided background information. Then they were
allowed to ask for clarifications. After that, they could not ask any questions related to the directed task.

The packet instructed the students to fill out the questionnaire first, then it instructed them on how to open the hypertexts that were used for the directed task. After the students opened the hypertext, the hypertext asked for their ID number. After they entered their ID number, the hypertext opened a file with that number as part of the file's name. The file was placed in a data folder that was located in the same folder as the hypertext document. As the user traveled from screen to screen, the hypertext wrote both the screen's name and ID to the file that it created. In this way it kept track of the screens that the reader traversed.

After the hypertext created the data file, it displayed to the students the instructions for answering the ten directed task questions that were presented by the hypertexts. When the students finished reading the instructions, the hypertext presented the first question to them and recorded the current time to its data file. At this point, the students were free to navigate the hypertext in search for the answer. Once they found the answer, they could come back to the question screen and select the correct answer. The program would then go to the next question after the students indicated that they had answered the question. The interaction continued in this fashion until the last question was answered. Then the computer wrote the total number of data and browser screens that the students traversed to the data file and closed the file. After the subjects finished answering the questions, they were allowed to leave the laboratory.

The following variables were measured by this procedure: the time at which a question was presented to the subject, the time at which the subject either answered the question or gave up, the name and ID of each screen that the user
read, the total number of screens that the user read, the total number of browser screens that the user read, and the student's answer to each question.

**Threats to Internal Validity**

The data collection procedure was developed to minimize as many threats to internal validity as possible. The threat of instrumentation was minimized by having the computer measure the different variables under study. Because only a single entity was making the measurements, inter-rater reliability was not a factor.

The threat of testing was addressed by testing the students only one time on the hypertext. The pretest was a different type of test from the one used in the hypertext. Therefore, the subject's performance with the hypertext was not confounded by any practice on the pretest. Testing the groups at one time also reduced the threat of mortality as well as regression towards the mean. The subjects were less likely to quit in the middle of the study if there were only one measurement session. Maturation, history and instability were also controlled by holding the pretest and the quasi-experiment very close to each other in time. This limited the amount of change the students experienced during the study.

The only other possible threat to internal validity was diffusion caused by the classes interacting as one class left and the other one entered the test site. However, it was not likely that people from the separate classes knew each other. Also, they did not have enough time to discuss the study beyond a few inconsequential words.

In terms of external threats to validity, the Hawthorne Effect was minimized by having the computer monitor the student's activities. This reduced
their awareness of the test itself. The awareness could not be eliminated because
the experimental situation could not be hidden. Since all of the internal threats to
validity have been controlled by the experimental design, any interactions
between them were minimized.

Data Analysis

After the subjects completed their directed task sessions, the means and
standard deviations were calculated for all of the variables. These variables were
checked for normalcy and then were subjected to a two way ANOVA. The
ANOVA was performed on the variables to test for statistical significance, and
the time and screen variables were checked for a correlation.
III. RESULTS

Because this research is a comparative study that attempts to determine whether novice users of a hypertext software user manual found a graphic style of browser to be easier to use than a TOC style of browser, the equality of the two classes must be established by the pretest before any meaningful comparisons can be made from the directed task's data. This section will summarize the pretest results before reporting on the directed task's results. The data focuses on the results which allow the two classes to be compared in terms of their general demographics and in terms of their computer, hypertext, and drawing software experience.

Profile Data

All students present for the experiment completed a profile: 20 students for one class and 21 students for the other class. The student's responses indicated that they were predominantly undergraduate upperclassmen (juniors or seniors). Only two people in the group, one sophomore and one graduate student, were not undergraduate upperclassmen (see Table 1). The classes were also predominantly male, five out of a total of 41 students were women. The educational background of the majority of these students was science related: twenty-seven students were in a hard science or engineering related field, six were in a biological science field, three were in a social science field, three were in economics, one was in physical education, and one was in English. Ten students were not native English speakers (see Table 1).
Table 1 Results of the pretest

