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TOWARDS THE DESIGN OF AN ELECTRONIC JOURNAL

BY
ANNETTE SIMPSON

A DOCTORIAL THESIS SUBMITTED IN PARTIAL FULFILMENT
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TOWARDS THE DESIGN OF AN ELECTRONIC JOURNAL

The main focus of this thesis is on the design of an electronic academic journal. The thesis commences with an examination of the way in which the paper-based journal system is used, in order to identify its associated problems, which may be alleviated through the use of the electronic medium, and those features which should be retained in an electronic journal system.

The use of location as an incidental navigation cue by readers of both paper and electronic documents is explored. It is concluded that, although of significant benefit, certain types of location cues are lost in the electronic medium, and other navigation aids must therefore be found.

Although it may be possible to imitate paper documents on screen, there are several arguments against such an approach. Hypertext systems enable the capabilities of the electronic medium to be more fully exploited, and make it possible to use alternative document structures, but these may present problems for readers. The major difficulty would appear to be that, due to the flexible access which hypertext permits, readers get lost. A series of studies was therefore conducted examining the utility of various facilities in assisting readers to navigate through a hypertext document. A number of features were identified which helped readers to relocate information from within the hypertext, and it would appear that the same facilities were of benefit for both hierarchical and web structured documents. It was also found that navigation efficiency was positively correlated with the ability to construct an accurate map of the document's structure.

In the final study, a database of journal articles containing the facilities derived from the previous studies was constructed, and performance in an essay-question type task was compared using two interfaces to the database. The first was a chronological list of the articles in the database, and the second contained the same navigation facilities as the individual articles. Objective and subjective performance measures both pointed to the superiority of the second type of interface, and these findings are discussed in the context of future electronic journal systems.
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CHAPTER ONE

INTRODUCTION AND LITERATURE REVIEW

1.1 INTRODUCTION

This thesis is concerned with the use of the electronic medium for the presentation of academic journals. The main focus of the research is on readers' ability to locate information efficiently from within an electronic journal.

The present chapter reviews the literature relevant to the design of an electronic journal, commencing with investigations of the way in which the present paper-based journal system is used. Previous electronic journals are then described, and the implications of studies concerning reading from paper vs. screen are discussed. The use of a navigation metaphor in a reading context is then examined, and alternative approaches to the design of electronic documents are described. Hypertext as a possible vehicle for the presentation of an electronic journal is discussed, together with the proposed advantages and disadvantages of such systems. Existing hypertext systems are described, with particular emphasis on those features intended to assist readers in navigating through hypertext documents and databases. Finally, previous studies concerning the use of hypertext systems for a variety of tasks are reported.

1.2 THE PAPER JOURNAL

This section commences with a discussion of the problems encountered by users and providers of the present paper journal system. A number of usage studies are then described, and the implications of their findings for the design of an electronic journal are noted.

1.2.1 Problems with the paper journal system

"...the scientific information system, for so long taken for granted in the UK, can no longer be regarded as stable" (Royal Society, 1981, p.40).

The academic journal is the main vehicle for the dissemination of scientific research, and has played a major role in the research process for over 300 years. However, the future of traditional procedures in academic refereed papers journals would now appear to be in question. There are several reasons for this. First, the ever-increasing costs of
printing and associated processes. The economics of the publisher/library system are already finely balanced, and the rising cost of conventional journal production has resulted in many libraries being forced to make cuts in the number of serials to which they subscribe. The expanding volume of information available is also an important factor. As Seiler and Raben (1981) state:

"It is the very success of the print medium which has now brought about a storage and retrieval crisis" (p.77).

The storage problem is exacerbated by the need for libraries to store materials such as records and films, in addition to printed materials. Kilgour (1987) proposes that, for a variety of reasons, as much as forty percent of the material that has been acquired by a library is still not on the shelves.

In addition to the problems encountered by libraries, users also face difficulties. For example, material may be already on loan, at the binders, missing, unshelved, vandalized or even stolen. Furthermore, library hours are limited, buildings may be inconveniently situated, and the working conditions are often not conducive to study. The library may not have the desired material, in which case interlibrary loans are slow for the user and expensive for the library. According to Kantor (1976), there are five main reasons why users may fail to obtain the desired information:

1. The library had not acquired the book.
2. The book was on loan.
3. Failures relating to library procedures or errors.
4. User error – failure to locate catalogue entry.
5. User error – failure to find the book on the shelf.

A further reason why the future of the paper journal may be in question is that for a long time, paper has remained unchallenged as the only viable presentation medium for journals. However, recent advances in computer-based technology make it possible to present journals electronically, and the considerable advantages of the electronic storage and retrieval of information have also been demonstrated. The format of the paper journal has been largely dictated by developments in the paper-making and print industries, and it imposes certain restrictions. For example, limitations concerning the size and weight of volumes, and, as a consequence, the number and length of the articles within them.

Seiler and Raben (1981) conclude that changes in scholarly publication will soon occur simply because the print medium is increasingly inefficient in academic settings. Space
limitations on the number of articles which can be accepted for publication and delays in the publication process are said to constitute 'serious impediments' to the flow of information.

As early as 1977 Lancaster mentions the possibility of an electronic journal. He suggests there to be four main reasons for this:

1. The rapid growth of the literature.
2. Literature scatter.
3. Rising publication costs.
4. Delays in the dissemination of information.

It has been proposed that the use of electronic techniques as the basic means of communicating information can resolve many of the problems presently faced by both libraries and publishers:

"From a technical point of view, we are henceforth emancipated from the card catalogues, the printed indexes, the searches through miles of dusty stacks, the check at the circulation desk for missing volumes, the reservations, the application to interlibrary loan, and the final discovery — when the sought-after volume is finally obtained — that the vital information has been torn out by a previous user, or that it is not relevant to the research project at hand" (Seiler and Raben, 1981, p.79).

Furthermore, the use of the electronic medium removes restrictions imposed by the paper one and permits the exploration of alternative structures:

"...articles as at present structured are unsuited to online reading. A better structure would be one that stimulated and aided scanning and permitted focussing on particular parts as required" (Line, 1984, p.60).

However, it should be noted that not all writers fully support the concept of an electronic journal. Line (1982) says that pressure for change will be great, and

"Changes could be profound: the ultimate vision (or nightmare?) is of the so-called paperless society, where no input, editing or reading involves paper — everything is done by keyboards (or lightpens) and screens" (p.142).

The author draws our attention to some of the advantages of paper journals which he considers will be lost in the electronic medium. These include portability, speed of access, the ability to have multiple documents open side-by-side, and ease of scanning and browsing. However, technology has advanced considerably since this was written, and many of these things are now possible in the electronic medium.
Line envisages that the conventional journal will cease to exist, and provision will be at the article, rather than the journal, level. He expresses some concern that decisions regarding the acceptance of an article will be dependent upon considerations of how many people will read it, as well as the quality of the article.

1.2.2 Usage studies

A number of investigations have focused on the way in which the existing paper-based journal system is used. These may perhaps be divided into three main groups. First, those with a statistical emphasis, second, those which examine sources and uses of information, and third, those which were carried out in the light of the possibilities offered by the electronic journal.

1.2.2.1 Statistical studies

The majority of these studies were initiated by factors such as rising subscription costs, space restrictions and attempts to improve provision for users. A common finding in all such studies was that a small number of titles accounted for a high percentage of usage.

Trueswell (1969) proposes that eighty percent of circulation requirements may be satisfied by twenty percent of library holdings. The results of recent investigations, such as that by Haarala (1983) have supported this suggestion. Haarala’s study was based on the premise that

"The selection of serial titles can no longer be based on quality criteria, because resources are too limited to maintain a representative collection of serials" (p. 179).

The results of the investigation, conducted in a university library, indicated the existence of a core group of serials, formed by approximately 200 titles and covering fifty percent of the total use. Ninety percent of the total usage was covered by 740 titles, and eighty percent by 534 titles.

Impending space restrictions was the impetus behind a study by Konopasek and O’Brien (1984). The investigation sought to rank journals in terms of their usage levels, the main aim being to identify those titles expected to satisfy ninety percent of needs. The results of the study were intended to provide a statistical basis on which to make decisions concerning the transfer or withdraw of certain titles. It was again found that a small number of issues accounted for a high percentage of use. In a similar study Norton (1985) concluded that fifty-six percent of the total usage centered around those journals received during the ten-month period of the survey (i.e., the most recent ones).
Sixty-five percent of the usage centered around 252 titles, each of which was used more than 100 times.

A study by MacDougall, Woodward and Wilson (1987) sought to evaluate the relative cost-effectiveness of different types of journal provision by libraries in the light of the possibilities offered by the electronic transmission of articles. Several methods of data collection were employed; a usage questionnaire and monitoring requests for photocopies, interlibrary loans, and articles held in the Short Loan collection. Various scenarios, based on the provision of issues or articles, were modelled and compared.

The data obtained suggested that only six percent of articles consulted were consulted twice or more, and a smaller percentage were consulted three or more times. In addition, there was evidence that 316 current titles received no usage during the period of the survey. Only three percent of articles handed in for photocopying were requested twice or more, and there were only four cases of duplication in interlibrary loan requests. It was concluded that the type of provision would largely depend on the cost of electronic articles. If this was fairly low, then the best service could be provided by establishing a small core collection, catering for seventy-five percent of demand, with all other demand being handled electronically and by interlibrary loans. However, it was stressed that although the pattern of journal usage could be established for a particular year, various circumstances may cause it to change.

1.2.2.2 Sources and uses of information

Perhaps the most extensive study in the second category is that reported by Line (1971), in which the information requirements of the social scientist were examined. This wide-ranging study was intended to gather data which could be used to improve existing information systems and to design new ones. It covered sources, types of information, methods of location, abstract and indexing journals, library catalogues and bibliographies, libraries, current awareness, and informal channels of communication. Some of the findings of this extensive study are described briefly below.

Following up references in books and periodicals was considered to be the most useful method of locating information. This method was used by ninety-four percent of respondents, and rated as being the most useful by fifty-nine percent. Eighty-four percent of those surveyed considered it important to keep up-to-date with new publications. The largest proportion indicated that a delay of one to three months between the publication of an article and its appearance in an abstracting or indexing journal was acceptable. It is suggested, however, that this figure was influenced by expectations. Seventy-eight percent of respondents claimed that information was
frequently found too late to be of use, while the accidental discovery of information was reported by almost all subjects. The most common method of making accidental discoveries was scanning current periodicals; forty-six percent of the sample indicated that this happened often. Seventy-two percent of interviewees said that they never delegated searching for information. Reasons for this included the loss of serendipity and the opinion that no-one else was competent to carry out the search. The Royal Society report (1981) supports the importance of browsing, concluding that the majority of users obtained information for current awareness by browsing through primary journals.

An investigation by Martyn (1987) examined the information-seeking practices of a group of scientists from various backgrounds in relation to their current research. The main emphasis of the study was on the possible causes and costs of late-found information. The results indicated that the most popular method of seeking information was by following up references cited in relevant papers (reported by ninety-six percent of respondents). The most common method of discovering late-found information was having attention drawn to it by someone other than library or information staff. Forty-six percent of those subjects reporting late finds said that they would have saved time, money or research effort if the information had been found earlier.

Cooper (1985) sought to determine how authors locate material when conducting a literature search for review-writing purposes. It was again concluded that journal articles were the most common source of references.

The need to be able to obtain more information about an article than its title is stressed by Kilgour (1987). He cites an example of three books obtained on interlibrary loan, whose titles suggested that they were useful. Two were found to contain nothing of relevance, and the third contained only one sentence. The author also points to the fact that studies have concentrated on the availability of a book or journal, rather than the user's success in obtaining the desired information.

A study by Sabine and Sabine (1986) compared the way in which books and journals were used by members of university, special and public libraries. Sixty-nine percent of the respondents worked in the physical sciences, twenty-one percent were social scientists, and the remainder were from a wide variety of occupations. Subjects were asked questions relating to the type of material accessed, how it was located and used, and the amount of information contained in a book or journal which was relevant to their needs. The survey also included questions concerning the availability and use of computers.
The physical scientists reported reading very small portions of books and journals, with sixty percent reading ten percent or less. Half of the interviewees took notes or photocopies of material. Eighty percent of the sample had access to a computer, but only five percent had ever used one to call up information from a book, rather than merely a citation. The problems encountered in dealing with the vast amount of information available were frequently mentioned by respondents.

1.2.2.3 Studies influenced by the possibility of electronic journals

In an investigation by Pullinger (1983), a group of potential users of the BLEND system were questioned as to their reading and writing habits and opinions of the present publishing system. All of the respondents were researchers in the field of Computer Human Factors (computer scientists, human factors engineers and psychologists).

Subjects expressed a strong dislike of delays in the present publication process. Sixty-eight percent of respondents considered the maximum acceptable time for initial editorial processing to be three months or under. Refereeing was viewed as a mechanism for maintaining the quality of journals, but a number of subjects complained about occasional arbitrary and unhelpful refereeing.

Responses suggested that sixty-five percent of browsing and eighty-five percent of reading papers took place out of office hours, either at home or whilst travelling. Sixty-three percent of those interviewed wrote mainly in the evenings, with a large number claiming that they would like to write more papers than circumstances permitted. Little communication between readers and authors was reported. Only nineteen percent of the sample said that they asked for reprints from authors, and the number of requests received by subjects for reprints of their own papers was considered to be declining. The desire for a greater amount of communication was clearly expressed, and it was anticipated that an electronic journal might facilitate this process.

In a later study, Dillon, Richardson and McKnight (1988) interviewed fifteen human factors researchers concerning their use of the paper journal system. The department in which these interviews were conducted is a distance of two miles from the main campus, and has its own library. However, this does not hold the full range of the journals in which respondents might find relevant material. Of the 15 subjects interviewed in the study, only one said that he visited the main campus library regularly, six did so occasionally, seven seldom, and one never. Reasons for not using the superior facilities on campus included the physical distance involved and, a related factor, lack of time. Five of the interviewees mentioned using the interlibrary loan
service (based in the main campus library) in order to obtain material. None of the subjects reported that they did any reading in the library, three of them (20%) expressing a strong dislike of libraries as a place in which to work.

None of those interviewed felt that they covered all of the journal material relevant to their needs, 20% considering that it was likely they missed a lot of relevant material. The majority (54%) felt that they missed some material, while a third were satisfied that they covered most of it. All of the interviewees reported that relevant material was pointed out to them by colleagues. Subjects distinguished between two types of journal accesses. The first was occasioned by work demands, and the second by personal interests. It is difficult to give an access rate for the former type of usage, as this obviously depends upon the individual's current work. However, 60% of interviewees claimed that they accessed a journal at least once a week for personal interests. The lowest rate was once every two months (one subject), and the highest was twice per week (four subjects). Seven subjects had a subscription to one or more journals, although the authors note that subscription to a journal is obligatory for membership of the Ergonomics Society.

Journal articles were photocopied regularly by all of those interviewed, and a number of reasons were given for doing so. First, not wanting to remove a journal in case another person wanted it. Second, a photocopy can be read in detail at the user's convenience. Third, it is possible to annotate and highlight photocopies. Finally, they can be stored for easy retrieval at a later date. However, eight of the fifteen subjects admitted to photocopying articles that were never read.

1.2.2.4 Reading strategies

In the second part of the study by Dillon et al. (1988), subjects' reading strategies in the paper medium were examined. The authors propose that when readers encounter a new issue of a journal,

"It is possible to identify a general pattern to these interactions by tracing the sequence of activities typically performed and the decisions made by readers as they use journals" (p.42).

Readers were observed to scan the table of contents of an issue first, looking primarily at the titles and authors (although some subjects did suggest that the titles were sometimes misleading). The issue was put aside if nothing of interest was found at this stage.
When an article of interest had been identified, it was opened at the beginning, and the abstract was examined. However, some readers were critical of the abstract, again considering it to be misleading, and the majority of subjects were observed to view at least one other part of the text prior to making a decision about rejecting the article.

A quick scan of the remainder of the article then followed. Most subjects browsed the beginning of the introduction, then scanned the section headings. The conclusions were also frequently browsed at this point, and sometimes the references. Dillon et al. suggest that references were looked at in order to identify the possible relevance of an article through its theoretical stance. The articles referenced by an author also assisted in the assessment of relevance.

By this point in the interaction the subject had decided whether to proceed with the article or not. A number of reasons were mentioned for rejecting an article. These included: lack of relevance, poor sectioning, long method and results sections, short discussion and the number of pages (too few or too many). Articles were also said to be selected according to purpose (e.g., work or personal use), and it was noted that the range of journals used regularly was fairly restricted.

If an article was judged to be relevant to the current task, then three reading strategies were identified:

1. Rapid scanning of abstract and/or introduction, then section headings and occasional paragraphs within sections, figures and tables. The level of mathematical content and the length of the article were noted at this stage. Browsing the conclusions also appeared to be a method of extracting the main ideas from an article.

2. The article was read in a non-serial manner, reading some sections fully and skimming or even omitting others. Usually the introduction and discussion were read fully, while the method and results were just skimmed.

3. A detailed serial read from start to finish. Most subjects reported that an article selected as relevant would eventually be read in this way.

However, Dillon et al. concede that it is unlikely that any of these strategies are rigidly adhered to, and most subjects reported that an article would eventually be read serially, in a fairly detailed manner.

An important point to emerge from this study is that readers would seem to overlook a large proportion of the material in journal articles.
1.2.3 Implications for an electronic journal

The findings of the studies reported above provide an indication of (i) the problems concerning the existing paper journal system, which an electronic journal may help to solve, and (ii) the facilities which an electronic journal should provide.

From the library's point of view, difficulties with the paper system are mainly due to the rising costs of journals, restrictions imposed by the paper-making and print industries, and the ever-increasing amount of information to be stored. Readers face problems concerning access to information, both within the library itself (the journal may be on loan or mis-shelved, etc.) and in physically accessing the library in which the journals are stored. Further difficulties are caused by delays in the publication process.

An electronic journal would not be subject to restrictions concerning the number and length of articles which could be published, and delays in the publication process could be reduced. The use of the electronic medium (especially CD-ROM) would permit the effective storage of vast amounts of information. Users would be released from the necessity to travel to a library, which is only open for a restricted number of hours, and they would not have wasted journeys because journals were on loan or otherwise unavailable. Instead, readers would be able to access information from their own desks, and at a time which suited them. Furthermore, the removal of lengthy delays in the publication process would mean that the information available was more up-to-date than in the present system.

Several writers have concluded that a fairly small number of articles account for a large percentage of the material used by readers. In addition, it would appear that the majority of these articles are those most recently acquired by the library (again emphasising the importance of rapid access to new material). These findings have implications for the conversion of existing journals into the electronic medium, suggesting (i) that the most recent article should be processed first, and (ii) that as a first step, certain key articles could be identified and used to form a 'core collection'.

The variety of reading strategies employed by users in Dillon et al.'s (1988) study point to the need for flexible access to the information contained in a journal. This view is supported by Kilgour's (1987) proposition that the facility to obtain more information about an article than its title quickly is important.
1.3 THE ELECTRONIC JOURNAL

In this section, the term 'Electronic Journal' is briefly discussed and the two major electronic journals, EIES and BLEND, are described.