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Class 1</th>
<th>Class 2</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>19</td>
<td>19</td>
<td>38</td>
</tr>
<tr>
<td>Female</td>
<td>3</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Classification</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Graduate</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Senior</td>
<td>16</td>
<td>18</td>
<td>34</td>
</tr>
<tr>
<td>Junior</td>
<td>4</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Sophomore</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Freshman</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Major Area</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biological Science</td>
<td>3</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Economics</td>
<td>0</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Engineering or Physical Science</td>
<td>13</td>
<td>14</td>
<td>27</td>
</tr>
<tr>
<td>English</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Social Science</td>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Physical Education</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>English Language Skills</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Native Speaker</td>
<td>17</td>
<td>14</td>
<td>31</td>
</tr>
<tr>
<td>Non-Native Speaker</td>
<td>3</td>
<td>7</td>
<td>10</td>
</tr>
</tbody>
</table>
It was important that the subjects were relatively equal in terms of experience with computers, with hypertext, and with the manual's drawing program because experiences in these areas would affect the performance of the subjects. The profile showed that the students had similar computer experience. All of the students had at least ten weeks of experience of using the Macintosh computer for their writing assignments, and both classes had an approximately equal number of people who had used microcomputers prior to that semester, 18 in first class and 17 in the second class.

The two classes also had very similar experience in terms of the type of computers they had used before the semester in which they took part in the study. The specific computer models that were listed in the survey were selected because they either had a graphic interface like the Macintosh or because they were a common machine (see Table 2). The Macintosh, Amiga, and Atari microcomputers all use a very similar windowing interface. Any previous experience with them would transfer directly to the Macintosh computers used in the study. The MS-DOS and Apple II categories were included in the survey because they are common microcomputers. While their interfaces are different from the Macintosh, it was felt that they would provide a more complete view of the subjects.

The profile results of the first class indicate that 14 people had previous Macintosh experience, 11 people had previous MS-DOS experience, two people had previous Amiga experience, one person had previous Atari experience, and seven people had Apple II experience. Obviously, there were a number of people in this class who had experience with more than one type of microcomputer. The results
Table 2. Results of the pretest

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Class 1</th>
<th>Class 2</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Previous computer experience</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>18</td>
<td>17</td>
<td>35</td>
</tr>
<tr>
<td>No</td>
<td>2</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Primary Microcomputer Use</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spreadsheet</td>
<td>8</td>
<td>7</td>
<td>15</td>
</tr>
<tr>
<td>Word Processing</td>
<td>14</td>
<td>13</td>
<td>27</td>
</tr>
<tr>
<td>Programming</td>
<td>7</td>
<td>7</td>
<td>14</td>
</tr>
<tr>
<td>Other</td>
<td>3</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>Type of Microcomputer Used</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Macintosh</td>
<td>14</td>
<td>12</td>
<td>26</td>
</tr>
<tr>
<td>MS-DOS</td>
<td>11</td>
<td>14</td>
<td>25</td>
</tr>
<tr>
<td>Amiga</td>
<td>2</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Atari ST</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Apple II</td>
<td>9</td>
<td>7</td>
<td>16</td>
</tr>
<tr>
<td>Previous Hypertext Experience</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>3</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>No</td>
<td>14</td>
<td>14</td>
<td>28</td>
</tr>
<tr>
<td>Don't Know</td>
<td>3</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>Drawing Program Experience</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>3</td>
<td>5</td>
<td>8</td>
</tr>
</tbody>
</table>
of the second class indicate that 12 people had Macintosh experience, 14 people had MS-DOS experience, two people had Amiga experience, and seven people had Apple II experience (see Table 2). Like the first class, this second one also had a number of people who were familiar with more than one type of microcomputer.

The profile also showed that the two classes were similar in terms of the their experience with hypertext. Three people from class number one had used hypertext before, 14 people from class number one never used hypertext before, and three people from the class didn't know if they had used hypertext before or not. Three people from class number two had used hypertext, 14 people from class number two had never used hypertext before, and four people didn't know if they had used hypertext before (see Table 2).

The classes also showed that they had a similar level of experience with the drawing program. Seventeen people in class number one had not used the drawing program before while 15 people in class number 2 had not used the drawing program before.

**Directed Task Data**

Because a large number of questions were not completed, the screen count per question and time count per question variables were not distributed normally. Therefore further analysis was restricted to the following variables: (1) the total number of screens, (2) the total time taken to answer the questions, (3) the accuracy of the answers, and (4) the total number of browser screens. The first three variables were already distributed normally so they don't need any further manipulation. The logarithm of the last variable, total number of browser
screens, was used to establish a normal distribution. Then a two-way ANOVA was performed on these four variables as a test for statistical significance.