1.3.1 What is it?

As Gurnsey (1985) states the term 'Electronic Journal' is increasingly used to describe the on-line publishing of newsletters and journals which are presented in a way that does not permit readers to interact with the document. However, this is full text delivery:

"and differs from conventional bibliographic on-line provision only in the nature of the material being carried. It is an essentially passive service, and not the technology for which the term 'electronic journal' was coined... An electronic journal is one where the writing, editing, refereeing and distribution of an item are carried out without any paper intermediaries" (p.131).

He considers that:

"What essentially distinguishes the electronic journal from full text on-line retrieval is its degree of interaction" (Gurnsey, 1985, p.134).

1.3.2 The EIES System

The first major electronic journal project was in the USA, and ran on the EIES Computer Conferencing system. The origins of the project were in the work on Editorial Processing Centres. The refereed papers journal on the EIES, entitled Mental Workload, ran for one-and-a-half years between 1978 and 1980. The project did not achieve all of its objectives, failing to publish a single paper in the first year. However, some useful lessons can be learnt from the problems encountered (Sheriden, Senders, Moray, Stoklosa, Guillame and Makepeace, 1981). Difficulties included:

1. The large number of projects and users resulted in long and variable system responses.

2. The command structure and editing system were too complex – many users commented on difficulties relating to the interface to the journal.

3. Publishing procedures were inflexible.

4. An unpublished journal was regarded as low status and this led to some reluctance...
among authors to submit papers.

5. The terminals were inflexible and of limited quality.

6. There was little user involvement in the project.

7. The duration of the project was too short.

An important point is that:

"...where EIES failed, it was not usually the technology which failed, but the relationship of that technology with the end user" (Gurney, 1985, p.133).

However, as Shackel (1987) emphasises, it would be wrong to suggest that the project as a whole was not successful – other types of journal on the system were well supported.

1.3.3 The BLEND project

The Birmingham and Loughborough Electronic Network Development (BLEND) project ran from 1980 to 1984. The aims of the project were to explore and evaluate the use of an electronic communication network as an aid to writing, submitting and refereeing papers, and as a medium for other types of scientific and technical communication. There were several types of journal on the system, including a refereed papers journal, entitled Computer Human Factors. The articles for Computer Human Factors were specially written for the journal; they were not electronic presentations of existing articles from the paper medium. The primary group of users comprised computer scientists, human factors engineers and psychologists engaged in research in these areas. In view of the fact that Computer Human Factors was the first successful refereed electronic journal, it will be described in some detail.

In the electronic medium it is possible to move away from the concept of distributed issues, and make an article available to readers as soon as it is ready. However, as Pullinger (1984) reports, it was decided to continue producing articles in issues for BLEND. One reason for this decision was that Sheriden et al. (1981) found that readers preferred a newsletter to appear regularly on a set date in the EIES system. Other reasons for preserving the existing journal structure were (i) that Computer Human Factors would be easier and "more obvious" to use if it was structured in a familiar way, and (ii) that a journal broadly corresponds to the reader's interests – he knows from its title the type of articles it will contain.
The articles in *Computer Human Factors* were divided into "entries", each comprising a maximum of 22 lines of text, thus permitting one entry to be displayed per screen. As typographic cues were not available, a contents list was provided for each article (similar to those occasionally seen for book chapters). The journal articles were structured as follows: title, author, contents, summary, introduction, main text, conclusions, references, author's address.

Pre-experiment interviews (see Pullinger, 1983) had indicated three strategies for the selection of journal articles:

1. Filtering through the stages of title, abstract, results/conclusions, references, other sections.

2. Preliminary filter of title and abstract, followed by a request for a photocopy for later reading.

3. Skimming through articles looking for new ideas, with no particular note of the content.

It was proposed that the existence of strategies such as these were an indication of reader expectations concerning the structure of the article, and that this should therefore be preserved.

When a reader entered the BLEND system, he was presented with a list of the journals available. When one of these was selected, a contents list for the journal was displayed. Two sets of numbers down the right-hand side of the screen indicated (i) the entry number at which each of the articles commenced, and (ii) the number of lines of text it occupied, thus providing the reader with a guide to the size of the article. Anything new since the reader had last logged into the system was indicated in the contents list of the journal. In the contents list for the individual articles, the entry numbers for the sections were shown down the right-hand side of the screen, and the section numbers appeared down the left-hand side. The latter numbering system was discontinued after preliminary trials, as there were found to be many numbering systems operating within the system.

References in the text of an article contained both the author and date (as in a paper journal) and also the entry number of the full reference. The latter enabled the reader to jump directly to the full reference and then back to the same place in the text. Entry numbers were also added to references to figures and tables in the article.
The BLEND system was based on the Notepad conferencing suite, which was not developed for the reading of a full text article. Consequently, some modifications were made by the BLEND team, which permitted readers to move about more freely in an article. These are described in some detail in Pullinger (1983). The four main facilities enabled readers to:

1. Step backwards and forwards one entry in the text.
2. Jump to any numbered entry.
3. Return to the previously displayed section of text.
4. Perform a string search on the first lines of entries, thus permitting jumping to named section headings.

It was proposed that the design of Computer Human Factors would assist the user in several different ways: by producing the journal in issues, by preserving the familiar structure of the article, by developing a computer program which enhanced the display of text to the reader, and by changing the reference citations in order to take advantage of the electronic medium and reduce search time.

A number of the difficulties noted in relation to the EIES system were solved in BLEND. For example, there were no system delays, procedures for entering papers were more flexible, authors were permitted to publish papers conventionally after three months on the BLEND system (thus increasing submission rates), and user involvement in the project was encouraged.

Unlike EIES, technological restrictions were mainly responsible for the problems encountered by users of the BLEND system. Although the quality of the display had improved considerably since EIES, it was not acceptable to all readers (e.g., slow refresh rate and poor resolution) and

"The penalties in electronic journals of not having integrated text and graphics seem to be very high" (Pullinger, 1984, p.180).

The lack of graphics influenced both the author's ability to display material and the reader's ability to interpret information.

Another difficulty concerned physical access to the system, i.e. the availability of equipment, and users considered that having a machine on their own desk was the optimum situation.
Nonetheless, the BLEND project demonstrated that a refereed papers journal could successfully be run on an electronic communication system. At the end of the project, 20% of the 88 papers submitted to BLEND had been published in *Computer Human Factors*, and most of the others had appeared in one of the other journals on the system. As with the EIES system, the successes and difficulties encountered during the project point to those areas in which further work is required. Prominent among these is the provision of methods to allow readers to browse through, search and retrieve information more easily from an electronic journal. As Sheriden *et al.* (1981) conclude:

“When terminals and computers do not meet the needs of users, then users will not use the system”.

1.4 READING FROM PAPER AND SCREEN

It is often assumed that reading from screen is in some way 'more difficult' than reading from paper, and such an opinion may obviously influence attitudes towards the concept of an electronic journal. A number of studies have compared performance in the two media, with four main measures being employed. These are very briefly discussed as follows.

1.4.1 Measures

1.4.1.1 Reading speed

Perhaps the most frequently studied performance measure is reading speed. Several investigations have found that reading from a VDU is significantly slower than reading from paper (e.g., Kak, 1981; Muter, Latremouille, Truerniet and Beam, 1982; Gould and Grischkowsky, 1984; Wright and Lickorish, 1983). However, the results of other studies, such as those by Askwall (1985), Cushman (1986), Swithinco (1984) and Oborne and Holton (1988), have indicated there to be no difference in reading speed between the two media.

1.4.1.2 Accuracy

A second factor examined is the accuracy of (usually proofreading) performance. Again contradictory evidence exists, with no significant difference reported by some authors (e.g., Wright and Lickorish, 1983; Gould and Grischkowsky, 1984), but impaired performance in the VDU condition being found by others (e.g., Creed, Dennis and Newstead, 1987; Wilkinson and Robinshaw, 1987).
1.4.1.3 Comprehension

A third, and perhaps more important, factor studied is the influence of presentation medium on comprehension. One of the major difficulties here is in the measurement of comprehension. Methods have included post-task questions (Muter et al., 1982) and standardized reading tests (Kak, 1981; Cushman, 1986; Belmore, 1985). In general, the literature would suggest that there is no comprehension difference between paper and screen, but it should be noted that suitable comprehension measures for such studies are difficult to devise.

1.4.1.4 Fatigue

Studies by Muter et al. (1982) and Gould and Grischkowsky (1984) have indicated there to be no difference between the two media. However, in a more detailed investigation of fatigue, Cushman (1986) found a performance decrement over time. It may perhaps be concluded that while reading from a VDU is not felt to be fatiguing in itself, performance levels may be more difficult to sustain for any length of time than in the paper medium.

1.4.1.5 Subjective measures

Subjective measures have also been examined in a number of studies. For example, Cakir, Hart and Stewart (1980) report that subjects preferred the paper medium, while subjects in the study by Muter et al. (1982) did not. However, it is likely that preferences may be influenced by factors relating to the ease with which the text can be manipulated in the electronic medium as compared to paper, and it is important to note that such factors have improved considerably since many of these studies were conducted.

1.4.2 Reasons for possible differences

Many investigations have sought to determine the possible causes for observed performance differences on paper and screen. The most exhaustive series of studies was that by Gould and his colleagues, the conclusions of which are reported in Gould et al. (1987a). The possible influence of a number of variables on reading from VDUs was examined, using a variety of measures. These included: screen orientation, eye-movement patterns, reading distance from the screen (line length), aspect ratio, rate and direction of scrolled text, refresh rate, luminance, polarity, contrast ratio, anti-aliasing and display characteristics such as character size, line spacing and character spacing. Gould et al. (1987b) demonstrated that under certain conditions, there is no
performance difference reading on screen as compared to paper. No single variable has been identified, but it would appear that performance decrements observed on screen are due to the interaction between several of the variables investigated in the earlier studies. Contributory factors would seem to be polarity, resolution and anti-aliasing, and a visual, as opposed to cognitive, explanation for reported differences was proposed.

1.4.3 Implications for an electronic journal

The majority of the studies mentioned in the preceding sections have concerned reading for fairly short periods of time, often using sub-optimal equipment and short passages of text. The tasks employed in these studies have varied, but in the main have involved proof-reading or visual inspection type tasks. In contrast, the use of VDUs for an electronic journal involves reading for sustained periods, using considerably longer texts and in order to perform a variety of tasks. Nonetheless, Gould et al. (1987b) have shown that it is possible for electronically presented text to be read as quickly and accurately as that in the paper medium. Those studies whose results have suggested that people do read slower from a VDU have typically used screens of poorer quality than those which Gould et al. found to produce equivalent performance between the two media.

1.5 THE NAVIGATION METAPHOR

According to the Oxford English Dictionary (OED), “navigation” may be defined as (i) ‘the skill or process of plotting a route’, or (ii) ‘the act or practice of navigating’. Definitions of “navigate” include (i) ‘to travel over, through or on’, and (ii) ‘to direct carefully or safely’. A number of writers have applied a navigation metaphor to the way in which users interact with a computer system. The present section commences with a brief discussion of metaphors, and then examines their application to a computer environment.

1.5.1 Metaphors

A metaphor enables people to draw upon existing world knowledge for use in other domains (Carroll and Carrithers, 1984). It may help them to extend a mental model developed for one domain to incorporate components of a new one – thus permitting the extension of an existing cognitive structure. Two dimensions of a metaphor are its scope (the number of concepts that the metaphor addresses) and the level of description of the knowledge it is intended to convey. Hammond and Allinson (1987) propose that
whether or not a given metaphor will be of assistance depends mainly on the nature of the information that the user reads into it:

“A metaphor need not be appropriate at all levels of description: the concept of an electronic book may be helpful in communicating concepts to users even if they cannot turn pages by stroking a touch-sensitive screen” (p.83).

Difficulties may occur where a number of metaphors overlap at the same level of description, such as in Weyer and Borning’s (1985) encyclopaedia, where models, tours, filters and a guide are all available at the same level.

1.5.2 Navigation and computers

It has been proposed that people form mental maps of the physical environment in which they live (e.g., Lynch, 1960), which are used for navigating through the environment. Most writers would appear to agree that such maps are formed in a number of stages. For example, Wickens (1984) considers there to be three stages: (i) the representation of knowledge in relation to landmarks, (ii) the acquisition of route knowledge, using these landmarks, and (iii) the acquisition of survey type knowledge about the environment, which permits the planning of journeys along routes not previously travelled.

Siegel and White (1975) propose that possessing a survey type cognitive map has two advantages over route type knowledge:

1. People are able to work out and use shortcuts to destinations.

2. If they become disorientated or lost, there is a greater chance of regaining their bearings and reaching the intended destination using a cognitive map, as opposed to merely route type knowledge.

Four aspects of navigation are discussed by Canter (1984):

1. Where am I?
Knowledge of present location is crucial for navigation:

“Probably the most fundamental starting point for way-finding is the knowledge which the individual has about his present location. Any future navigation is probably build upon knowledge of present location” (p.247).

Furthermore,
"In considering the processes involved in knowing where you are, it is worth emphasizing that this knowledge would appear to be built upon knowledge of where you have been. The knowledge of earlier location will then be linked to knowledge of present location by the person's understanding of how he travelled in between" (Canter, 1984, p.248).

2. Where there is
Features such as landmarks and boundaries are identified as being important orientating points, and there is evidence that knowledge of physical surroundings is stored by simple geometric forms.

3. How places are organized
It is claimed that we have process knowledge of the typical logical/psychological structure of places, and different types of processes have different strategies associated with them. An important aspect of our knowledge about the way in which places are organized is an understanding of where further information about the organization of the place can be found.

"The structural information we have about how the physical world is organized and the process information we have about how any particular facility is used, or how knowledge of that facility is to be gained, are both built upon and provide us with an understanding of where we are at the present time" (p.252).

4. Location
Canter (1984) considers that location must be represented in terms of some knowledge which the individual has already, while Best (1970) proposes that the more choice points there are at a given location, the more likely a person is to feel lost.

Canter, Powell, Wishart and Roderick (1986) remark upon the number of researchers who have referred to 'navigation' in relation to computers, either directly (e.g., Billingsley, 1982; Spence and Apperley, 1982; Dehenefe and Hennebert, 1976; Canter, Rivers and Storrs, 1985) or indirectly, through discussing issues such as 'mapping' (Hollnagel and Woods, 1983), 'lostness' (e.g., Tombaugh and McEwen, 1982; van Ness and Tromp, 1979), 'signposting' (e.g., Benest and Potok, 1983) and 'routes' (e.g., Wright and Bason, 1982).

The navigation metaphor has been applied to both computer systems and databases. In the former context, Fitter (1979) uses a navigation metaphor when he proposes that in order for the user to feel in control of a system, he needs to have an adequate knowledge of it. This is defined as knowing (i) where he has been, (ii) where he is, and (iii) where he can go from where he is.
“These clearly represent navigational matters and it should also be considered that in the case of the naive user, the means of travelling may be obscure as well as the destination” (Canter et al., 1986, p.249).

Carroll and Carrithers (1984) compare the new user of a wordprocessor to a stranger in an unfamiliar city with an inadequate map, speaking of the user being unaware that he has taken a wrong turning. However, as Hammond and Allinson (1987) say, the boundaries of the mappings between a metaphor and the system are often fuzzy – the metaphor does not explain everything about the system (indeed, the user does not expect it to) and not all of the metaphor maps onto the system.

The functions of spatial knowledge in a computer environment are described by Vigil (1988) as follows:

“The general consensus on spatial knowledge is that it can be categorized in two parts: route and survey (Chase and Chi, 1981). Route spatial knowledge is the memory of a sequence of events that take place during a given activity or the knowledge to execute a given task, when appropriate. These may be instructions that guide a user along a physical path or an intellectual one, as through a computer dialogue. Survey spatial knowledge is the global perspective of the network of events that organizes the activity or task. It is this knowledge which allows a person to understand relationships of various parts in the network regardless of their position” (p.52).

He considers that the role of the interface designer is to reduce the time necessary for the achievement of survey knowledge status.

Canter et al. (1985) point to the fact that it is now common to speak of databases as not only being searched – they are browsed, explored and scanned, and it is also recognized that people can get ‘lost’ in them. The authors propose that:

“...it is fruitful to recognize the direct parallels between navigating concrete environments, such as cities or buildings, and navigating data. After all, such parallels are implicit in the navigation metaphor, so it is worth establishing whether or not there is a fruitful analogy between the psychological processes involved” (p.93).

A place in the physical environment may be thought of as a node of data in a network, and a journey between two places as a path or link between two nodes.

“Selecting and arriving at a destination on a journey can serve as an analogy for asking and answering a question (or posing and solving a problem); planning a trip and navigating a course are similar to describing and locating areas in the information terrain” (Weyer, 1982, p.88).

According to Hammond and Allinson (1988),
"It is common to think of information in spatial terms, and many systems use a spatial analogy for representing a database. Travel therefore seems a promising metaphor for accessing structured information" (p.270).

A document and a database have some similarity in that they both provide information and cues for the selection of further information (Marchionini and Shneiderman, 1988).

1.6 LOCATION AND DOCUMENT NAVIGATION

According to the OED, "Location" may be defined as (i) 'a site, position or situation', or (ii) 'the act or process of locating'. One of the definitions of "locate" is 'to discover the situation, position, whereabouts of; find'. In discussing the process of navigating through a document, there are two aspects of location to be considered. First, the location of the desired information within the document, and second, the location of the reader within the document. Efficient navigation involves the reader's ability to travel through the document from their present location to that of the information which they are seeking.

1.6.1 Location as a cue

It has been proposed that mental operations may differ in the amount of attentional capacity that they require (Kahneman, 1973). Some writers (e.g., Schneider and Shiffrin, 1977) speak of a continuum of attentional requirements, while Hasher and Zacks (1979) contrast effortful and automatic processes. Effortful processes occur intentionally, benefit from practice, and interfere with other cognitive activities. Automatic processes, however, occur unintentionally, do not benefit from practice, and do not interfere with other cognitive activities. They may involve the encoding of information that is incidental to the main task. Spatial location is one type of information which may be automatically processed:

"While the data on the incidental processing of spatial information are not as numerous nor as clear as those on frequency processing, they may be interpreted as suggesting that spatial location, like frequency of occurrence, is processed automatically" (Hasher and Zacks, 1979, p.374).

A number of writers (e.g., McCormack, 1976; Underwood, 1983) consider spatial location to be one of the fundamental attributes comprising the constellation involved in an episodic memory (e.g., Brown and McNeill, 1966; Wickens, 1970). Spatial
memory has been shown to act as an effective retrieval scheme (Bower, 1970; Yates, 1966) and it may also function as an organiser for memory search:

"Retrieving available information from text in a spatial-temporal order may serve to reinstate salient retrieval cues" (Zechmeister, McKillip, Pasko and Belaspec, 1975, p.44).

1.6.2 What does the ability to navigate through a document involve?

According to Elm and Woods (1985), good spatial navigation skill is shown by three qualities:

1. The ability to generate specific routes as task demands require.
2. The ability to traverse or generate new routes as skilfully as familiar ones.
3. Orientation abilities – the development of a concept of ‘here’ in relation to other places.