While there were differences in how the classes performed on the four major variables (number of screens traversed, time taken to answer the questions, number of browser screens traversed, and accuracy of the answers), a two way ANOVA found that none of these differences were statistically significant at a p value of 0.20. It is important to note that a p value of 0.20 is the maximum value that many researchers will accept for tests of statistical significance (Lauer & Asher 162).

Since none of the variables were statistically significant, they were checked to see if they approached statistical significance. It was found that one variable, total number of screens, was significant at $p = 0.28$. The other three scores were statistically significant in the $p = 0.5$ to $p = 0.6$ range. Since these $p$ values are much higher than the accepted maximum $p$ value of 0.20, it can be safely stated that these results do not approach statistical significance. Factoring out the non-native English speaking students from the data did not affect the significance of the results. Therefore, their presence did not change the results in any systematic manner.

Even though the responses were not significantly different, it is instructive to examine the actual mean scores to get a better feel for the students' responses. In other words, "to see what actually happened." The means of the two groups for the variable "number of screens traversed" were 135.35 screens for the TOC browser groups (Standard Deviation of 86.50 screens) and 174.48 for the graphic browser groups (Standard Deviation of 47.81 screens) (see Figure 4). In comparison to these results, if a direct path was taken to the place where each of
the answers could be found, then the average for the variable, total number of screens, should have been 59 screens. So the browser with the least number of screen transitions was still twice the optimum.

The means for the second variable, total time taken to answer all ten questions, were 17.33 minutes (Standard Deviation of 6.58 minutes) for the TOC groups and 20.19 minutes (Standard Deviation 3.94) for the graphic browser groups (see Figure 5). Also, there was a weak correlation between the time taken to answer all of the questions and the total number of screens. The correlation was .43. This is fairly low, but it is significantly different from zero.

The accuracy of the answers for each browser was also very close to being the same. The TOC groups had an accuracy of 61.28% correct answers with 17.24% of the responses indicating that the students gave up and 3.21% of

![Figure 4. Means for the variable "total number of screens"](image)
the responses indicating the students were not sure if they found what they were looking for. The standard deviation of the correct, give up, and unsure responses was 29.19%, 19.22%, and 6.06% respectively (see Figure 6). The graphic browser groups had an accuracy of 68.89% with 18.10% of the responses indicating that the student gave up and 3.65% of the responses indicating that the students were not sure if they found what they were looking for. The standard deviations for the graphic browser groups were 19.67%, 14.02%, and 7.26% respectively. Finally, the number of browser screens traversed by the TOC group was 28.15 (Standard deviation of 38.51) and for the graphic browser group it was 26.67 (Standard deviation of 36.32) (See Figure 7).
Figure 6. Accuracy of each group's answers

Figure 7. Means for the variable "total number of browser screens"
IV. DISCUSSION AND CONCLUSIONS

The results of the study need to be reviewed in terms of its purpose which was to determine whether novice users of a hypertext software user manual found a graphic style of browser easier to use than a TOC style of browser when they were asked to perform directed tasks.

The results of the pretest showed that the directed task results should not have been affected by the composition of the two classes because they were approximately equal in terms of past experiences with the computer and with hypertext. But even with the pretest demonstrating that the two groups were equal, the directed task results did not completely fulfill expectations.

Predicted vs. Actual Results

Before the data was collected, the students using the TOC browser were expected (1) to traverse fewer screens when answering the questions, (2) to take less time to answer the questions, and (3) to be more accurate in their answers. The data collected tentatively supported the first two of the three proposed results of the study while tentatively contradicting the third proposed result.

In terms of the first expected result, the TOC browser marginally fulfilled the expectations of the study. The TOC browser seemed to be more effective because the two groups of students using it did manage to perform the directed task in a smaller number of screen transitions than the two groups of students that used the graphic browser. But this result was weakened because the difference between the groups was not statistically significant. Therefore, the TOC browser was not shown to be clearly superior to the graphic browser when
the total number of screen transitions for the four groups of students was compared.

In terms of the second expected result, the TOC browser didn't perform quite as well as was expected. Even though the two groups of students using the TOC browser performed better than the two groups of students using the graphic browser by taking less time to perform the task, the difference between the four groups wasn't statistically significant. Therefore, the TOC browser was not shown to be clearly superior to the graphic browser when the total amount of time needed to perform the directed task was compared between the four groups of students.

In terms of the third expected result, the two groups of students that used the graphic browser performed better than expected in terms of the accuracy of the subjects' response. But again, this was not a strong difference because it was not statistically significant. So the TOC was not shown to be clearly inferior to the graphic style of browser when the accuracy of the students' answers to the questions was compared between the four groups of students that used the browsers.

Not only were these results not significant, they never came close to achieving statistical significance. The measured differences between the two browsers did not achieve statistical significance until the significance level was raised to $p = 0.28$ for the variable, total number of screens that were traversed, and between $p = 0.5$ and $p = 0.6$ for the variables, accuracy of the answers, and time taken to perform the directed task. These results are well beyond the maximum of $p = 0.20$ that is considered acceptable by many researchers.
It can be concluded that because of the lack of statistically significant differences in the performance data, the students used in this study didn’t find the TOC browser to be more useful than the graphic style of browser. The TOC’s similarity to a printed table-of-contents and the graphic browser’s greater complexity apparently did not adversely affect the students’ performance. The implication of this result is that writers and designers of hypertexts may be free to pick the best browser style in terms of ease of implementation or of stylistic continuity with the rest of the document.

Some Factors Affecting the Study

While the above conclusion is a valid interpretation of the data, it does not consider that other factors might have affected the results by decreasing the differences between the two browsers. This section will examine two possible factors.

Low browser utilization

The first possible factor that might have affected the results was the low number of accesses to the browsers. It was surprising to see the low number of browser screen transitions that were recorded. The browser screen transitions were responsible for only 21% of the TOC group’s total number of screen transitions and for 15% of the graphic browser group’s total number of screen transitions. In comparison to other studies, Hammond and Allinson reported that their graphic browser was responsible for 31% of the screen transitions for their groups that had a graphic style browser as a navigational aid (Extending 298). Because their browser was used more extensively than were the browsers that
were created for this study, the students in the current study may not have perceived these browsers to have been helpful for aiding them with navigation. As a result, the browsers were underutilized which may have resulted in them having little effect on the student's performance.

Two implementation issues may have been responsible for the low utilization of the browsers in this study. The first issue revolves around the browsers' visibility. In this hypertext, the browsers had to be called up with a button before they were visible. Keeping the browsers out of sight in this fashion could have discouraged their use, thus diluting their effectiveness as a navigation tool. Another implementation issue that might have reduced the browsers' effectiveness was how the browser returned the subjects to the hypertexts' data screens. Every time the subjects returned from the browsers, they were not returned to the same spot from which they originally accessed the browser in the hypertext. They were returned to the introduction screen instead. This forced them to re-navigate to their original location. As a result, they may have found this feature to be frustrating and thus ignored the browsers.

Hypertext size

A second factor that might have affected these results is the size of the hypertext document. A graphic browser created for a document of 70 nodes may not be sufficiently complex to create a real advantage for the TOC browser. This speculation is based on the fact that the graphic browser in this study was not as visually complicated as was expected for a hypertext document of that size. A larger document would increase the number of explicit links that would be shown in the browser, thus increasing its complexity. Because Conklin's example of a
highly complex browser represented only 88 nodes, increasing the current study's hypertext size from 70 to 140 nodes would insure that the document is sufficiently complex to create an advantage for the TOC browser (Conklin 39).

Further study

In continuing this study's comparison of these two types of browsers, there are three possible avenues of research that can be pursued. They are (1) validation of the results, (2) investigation of the impact of different browser presentation strategies, and (3) investigation of tasks that are best supported by a browser.

Validation studies

While the initial results of this study indicate that there is no real difference between the browser styles that were compared, further work needs to be done to validate these findings for demographic groups that weren't represented by this study's subjects. Also, care should be taken in extending these findings to other demographic groups because the subjects in this study were from a very specific population and are probably not representative of users of computer documentation as a whole. Therefore, a next step in this line of inquiry is to replicate this study with a sample from a more broad based population so that the findings of this study can be generalized to the average user of computer documentation.