Edwards and Hardman (1989) question Elm and Woods’ latter point, but it may be argued that the answer to the question “Where am I?” is meaningless unless it is in relation to the structure as a whole, where the person wants to go, or where they have already been. This is the case whether navigating through the environment or a document: “here” is a relative concept, having different meanings in different contexts.

Foss (1987) considers that navigation skills include:

1. Knowing the layout of the document, and your current position within this.
2. Knowing where you have been.
3. Being able to form a coherent summary (integration).

It has also been suggested that the ability to form an accurate overview of a document’s structure (i.e., knowing the layout) makes it possible to answer questions such as “Where was I when I saw...?” in other words, to locate an item of information that has been read previously (Mahony, 1988).

Wright (1987) considers that navigation skills involve the ability to answer three types of question:

1. Where am I now?
This may involve several questions, e.g., how a reader’s location relates to the structure of the document, or to their desired location within the document.
2. Where should I go next?
Associated with this are questions such as “Where have I been already?” and “What have I not seen?”.

3. How can I get back to...?
The ability to return to a previous location using the most efficient route.

1.6.3 Navigation cues on paper and screen

Cues to the structure of a document may be classified as either internal or external. Internal cues can be landmarks of various kinds within the text, such as diagrams or subheadings, or incidental cues used by readers, such as spatial location (e.g., Rothkopf, 1971; Lovelace and Southall, 1983). External cues are outside of the main body of the text, for example, contents lists, indexes, or maps.

Landmarks are one type of internal cue, attracting the reader’s attention, so they remember that a particular piece of information was before or after the landmark. Waller (1985) proposes that active reading strategies (initial browsing and skimming to preview the text, frequent looks-back and re-reading) help readers to

“build a ‘cognitive map’ of the text as a physical object, in which headings, illustrations, and other features act as landmarks. But this process relies on the text remaining stable...” (p.1),

and in a situation where menus and keywords are used (i.e., in electronic documents) “an intellectual construct has replaced the physical object”.

The use of landmarks in the electronic medium is noted by Hagelbarger and Thompson (1983), who found that users returned to the beginning of a menu system when they made an incorrect selection, thus relying on a landmark to guide navigation. McKnight, Dillon and Richardson (1990a) found that readers of a hypertext document spent more time looking at the contents and index sections of the document than did those using a linear version. Readers of the hypertext version used a style of interaction characterized by jumping into sections of the text and back to ‘base’ (i.e., a landmark) for further guidance.

These findings support Canter et al.’s (1985) hypothesis, that users return to known locations using ‘safe routes’. Methods of locating, characterizing and enhancing the visibility of landmarks may therefore be important in the electronic medium.
In the paper medium, the provision of a contents list is one of the conventional methods of helping readers to gain an overview of a document's structure. A contents list is a type of 'list structure' (Hartley, 1987), comprising a number of main elements containing a number of sub-elements. In the paper medium these are differentiated by typographic and spatial cues. Hartley says that:

"My own research in this area indicates that an important feature in the design of a list-structure is its spatial arrangement. Whereas readers prefer a combination of spatial and typographic cues to indicate each element in a list-structure, when given a choice between a spatial arrangement without typographic cues and continuous text with typographic cues, readers generally prefer the spatially arranged text" (p.73).

This again points to the importance of spatial cues in readers' interactions with documents.

1.6.4 Previous studies

1.6.4.1 The paper medium

A number of experiments have examined incidental memory for the location of text in the paper medium. For example, Rothkopf (1971), using a text presented on separate sheets of paper, concluded that incidental memory for its within-page location and the text-sequence location was significantly more accurate than by chance. The first of these findings was supported by the results of a study by Zechmeister et al. (1975).

An experiment by Lovelace and Southall (1983) compared performance on a number of tasks with a text presented in four different forms: (i) on a continuous paper scroll, (ii) on a scroll with pages marked, (iii) in a book form, and (iv) on single pages. There was no significant difference between the three ‘paged’ conditions in the accuracy of either substantive content recall or within-page location recall. However, the availability of within-page location information did have a significant effect on the accuracy of substantive content recall, this being poorer in the ‘no pages’ condition. In addition, the results of a study by Christie and Just (1983), indicated that, even when the passage was disorganized, readers were able to use the order in which information appeared as a relocation cue.

As Schulman (1983) says, words on a page are much more difficult to encode spatially than many other objects, and successive pages appear to have very similar outlines. Consequently, although the absolute levels of performance found in these studies have been ‘modest’, the effect is particularly noteworthy because:
Studies have also investigated the possible relationship between memory for the location of text and memory of its substantive content. Rothkopf (1971) found that accuracy of substantive content and within-page location recall were correlated, but accuracy of substantive content and text-sequence recall were not so. Within-page location recall was more accurate when substantive responses were correct than when they were incorrect, and the trend suggested that within-page location recall was also present for incorrect substantive recall.

The results of an investigation by Zechmeister et al. (1975) indicated that informing subjects of a subsequent test for spatial recall did not significantly influence accuracy of either content or location recall, thus providing evidence that spatial location is processed automatically. It was again found that within-page location recall was more likely to be accurate when content recall was correct.

Zechmeister and McKillip (1972) concluded that when spatial knowledge was provided, accuracy of content recall was not affected. However, Lovelace and Southall (1983) proposed that the cues provided in this earlier study may not have been sufficient to reliably reinstate the location information. The results of their investigation indicated that the provision of content information did significantly improve accuracy of location recall. In addition:

"Precise reinstatement of the configuration of within-page location cues apparently results in greater recall of the content of a prose passage" (p.433).

These findings of the above studies support Christie and Just’s (1983) proposition, that

"When content is stored in an external display, location information can serve as an index to the content information. The locative information tells the subject where to look for the content information he wants" (p.709).

Rothkopf (1971) suggests three possible explanations for the relationship between accuracy of content and spatial recall:

1. A content item for which a correct response cannot be supplied is a less complete cue for making a location judgement than a content item for which a correct response is given. Less accurate location recall for incorrectly recalled content items is due to stimulus generalization decrements.
2. Conditions precipitating failure to learn content also produce failure in the learning of location. This is an attention theory – subjects fail to attend to a particular section of the text.

3. Location memory is a mnemonic aid for content recall, and vice versa. This latter hypothesis is in agreement with Underwood’s (1969) theory that spatial attributes may fulfill a discriminative function in memory.

Both Lovelace and Southall (1983) and Zechmeister et al. (1975) consider that the second explanation is untenable, because recall of content does not appear to be differentially related to quadrant of the page, but accuracy of location recall is so (Zechmeister and McKillip, 1972).

Lovelace and Southall (1983) argue that any model of memory assuming that (i) a coded memory representation for an event is a constellation of attributes and (ii) the greater the number of attributes retrieved, the greater the cueing value for accessing individual attributes, may support the other two explanations. They consider the most important question to be whether certain attributes are fundamentally independent in their activation at the time of attempted recall, or whether they interact so that each may facilitate activation of, or access to, the other. The recall of a given attribute is facilitated by the recall of other attributes that are:

“components of some constellation of attributes constituting the memory for that prose passage” (Lovelace and Southall, 1983, p.434).

When the recall of a content word is unsuccessful, a spatial attribute may “mediate a subject’s subjective belief that a memory has been established” (Zechmeister and McKillip, 1972, p.446). Spatial recall may then perhaps precipitate a ‘tip-of-the-tongue’ state (Brown and McNeill, 1966). It would therefore appear that:

“visually mediated spatial memory is a fundamental attribute when text material is encoded, and may be of mnemonic worth when retention of information is required” (Zechmeister et al., 1975, p.43).

1.6.4.2 The electronic medium

The studies described above presented texts to subjects in a paper medium. The first experiment in a study by Haas and Hayes (1985a) compared subjects’ performance in a location task using text presented on paper and screen. It was found that recall of the vertical location of the text was significantly more accurate in the paper medium, but neither horizontal or text-sequence (page or line number) location accuracy were
influenced by presentation medium. In a second experiment, subjects were asked to relocate information from within a text presented on paper or in one of two screen conditions, the latter differing in both the number of lines per screen and the quality of the display. Performance was slower using the ‘standard’ CRT display, but there was no significant difference between the other two conditions. However, the results were confounded by the fact that the screen conditions used different text editors.

In a follow-up study (Haas and Hayes, 1985b), subjects were required to re-organize a disordered passage. Performance was compared using text presented on paper and in four screen conditions. The latter differed in the size of the display (46 lines or 22 lines) and in the method of advancing the text (scroll bar or function keys). Subjects reading from the 22-line display completed the re-organization task significantly more slowly than those using either the 46-line display or the paper version of the text, but there was no significant difference in performance between the last two conditions. The method of advancing the text was not found to have any influence on performance.

Readers of electronically presented documents often have difficulty in relocating information that they have previously read. For example, in a refereeing task (Wright and Lickorish, 1984) it was observed that subjects appeared to lose some of the incidental cues that they would pick up when reading from paper, and so were more unsure where in the text they had read a particular piece of information.

There is some evidence that using a screen with a display larger than 80 x 24 lines is beneficial, because more of the text is visible at once, and so there are fewer screens to be searched (e.g., Haas and Hayes, 1985b). However, as Wright and Lickorish (1988) point out, it may well be that part of the available screen space is occupied for another purpose, thus reducing the size of the window in which the document is read. They suggest that an alternative solution is to introduce other visual cues into the document.

A study by Wright and Lickorish (1988) examined the influence of using colour as a visual cue, in both the paper and electronic media. The text employed in the study was in several sections. In the paper medium, each of the sections was printed on a different coloured piece of paper, while in the electronic medium, the background colour of the screen was varied. It was found that although colour cues were of significant benefit for the relocation of information in the paper medium, they were not so in the electronic one.