Validation work of this kind is important when using an experimental or quasi-experimental method because much of these two methodologies' ability to establish cause and effect stems from their ability to have results that can be
replicated. No single experiment or quasi-experiment can prove or disprove the hypothesis that it sets out to test. It can only establish that any differences measured by the experimenter are unlikely to be caused only by chance (Edwards 21). But when an experiment has been performed repeatedly, and the results are essentially the same, then the possibility of the result being due to chance becomes very small and the hypothesis can be considered to be proven (Edwards 21).

Presentation strategies

Also, the impact that different presentation strategies may have on browser use and on the other performance variables needs to investigated further. As was suggested in the discussion on low browser utilization, it is possible that how a browser is integrated into a hypertext is as important or more important than the type of browser that is used. So a second avenue of investigation would be to examine what would be the best way to integrate these browsers into the hypertext. For example, should the browser be presented in a separate window from the text, or should it be presented in the same window that displays the text.

Browser tasks

A third avenue of investigation is to explore more closely what kind of tasks are best supported with a browser. The directed task in this study was relatively simple. What happens if the task becomes more complicated? Will the TOC be better for simple tasks than for complex tasks? While Hammond and Allinson have done some discussion on this topic in terms of directed tasks vs. exploratory tasks, more work needs to be done to provide a detailed picture (Extending 303).
Like other areas of writing, the problems of authoring hypertext documents are complex and interrelated. The hypertext author needs to know how factors such as differences in the type of browsers and differences in browser integration into the hypertext will affect the reader's ability to navigate and utilize the information within the hypertext document. Without this knowledge, the hypertext author is reduced to creating effective navigation aids through trial and error.
V. BIBLIOGRAPHY


VI. APPENDIX A: EXAMPLE GRAPHIC BROWSER SCREENS

This appendix shows some of the screens from the graphic browser that was used in the study.
The Edit Menu

- Undo
- Cut
- Copy
- Paste
- Clear
- Duplicate
- Select All
- Round Corners
- Reshape
- Smooth
- Unsmooth
- Show Clipboard
VII. APPENDIX B: EXAMPLE TABLE OF CONTENTS (TOC) BROWSER SCREENS

This appendix shows some of the screens from the TOC browser that was used in the study.
Table of Contents

Click on the heading's name to go to that section of the text.
Click on the arrows pointing right to go to the subheadings.
Click on the arrows pointing left to go to the higher level headings.

Introduction

Basic Procedures
- Setting up a document
- Basic Drawing

Reference
- MacDraw II Tools
- MacDraw II Menus

MacDraw II Menus
- The Apple Menu
- The File Menu
- The Edit Menu
The Apple Menu
- About MacDraw II

The File Menu
- New
- Open...
- Open as Library...
- Close
- Save
- Save As...
- Revert
- Page Setup...
- Print
- Quit
The Edit Menu

- Undo
- Cut
- Copy
- Paste
- Clear
- Duplicate
- Select All
- Round Corners
- Reshape
- Smooth
- Unsmooth
- Show Clipboard
VIII. APPENDIX C: THE PRETEST

This appendix shows the pretest that was used to establish the equality of the two classes that were used in the study.
User Profile

Please enter the letter of the answer that is most correct between the brackets. Please pick only one answer unless the question tells you that you can choose more than one.

[ ] 1. Gender

A. Male
B. Female

[ ] 2. Classification

A. Freshman
B. Sophomore
C. Junior
D. Senior

[ ] 3. College

A. Agriculture
B. Business Administration
C. Design
D. Education
E. Engineering
F. Family and Consumer Sciences
G. Liberal Arts and Sciences
H. Veterinary Medicine

4. What is your major?
(type answer here -->) __________________________
5. Is English your first language?
   A. Yes
   B. No

6. Is English 314 a required course for your degree program?
   A. Yes
   B. No

7. Have you used a microcomputer before this semester?
   A. Yes
   B. No

8. If you answered yes to question 7 (Yes, I have used microcomputers before), what has been your primary use of microcomputers?
   (Please enter into the space between the brackets all choices that apply to you.)
   A. Spreadsheet
   B. Word Processing
   C. Programming
   D. Other

9. What kind of microcomputer have you used?
   (Please enter into the space between the brackets all choices that apply to you.)
   A. Macintosh
   B. MS-DOS
   C. Amiga
   D. Atari ST
   E. Apple II
10. When you registered for this class, did you know that you would be using Macintosh computers regularly?

A. Yes
B. No

11. If you answered yes to question 10 (Yes, I knew that I would be using Macintosh computers), did you register for this class because you knew that you would be working with the computer?