In a later experiment (Tombaugh, Lickorish and Wright, 1987) the use of multiple windows as a method of introducing spatial cues into an electronically presented text was examined. Subjects’ performance in an information retrieval task using a single
window was compared to that using a 'reverting stack'. The two special features of the latter were referred to as 'perceptual' and 'procedural' stacking. The first of these terms meant that when all of the windows were closed they formed a perceptual overlapping stack, each window having a heading which was visible when the stack was tidied. The second term meant that whenever a window was closed, it returned to its correct position within the stack. Consequently, at any one time, the only window not in its correct sequential order was the window at the front of the stack (i.e., the one currently being read). This produced a situation in which the windows retained a permanent location relative to each other within the stack.

It was found that performance was significantly better in the multi-window condition — readers remembered in which window information was located and were able to use this cue to retrieve the information. Furthermore, it did not appear to be necessary for the window’s contents to always be visible, it was sufficient for the windows themselves to have a permanent location on the screen. The authors concluded that once a certain minimal ability to understand and manipulate the display has been acquired, multi-windows helped readers to relocate information from within a text.

However, as Tombaugh et al. themselves point out, their study did not ascertain which characteristic of the reverting stack was responsible for the superior performance. They also suggest that the use of a fully tiled display, as would be possible on a larger bit-mapped screen than that used in their study, may be of even greater benefit to readers, because it enhances the spatial separation between the sections.

1.7 THE DESIGN OF ELECTRONIC DOCUMENTS

There are two basic approaches to the electronic presentation of documents. The first is to attempt to imitate the paper version, and the second, to exploit the capabilities of the new medium.

1.7.1 Imitating the paper medium

Several writers have pointed to the advantages of the paper medium, particularly those which are a consequence of its physical nature. According to Oren (1987), these include:

State preservation — the printed volume stays the same when it is not being used, i.e., bookmarks, annotations and temporary notes remain.
Serendipity — this is said to be encouraged by the physical nature of the book.

Closure — it is obvious to the reader when the document has been finished, and it is easy to tell how much more there is to read (i.e., the amount and weight of paper on the left and right sides).

Oren also mentions the portability of a paper book, and the fact that its size, feel and design all convey information about the likely relevance of a book to a particular task. He claims that paper is a "low overhead" medium — if a reader wishes to, he can simply read the information in the order given by the author, knowing that it was designed to be comprehensible in such a way.

Benest and Morgan (1985) consider that the conventional book structure is so well known, there is no a priori reason for changing it:

"It is wrong to impose a new model on the basis that a new medium should provide a new solution, when the old solution is quite adequate" (p.4).

Furthermore,

"Any computerized system which attempts to change the way in which people work meets opposition when the change is incompatible with well tried and tested manual methods" (p.4).

The authors describe a book emulator which shows two pages side by side, with the pages beneath splayed out to show the position in the book of the current page. Paging forward and backward are accompanied by animation to reinforce the change of display and inform the user that he is moving in the intended direction. It is possible to select a specific page from the index, and place a bookmarker at the current page. When a book is chosen, if it has a marker from a previous session, it is opened at this marker instead of at the beginning. An additional feature of the emulator is a bar across the top of the display, representing the size of the book. It contains a marker showing the position of the current page and the reader's position in the book can be altered by selecting a new position from within the bar.

In a later article (Benest, Morgan and Smithurst, 1987), a metaphor for a library, claiming to model conventional mechanisms for searching, acquiring and reading paper documents, is described. The authors propose that the book model is so well learnt that if an electronic version is presented in the same way as the real one, then the system will be easier to use.
"The familiarity which professional people have with libraries of books overwhelmingly demands a solution based on that model of the library" (p.908).

More recently, Benest (1990) says:

"This paper argues in favour of rejecting the old computer solutions: of scrolled text, paged displays, multiple windows onto scrolled or paged text, and information hiding hierarchies, and replacing them by a new managed medium that is visually and navigationally based on, but not strictly limited to, the book metaphor" (p.53).

The structure of the paper book is preserved, on the ground that it allows the reader to locate key sections, such as the index, easily. It is intended that the emulator should

"open up the ‘tunnel vision’ effect notable of hierarchical and network orientated systems. The Book Emulator effectively provides the notion that all information within the book is contained within its visual boundary" (p.54).

Benest (1990) points to the fact that although books are in a sense hierarchically structured, they are physically linear. He considers this to indicate that hierarchical structures should also be presented linearly in the electronic medium. However, the author does acknowledge that the emulator is not intended as a means in itself, merely as an access mechanism for information. Consequently, if it is to be preferred to the paper version, it should provide additional benefits. Those provided in the more recent version of the emulator include:

**Navigation assistance**
When a reader of a paper book fails to turn a page successfully, his attention is diverted from the reading task, but pages never stick in the emulator. References in the emulator are indicated by a unique number in brackets, and if the reader wishes to see the details of the reference, he can either go to the back of the book, or click on the number, which causes the reference to be displayed on the opposite page. If he goes to the References section and clicks on the number, the pages of text on which this reference is made are displayed, and the citation blinks to attract the attention. In addition, a bookmark is placed in the References section when this happens, and selecting the bookmark causes the book to turn back to the original text. The page numbers in the contents and index sections are selectable, and a bookmark is placed in them in the same way as for the References section.

**Annotation support**
Items can be highlighted, underlined, or annotated. Bookmarks can also be placed in the emulator; if they overlap the top of the book, then they can be selected to open the book at the marked page.
Search assistance
A search facility permits the user to specify a word and cause the emulator to search for it in the text. The emulator highlights the lines of text on which the first occurrence of the word appears, and flicks through the remainder of the book to show the scope of the occurrences of the target word.

Dynamic content
Frames can be manipulated to produce simple animation.

Walker (1987) would appear to share Benest’s philosophy; discussing the design of Document Examiner, she says that:

"The most fundamental decision in the interface was to make the material that a person was reading look essentially as it would in a paper book. The reason for doing this was ‘ease of use’. We saw no reason to have the underlying information structure be reflected in the user interface model unless that structure was a good model for interacting with information. My experience in trying to help users with a tree-structured information interface (the ‘Info’ subsystem in Emacs) led me to believe that a book-like interface would be more palatable for many people" (p.314).

As Kerr (1986) states, some studies appear to assume that electronic and paper text are fundamentally similar, and consider the main issue to be how the conventions of the paper medium can be adapted to the electronic one. Other studies assume that the two media have little in common, and that conventions from the paper medium will therefore be of very limited utility on screen. He makes the suggestion:

"Would it not make sense, given the growing recognition that paper and screen share certain similarities and are separated by certain unique features, to first identify the singular aspects of video screen design, and focus research efforts on them?" (p.207).

Shneiderman (1987b) believes that we have the opportunity to create a new medium which is potentially more attractive and effective than printed books in many situations. As the author points out, techniques in the paper medium arose out of developments in the paper-making and print industries, and there is no a priori reason for assuming that they will be optimum in another medium. He concludes that imitating the paper medium will only be of utility in that it may act as a means of gaining acceptance for the new technology.

1.7.2 Alternatives

In contrast to Benest’s approach, Weyer (1982) proposes a ‘dynamic book’ for information search.
"A dynamic book is a new way of interacting with information. Ideally it should be portable, with all the ease of use we associate with paper books. A dynamic book can react to its readers, not only by changing the medium of the information from text to animated pictures or sound, but also by transforming the organization of its content into a more useful form and by actively aiding the reader in the search process. A dynamic book is a particular view on an interconnected network of knowledge" (p.90).

According to Weyer, paper books are static stores of information, whereas a dynamic book has 'active aids' for the search procedure. These include (i) being able to store a history of where the reader has already looked, (ii) being capable of returning him to previous choice points, and (iii) suggesting where he has not looked.

"In summary, a dynamic book would not only be a new kind of container for information, but also a collection of methods for accessing this content through many forms or maps. It could also aid the reader in searching through this collection of methods" (Weyer, 1982, p.91).

Weyer considers that electronic systems should not merely be imitations of the paper one, but should:

"offer the potential of increased availability of information, shared access to up-to-date versions, alternate presentation of information, flexible access through content and multiple indexes, and active help in searching. Help in searching includes not only augmenting and suggesting search methods, but also managing the new information created about the search itself: where we have looked and what we should look at next. These more powerful versions of electronic books can be called 'Dynamic books'" (p.87).

In a later paper (Weyer and Borning, 1985), a prototype electronic encyclopedia is described, in which the text of an existing encyclopedia is dynamically altered. The encyclopedia permits the application of a variety of techniques derived from research into areas such as knowledge representation, authoring systems, natural language, intelligent tutors and user modelling. The proposed electronic encyclopedia has the following features:

**Browser**
The browser is window-orientated, containing a set of non-overlapping panes. It comprises a selectable alphabetical article index, a selectable article list (maintaining a record of the articles chosen by the user), a contents table for an individual article and a text window. An index entry may contain a hierarchical structure for an article – the next level down the hierarchy is inserted into the index when the reader selects the appropriate symbol.
Active text
Active text areas are indicated by various typefaces for particular purposes. One example is the facility for browsing to cross-references within the text. When a cross-reference is selected, its name is added to the article list for later viewing.

Filters
A number of filters are provided, including filters permitting readers to alter the window layout and choose how much text is displayed when a subsection is selected.

Simulations
In some of the articles, the textual description is augmented by simulations of relevant features (e.g., an interactive abacus).

Spence and Apperley (1982) describe a method of representing information currently stored in the paper-based journal system, which they refer to as the ‘Office of the Professional’. It is proposed that memory for the previous location, spatial, symbolic and textual cues are all relied upon in the selection of a book from an office. Memory is enhanced if the books can be seen, then it is only necessary to recall the approximate location by a rapid browsing or scanning action. The authors consider that because spatial memory and search by visual scan have been developed to a high degree of efficiency, they should be exploited in an information system. In the Office of the Professional, journals are represented by icons on the wall of the office, and selection is by means of a pointing device, confirmatory feedback being provided by an illuminated spot on the wall.

The use of a ‘bifocal display’ is proposed, in which the screen is divided into three vertical sections. Information of prime interest is displayed in the centre of the screen at a high level of detail, and the outer two regions contain demagnified displays with just sufficient detail to give an overall impression of other available information. It is considered that

"The bifocal display presents a solution to the difficult problem of the blinkering effect of windowing, by providing an awareness, at a useful level of detail, of the entire context an item of information while simultaneously providing a detailed view of that item" (Spence and Apperley, 1982, p.53).

The authors refer to the concept of ‘information levels’, whereby the information is stored in a hierarchical manner at different levels of detail. Thus the journal comprises the same five levels as in the present paper-based system: library, journal, volume, issue and article. These levels are represented in the system as follows:
Level 1 — journal icon.

Levels 2 and 3 — volumes, in a bifocal display. Level 3, containing one year’s volumes, in the centre and the other available volumes down the sides (previous years on the left and future on the right) at level 2.

Level 4 — the index for one month of the selected volume in the centre of the display, with the other months from the volume in the outer regions.

Level 5 — the text of the article.

Spence and Apperley conclude that paper-based procedures should not be retained if new technology is able to offer facilities which lead to enhanced performance, but

“What should be mimicked and exploited are the highly developed and therefore instinctive human perceptual, cognitive and motor abilities that are at present constrained to operate within different technological and other limits” (p.53).

Many writers have expressed opinions similar to that of Walker (1987), who says that:

“Replacements for the good qualities of paper need to be more than mere imitations that try to carry surface features of paper into the electronic world. Instead, they should be functional analogies that provide the same kinds of benefits with an entirely different implementation” (p.313).

Yankelovich, Meyrowitz and van Dam (1985) suggest that by considering the strengths and weaknesses of paper and electronic documents, it is possible to formulate a set of capabilities that electronic document systems should possess in order to maximize the advantages of the electronic medium and overcome some of the disadvantages of the paper one.

1.8 HYPERTEXT

The present author considers that designers of electronic documents should take advantage of the facilities offered by the electronic medium, but it is vital that the design process is user, and not technology, driven. One approach to the design of electronic documents which does permit the facilities of the new medium to be exploited is by the use of hypertext systems. According to the OED, “hyper” means ‘over-much, above or beyond’, and “text” may be defined as ‘sustained argument, train of thought or
narrative, etc., in a written form'. The very name "hypertext" therefore implies that such systems may confer advantages over 'conventional' documents.

1.8.1 Background

Although the underlying concepts of hypertext have been around for some considerable time — 'Memex' was proposed by Bush in 1945 — it is only recently that technology has permitted them to be implemented. Major factors are the widespread availability of high resolution bit-mapped displays and direct manipulation interfaces.

Among the applications of hypertext are: as an ideas organizer, for online documentation, technical and repair manuals, tourist information, museum information, teaching, as an authoring tool and as a programming tool. It has also been used for product catalogues, exhibit/trade show information, large handbooks (e.g., Whole Earth Catalogue) and interactive fiction.

1.8.2 Definitions

The term 'hypertext' was first used by Nelson in 1965, and many definitions have been proposed. However, it would appear to be generally accepted that hypertext has some features in common with a directed graph:

"Hypertext denotes a technique for organizing textual information in a complex, nonlinear way to facilitate the rapid exploration of large bodies of knowledge. Conceptually, a hypertext database may be thought of as a directed graph, where each node of the graph is a (usually short) chunk of text, and where the edges of a graph connect each text chunk to other, related, text chunks. An interface is provided to permit a user to view the text in such a database, traversing links as desired to explore new areas of interest as they arise, check background information, and so forth" (Weiland and Shneiderman, 1989).

A similar view is expresses by Collier (1987):

"In graph theory a network is defined by a set of vertices and edges or nodes and links. All hypertext systems share the notion of text that has been 'stitched' together by a set of links" (p.272).

Conklin (1987) goes on to describe a directed graph of textual elements as being similar to semantic networks in an Artificial Intelligence context:
"The analogy to hypertext is straightforward: hypertext nodes can be thought of as representing single concepts or ideas, internode links as representing the semantic interdependencies among these ideas, and the process of building a hypertext network as a kind of informal knowledge engineering. The difference is that knowledge engineers are usually striving to build representations which can be mechanically interpreted, whereas the goal of the hypertext writer is often to capture an interwoven collection of ideas without regard to their machine interpretability" (p.37).

Hammond and Allinson (1989) suggest that the large number of interpretations of the term 'hypertext' is not surprising, because the essence of hypertext lies in the support that it provides for the user's task, not in specific data structures, facilities or interfaces. They consider it to be more fruitful to define what hypertext does, as opposed to what it is:

"through direct interaction with information items it permits the rapid and efficient access to further relevant information" (p.293).

This opinion is endorsed by Brown (1988a):

"The object of hypertext is to represent a body of information in a form that captures all the inherent interlinks in the information. Readers can then peruse the information, following the links of their choice. The aim is that by this means the reader will more quickly be able to gain an understanding of the information, and extract the parts he wants" (p.2).

Monk, Walsh and Dix (1988) point to the fact that hypertext removes some of the constraints of conventional linear text by providing mechanisms for physically realizing the conceptual links between related sections of material:

"With printed material and most text editors the underlying object manipulated by the user has serial or sequential structure. Thus, page one is followed by page two, line one is followed by line two and so on. Hypertext permits the use of hierarchies or any other form of connected network to access related material within the system. Further, if the links between screens can be of different types, then it is possible to impose alternative structures on an object" (p.422).

Several writers have attempted to list the features commonly found in hypertext systems. Nielsen (1989) proposes that hypertext has the following characteristics:

1. Nonsequential writing.
2. Interlinked pieces of text.
3. Units have pointers to other units of information.
4. Readers follow these pointers.
5. A backtracking facility is provided.
Akscyn, McCracken and Yoder (1988) conclude that there is no generally accepted definition of hypertext, but the majority of hypertext systems can be characterized by the following features:

1. Information is "chunked" into small units (cards, frames, nodes, etc).
2. Units of information are displayed one per window.
3. Units of information are connected by links, and navigation in the database is by traversing these links.
4. Users can build information structures for various purposes by creating, editing and linking units.
5. In shared systems, multiple users may simultaneously access the database.

Some writers argue that in its purest form, a hypertext system does not differentiate between reader and author:

"Ideally, authors and readers should have the same set of integrated tools that allow them to browse through other material during the document preparation process and to add annotations and original links as they progress through an information web. In effect, the boundary between author and reader should largely disappear" (Yankelovich et al., 1985, p.21).

An alternative approach to defining hypertext is to compare it with other electronic information systems which, although they may possess some of the attributes of hypertext, are not in themselves hypertext systems. Conklin (1987) describes the following types of systems in this context:

1. Windowing systems – these have the interface functionality of hypertext, but lack the single underlying database which characterizes such systems.
2. File systems – a file system is a database and the user moves among nodes, but a hypertext system must provide more machine support for the links than the user having to type in filenames.
3. Outline processors – these do have an integrated hierarchical database and interface, but there is little or no support for references between outline entries.
4. Text formatting systems – these allow text fragments in separate files to be gathered into one large document, but the interface provides no on-line navigation facility.
5. Database management systems – these have links of various kinds, but lack the single, coherent database interface of hypertext.
McKnight, Richardson and Dillon (1988) also discuss hypertext in terms of its relationship to other systems. They acknowledge that database management systems have links of various types, and it may be possible to construct a relational database resembling a hypertext one. However, the difference is explained in the lack of "a single coherent interface to the database which provides the 'look and feel' (if not the definition) of hypertext". An inverted file could be viewed as a set of links permitting any word to be accessed, but in such systems, "a word is simply an alphanumeric string, the basis for a search operation rather than a unit of meaning". The authors propose that it is possible to build a database which resembles hypertext in either of these two systems, but the difference is in the underlying purpose for which the systems were designed.

In conclusion, perhaps the simplest definition of hypertext is that proposed by Raskin (1987), who says that:

"Hypertext, in a nutshell, is text (in the sense of what one finds in books) where there are links between different text and portions of texts for some very large universe of knowledge" (p.326).

1.8.3 Systems

A number of methods of classifying hypertext systems have been proposed. For example, Halasz (1987) suggests that they can be classified along the following three dimensions:

1. Scope – the scale of the expected user populations and information bases.

2. Browsing vs. authoring –
   Browsing – the emphasis is on tools for the exploration and presentation of information, and less on creating and modifying the network.
   Authoring – the emphasis is on creating and modifying the network, and less on exploration and presentation tools.

3. Target task domain – systems may be designed for a specific task or provide general facilities to be used in a variety of applications.

Trigg, Suchman and Halasz (1986) consider there to be a distinction between systems that are designed to support the browsing of existing databases or the creation and modification of databases. In Fiderio's (1988) view, hypertext systems may be divided into four basic types: problem-resolution systems, on-line browsing systems, library or literary-exchange systems and multi-purpose systems.
However, for present purposes, Conklin’s (1987) approach will be adopted. He proposes that because of the difficulty of classifying hypertext systems according to their features, it is more fruitful to consider their applications. Four broad application areas for hypertext systems are suggested:

**Macro literary systems**
- large on-line libraries with machine-supported interdocument links.

**Problem exploration tools**
- support early unstructured thinking on a problem involving many disconnected ideas.

**Browsing systems**
- similar to macro literary systems, but smaller in scale.

**General hypertext technology**
- general purpose systems designed to allow experimentation with a range of hypertext applications.