A. Yes
B. No

12. Have you used a hypertext system before?

A. Yes
B. No
C. I don't know

13. If you answered yes to question 12 (Yes, I have used a hypertext system), what did you use it for?

A. Writing
B. Browsing
C. Directed reading

14. How often in the past year have you used the hypertext system?

A. Once
B. 1-5 times per week
C. 1-5 times per month
D. 1-5 times per year

15. Have you used the program MacDraw II before?

A. Yes
B. No
16. If you answered yes to question 15 (Yes, I have used MacDraw II), how often in the past year have you used it?

A. Once
B. 1-5 times per week
C. 1-5 times per month
D. 1-5 times per year
IX. APPENDIX D: EXAMPLE DATA SCREENS

This appendix shows some of the data screens from the hypertexts that were used in the study.
You use the selection arrow, shown in the adjacent figure, to pull down menus; select tools; use the pattern palette; and use MacDraw II controls, scroll bars, icons, and dialog boxes.

You also use the selection arrow to select, move, or change the size of the objects you create. After you draw an object, MacDraw II automatically activates the arrow so you can immediately reposition or change the size of an object. You use the selection arrow to select objects. You select an object by placing the arrow on it and clicking. You move a selected object by dragging it to a different position. You can change an object's size by dragging one of the handles that surround the object's boundary.
The Edit Menu

Undo

This command cancels the effects of the last action that changed a document. For example, if you change the size of an object, and decide the original size fits the drawing better, you choose Undo to change the object back to the original size.

You choose Undo from the Edit menu, or you press Command-Z.

With the Undo command, you can cancel any action you make on an object such as cutting or pasting, duplicating, resizing, reshaping, smoothing, changing patterns, or changing position and location.

Undo works for the last action only, however. Once another action changes the document, you cannot undo the preceding action. Undo works for actions that you perform while editing text as well as while drawing and editing objects. You can undo a deletion that you made by choosing the Clear command or by pressing Delete.

You cannot undo actions that don't change the contents of the document, such as scrolling, changing a dialog-box, selecting a drawing tool or resizing a window.

The Undo command itself can also be cancelled. After you choose Undo, the command then becomes Redo. Choosing Redo cancels the previous Undo command and reinstates the last change to the document.
APPENDIX E: THE DIRECTED TASK QUESTIONS

This appendix shows the questions that the students had to answer. The same set of questions was used with both types of browsers.
1. How many drawings can you open at one time?

A. One  
B. Three  
C. Seven  
D. I gave up looking for the answer.  
E. I think I found the right screen, but the text was not clear.

2. Can you fill an object that was created with the freehand drawing tool?

A. Yes  
B. No  
C. Sometimes  
D. I gave up looking for the answer.  
E. I think I found the right screen, but the text was not clear.

3. Will the text tool allow you to use colored text in a drawing?

A. Yes  
B. No  
C. Sometimes  
D. I gave up looking for the answer.  
E. I think I found the right screen, but the text was not clear.

4. If you want to draw an object that is oversized, how can you do it?

A. Drag the pointer to the edge of the screen. It will move automatically.  
B. Click in the scroll bar on the right side and bottom of the document window.  
C. It cannot be done.  
D. I gave up looking for the answer.  
E. I think I found the right screen, but the text was not clear.

5. If you want to lock the zero point, what menu command do you use?

A. Layout  
B. Rulers  
C. Pen  
D. I gave up looking for the answer.  
E. I think I found the right screen, but the text was not clear.
6. How is the Autogrid turned on?
   A. Choose Preferences in the Layout menu.
   B. Choose Page Setup in the File menu.
   C. Choose Turn Autogrid On in the Layout menu.
   D. I gave up looking for the answer.
   E. I think I found the right screen, but the text was not clear.

7. What is the fourth step in making a row of identical objects?
   A. Select Copy from the File menu.
   B. Drag the copy of the object to the second position in the intended row of objects.
   C. Use the Cut command to remove the object from the drawing.
   D. I gave up looking for the answer.
   E. I think I found the right screen, but the text was not clear.

8. Is the revert command reversible?
   A. Yes
   B. No
   C. In some situations
   D. I gave up looking for the answer.
   E. I think I found the right screen, but the text was not clear.

9. What is the first step in changing the document's size?
   A. Choose Drawing Size from the Layout menu.
   B. Choose Preferences from the Layout menu.
   C. Choose Page Setup from the Edit menu.
   D. I gave up looking for the answer.
   E. I think I found the right screen, but the text was not clear.

10. What kind of shape does the command "Round Corners..." work on?
    A. Triangle
    B. Circle
    C. Rectangle
    D. I gave up looking for the answer.
    E. I think I found the right screen, but the text was not clear.
XI. APPENDIX F: THE PROCEDURAL INSTRUCTIONS

This appendix shows the instructions that were given to the students. This set of instructions guided them through the testing procedure.
Instructions

Introduction

Thank you for taking part in this study. In this session, you will be asked to perform two tasks. The first task is to answer a user profile. The second task is to search for information within a hypertext manual that you will be reading online.

To insure that the collected data hasn't been influenced by input from me, I can answer questions only about how to open and close the documents. I can’t help you with any questions about their contents.

The User Profile

While the user profile is not located on "Class Files," the following instructions will guide you to it. Once you start answering the user profile, please answer each question as accurately as possible.

Opening the User Profile

1. Open the folder "Hypertext Study" that is located on the hard drive of your Macintosh.
   Inside of this folder is another folder named "Profiles." There are two other files here that are named "Hypertext A" and "Hypertext B" and a folder named "Data". You should ignore them for now.

2. Double click on the folder "User Profile" to open it.
   Inside of this folder you should see the file named "User Profile" and another folder named "Completed Profiles." The folder completed profile is where your response will be saved.

3. Open the file "User Profile" by double clicking onto it.
   This starts the application "Microsoft Word" and opens a document window for the file. Now you can start answering the questions in the user profile.
Answering the Questions

Answering each question is approximately a two step process.

1. Position the blinking bar between the brackets that are in front of the question.

2. Type the letter of the most accurate response into the space between the brackets.
   Please try to answer each question as accurately as possible.

Saving and Closing the User Profile

When you are done with answering the questions, you will need to save your responses to the hard disk. Because the original file is locked, you will need to use the "Save As..." command to save your responses.

1. Select the "Save As..." command from the file menu.
   This will bring up the "Save As..." dialog box.

2. Name your file using your id number.
   Your ID number is the two digit number that is located in the upper right hand corner of your instruction sheet. The file name should look like this: XX.UsrProf. The XX is your two digit ID number. The ".UsrProf" suffix indicates that the file contains your answers to the questionnaire.

3. Select "Close" from the file menu.
   This will close the user profile.

4. Select "Quit " from the file menu.
   This will close the application "Microsoft Word" and will return you to the folder "User Profile"

5. Put your response into the folder "Completed Profile."

The Search Task

After you finish answering the user profile, your next major task is to search for answers to 10 questions about a drawing program. These questions will be presented to you inside of the hypertext document.
Starting the hypertext document

1. Look for the name of your assigned hypertext document in the upper right hand corner of these instructions. It is located over your ID number. Your document's name will either be "Hypertext A" or "Hypertext B."

2. Double click on your hypertext document. Start your hypertext by double-clicking on it. Note: Only the hypertext that was assigned to you should be on the machine.

Entering your ID Number

The first page of the hypertext will ask for your ID number.

1. Enter your two digit ID number by clicking in the circles that correspond to each digit of your ID number. The left hand column is for the tens digit. The right hand column is for the ones digit.

2. Check the ID. Is it the correct ID number?
   • If the number is correct, then you should click on the button labeled "done." Do not click on done until the number is correct. You will not be able to correct it later.
   • If the number is not correct, click on the appropriate numbers.

Answering the Questions

After you have entered your ID number, the hypertext will show its title page for 2 seconds. Then the instructions for answering the questions will appear.

1. Click on the "continue" button when you are done with each part of the instructions.

2. Follow the instructions when you answer the questions.

   WARNING: Be sure that you have answered the question before clicking on the "Question Answered" button. You can't return to a question once you go on to the next question.

   NOTE: The Compass Button will help you get an overview of the hypertext.
The hypertext controls

This section explains the meaning of the buttons that appear on the lower left side of the hypertext cards (see Figure 1).

The "house" button: This button is used to quit if you decide to leave the hypertext before you answer all of the questions (see Figure 1).

The "compass" button: Clicking on this button will bring you to the map of the hypertext. This will help you find information (see Figure 1).

The "pointer" buttons: Clicking on these buttons will allow you to travel between all of the screens in the hypertext in a sequential fashion. They are best used for going to the next screen in multi-page nodes. Multi-page nodes contain up to three pages of information (see Figure 1).

The "Go to Question" button: This button is used to go back to either review or answer the question that you are currently working on (see Figure 1).

There are additional buttons that will appear on different screens. These buttons will allow you to travel to the topic that is listed on them.

Also, any bold text in the hypertext is a link to another screen.

Reference

This section of the manual provides information about the program's tools and controls. The following list displays the features that are found in this section:

- MacDraw II Tools
- MacDraw II Menus

This part does not provide step-by-step explanations for carrying out drawing procedures. See Basic Procedures for step-by-step instructions.

Figure 1. An example screen
Quitting

When you are done with the 10th question, the hypertext will automatically close.

• Type "command-Q" to finish quitting from the document.

If You Run Out of Time

Do not try to answer the rest of the questions quickly. Finish the question that you are doing and quit. The following instructions will help you in quitting from the document.

Instructions for Quitting

These instructions are structured to help you quit from any region of the hypertext document.

Case 1
If you are in a map or table of contents card.
1. Click one of the topic buttons to go to the body text.
2. Click on the "house" button to quit.
3. Click on "yes" when the hypertext asks you if you really want to quit to HyperCard.
4. Type "command-Q" to quit HyperCard.

Case 2
If you are in a question card.
1. Click on the "Look for answer" button.
2. Then click on the "house" button to quit.
3. Click on "yes" when the hypertext asks you if you really want to quit to HyperCard.
4. Type "command-Q" to quit HyperCard.

Case 3
If you are in the manual text of the hypertext.
1. Click on the "house" button to quit.
2. Click on "yes" when the hypertext asks you if you really want to quit to HyperCard.
3. Type "command-Q" to quit HyperCard.
XII. APPENDIX G: THE EXIT LETTER

This appendix shows the exit letter that was given to the students after the study was performed. It explains the purpose of the study and it gives the answers to the questions.
To: English 314 Students
From: Mark Satterfield
Department of English Graduate Student
Subject: Purpose of Hypertext Study
Date: April 8, 1992

Purpose of the study

I want to thank you for assisting me with this hypertext study. Your aid has been invaluable in determining which of two browser styles would be better for users of on-line computer documentation. In this case, one browser was made to look like a map of the document, while the other browser was made to look like a book’s table-of-contents. I am trying to determine if the familiarity of the "table-of-contents" style helps navigation more than the "map" style. In making this determination, I will be looking at how the following variables were affected by the different browsers. These variables are:

- the number of screens that you accessed before answering each question,
- the number of screens that you accessed for all of the questions,
- the id number of each screen that you accessed,
- the time taken to find the needed information,
- the accuracy of your answers
- the number of times you used the browser.

All of these variables measure your ability to place themselves in the document. Often the case is that the larger the value of each of the variables, the more likely that you were lost.

In my analysis, I will determine if there are any statistical differences between the performance of the people who used the different browsers on the basis of the above variables. I plan to provide you with the tabulated results later in the semester. If you have any other questions you can call me at the following number (501) 972-1428.
Answers to the questions

Here are the answers to the questions about the hypertext document.

1. How many drawings can you open at one time?
The answer is: C. Seven

2. Can you fill an object that was created with the freehand drawing tool?
The answer is: A. Yes

3. Will the text tool allow you to use colored text in a drawing?
The answer is: A. Yes

4. If you want to draw an object that is larger than the screen, how can you do it?
The answer is: A. When drawing the object, just drag the pointer to the edge of the screen. The screen moves automatically.

5. If you want to lock the zero point what command do you use?
The answer is: B. Rulers

6. How is the Autogrid turned on?
C. Choose "Turn Autogrid On" from the Layout Menu

7. What is the fourth step in making a row of identical objects?
The answer is: B. Drag the copy to the second position in the intended row of objects.

8. Is the revert command reversible?
The answer is: B. No
9. What is the first step in changing the document's size?
The answer is: A. Choose "Drawing Size" from the Layout menu.

10. What kind of shape does the command "Round Corners..." work on?
The answer is: C. Rectangle