Systems in each of these areas will be briefly described in the following pages, with particular reference to the navigation facilities provided in each.

### 1.8.3.1 Macro literary systems

**Memex**
The basic philosophy behind ‘Memex’ (Bush, 1945), was that a very large library and all of a person’s books, records, photographs and communications were stored in the system on microfilm. The essential feature of Memex was the ability to tie two things together to form a trail through the material.

**Xanadu**
The ‘vision’ of Xanadu (Nelson, 1967) was that nothing would ever ever deleted and all versions would be retained and accessible. Everyone would be able to cite/include/link to any other text, with readers paying the original author a fee for including their material. The emphasis was on creating a unified literary environment on a global scale, containing the following features:

1. Selective expansion or elision of sections.
2. Immediate following of cross-references.
3. Keyword searches restricted to parts of structures.
4. Inverted searches.
5. Dynamic expansion of terms in the glossary.

NLSA augment
In the oNLiNeSystem, files are structured into a hierarchy of segments called 'statements', each of which has an identifier showing its level in the file. Any number of reference links can be established between statements, both in and between files. Although the structure is mainly hierarchical, non-hierarchical links are also permitted. Information is selected from viewing filters, which enable the user to clip the level (depth) of the hierarchy displayed, truncate the number of items shown at any level, and write customized filters.

THOTH-II
Thoth-II differs from other hypertext systems in that instead of links connecting regions of text to other regions of text, the links connect nodes, and text is in turn connected to these nodes by other types of links. Although TextNet also shares the idea of text embedded in a semantic net, in this system only one piece of text is stored as a 'chunk'. In Thoth-II, nodes represent conceptual anchors around which pieces of text and connections to other objects are collected.

Browsing takes place by interacting with a graphic display of the nodes and connections, called ThothSpiders. It does not show the whole structure at once, as do systems such as SemNet. In the latter case the nodes have locations in 3-D space, and only a single display object exists for any given node. There are problems with such an approach, in that it is difficult to display all of the nodes and links clearly. In the browse mode of Spiders the space is a 2-D plane, rather than to a 3-D space. The location of a node has no particular meaning in terms of the abstract structure being displayed, it is purely a function of the user's interaction with the system. Users therefore create the graphic objects as they browse.

Nodes are initially shown unexpanded, and the structure is browsed by expanding the nodes, causing all of its links to be shown. Because the display is conceived as a window onto a larger plane, it is possible to move the window around over this to view other areas. When a text node has been selected for viewing, the text mode is invoked. In this mode a pop-up menu showing the text linked with the selected node is available.

Domain/Delphi (Jaynes, Barstow, Leeds and Cuti, 1989) is an interactive delivery system for manuals. An online set of documents is represented as a group of libraries, each containing several books. As in the paper medium, these books are composed of chapters and sections, using the same fonts and graphics as in the hardcopy versions.
The latter feature is claimed to make the electronic versions “attractive and easy to read”. When a selected portion of text is displayed, it is possible to scroll from page to page, search for specific text strings, and copy and paste to other documents in the system. Information is located by searching the index for topics or traversing the global table of contents to locate the information hierarchically, thus enabling readers to use Domain/Delphi to retrieve information in ways already familiar to them. The system’s features may be summarized as follows:

1. Pages displayed with multiple text fonts and graphics.
2. User-tailored keyword searches.
3. Hierarchical browsing.
5. Dedicated processes and windows.
6. State maintenance between sessions.
8. Support for cross-reference links between retrievable documents. Authors and readers may both create links and navigate between documents using this mechanism.

TextNet

TextNet has two basic types of nodes: those which have textual content (‘chunks’) and those which hierarchically organize other nodes (table of contents, ‘TOC’). The system therefore supports hierarchical trees (via the TOC nodes) and non-hierarchical graphs (via typed links). It also supports paths, which are ordered lists of nodes providing default routes through the network.

1.8.3.2 Problem exploration tools

gIBIS (Graphical Issue-Based Information System)

This system uses three basic types of nodes: Issue, Position and Argument, which can also be combined to produce composite nodes. The main interface is divided into four windows – a graphical browser, a structured index of the nodes, a control panel and an inspection window. gIBIS contains ‘primary’ and ‘secondary’ links. Primary links are created when a node is automatically linked into the existing network, and form the hierarchy which is the basis for the structured listing in the index window. All subsequent links are secondary links. The two types of links differ both visually and navigationally.

A visual representation of the graph structure is provided by the browser. Most of the browser is dedicated to a local view of the network – a zoomed-in view of the area of
current interest, with the nodes and links in full detail. In the bottom right is a global overview of the entire network, with no node labels, link-type icons or secondary links. A rectangular overlay shows the scope and position of the local view within the global one. There is a zoom facility, so that the user can scroll and click the mouse to centre the focus on that point. Selecting a portion of the global view makes it the new local one. To view an object (node or link), the user selects it from the display and the browser highlights the object and puts its contents into the inspection window.

**Symbolics Document Examiner**

Document Examiner is an interface for commercial hypertext documents. It does not have a directed graph as its interface model, but the database is organized as a set of modules, whose size is determined by the author. These modules are connected by directional links. The system is window-based, and has five ‘panes’:

1. **Viewer** — intended to simulate reading a book.
2. **Command** — system commands.
3. **Candidate** — these are retrieved in answer to a query.
4. **Bookmarks** — a chronological list of the topics seen.
5. **Overview** — shows a graph of the inclusion and outward links for a topic.

The names on the overview are selectable, perhaps calling up further overviews, and permit the reader to explore the ‘neighbourhood’. However, this graphic display is intended mainly as a decision-making aid, and only secondarily as a navigation one. Walker (1987) proposes that the type of overview used in Document Examiner has advantages over a table of contents or full display of the graph, because it constrains the amount of information presented to the user, while still providing sufficient relevant information on which to make a decision.

**WE**

The Writing Environment is designed to support the organization of a loosely structured network of ideas into a hierarchy, and its subsequent encoding into a linear sequence. It uses a relational database for storing the nodes and links in the network. There are two main windows in the system, one graphical and the other hierarchical. The latter has four display modes: (i) the tree depicting the hierarchy is laid out on its side, with the root node on the left, (ii) it is hung vertically with the root at the top, (iii) child nodes are displayed inside their parent node, and (iv) the hierarchy is shown in the traditional outline view. A third window is an editor for material in the current node, a fourth is for queries to the database, and a fifth window is used for the control system.
1.8.3.3 Browsing systems

ZOG
This is a general purpose system based on the concept of menu-selection. It uses ‘frames’ instead of nodes, and these are connected by two kinds of links — hierarchical and cross-referential. ZOG supports three forms of interaction: navigation (the default), invoking programs, and editing. Although it is possible to represent arbitrary structures, hierarchies are considered to be the main type of structure. A distinction is made between movement within the levels of the tree structure and cross-references not within the structure. The system does not support overlapping windows, and there is no browser provided.

KMS
KMS is a distributed system, based on ZOG. A distributed system means that portions of the database are distributed across multiple workstations and file servers on a network. A KMS database comprises a set of interlinked units, termed ‘frames’. These may contain a combination of text, graphics and images, and can be linked to other frames or used to invoke a program. Most KMS databases have a strong hierarchical orientation, although

“The central metaphor is that the database is a universe of connected spaces through which users rapidly travel, like pilots navigating spacecraft in the real universe” (Akscyn, McCracken and Yoder, 1988, p.822).

There are two types of links and one type of frame in the system. Links are unidirectional, and their destinations are whole frames (like NoteCards and HyperCard). The screen of KMS may be bisected, and the user has two options — to view two nodes, one in each window, or to view one node taking up the whole screen. Two navigation facilities are provided: a breadth-first view of the frames and a linear view of the hierarchy of frames. There is no graphical browser, but KMS contains a number of features which are intended to prevent disorientation:

1. A hierarchical skeleton, which also shows whether a link is hierarchical or a cross-reference.

2. Commands which permit the user to go directly to a specific location within the database. It is proposed that if he has arrived at an unfamiliar part of the database, the user can follow the links up through the hierarchy to see the global context.

3. Flagging previous selections — the item linked to the frame from which the user has just backtracked is marked.

*SuperBook*

There would seem to be some debate as to whether SuperBook is a hypertext system or not. However, as Remde, Gomez and Landauer (1987) conclude:

“When SuperBook is considered in contrast to many other systems which are generally labeled hypertext, we must ask the question – is SuperBook a hypertext system? Yes and no. Yes, at least in spirit, SuperBook is a hypertext system because it is a collection of tools explicitly designed to encourage the flexible exploration of ideas by making information more available. This goal was the original appeal of hypertext-like ideas. However, judged by its formal or architectural similarity to other recently developed systems, SuperBook may not be an example of a hypertext system. Those recently developed information browsing tools commonly designated as hypertext, have data structures which directly support handcrafted author generated machine readable links between elements in an information space. In addition, these systems usually have sophisticated graphics tools and displays, to aid authors and readers in the creation and modification of the structure connecting the information modules. But, are these features, which SuperBook lacks, necessary to accomplish the basic hypertext goal: a useful environment for the flexible exploration and creation of ideas? We think this is an open question” (p.186).

In a later paper (Egan et al., 1989) it is proposed that SuperBook fits Conklin’s (1987) description of a structured browsing system, and it will be described in that context in the present discussion.

SuperBook transforms an ordinary text into a multi-windowed display with rich search, navigation and annotation enhancements. Each text window has a heading providing information concerning its location within the structure of the document. A separate window contains a table of contents which displays various levels dynamically, as in a fisheye view. This contents list expands like an unfolding in hypertext, and search words which occur as topic headings are highlighted. In the text window the user can either view text, select from a table of contents entry, or ask to see the context surrounding the next occurrence of a search word. Active search words are automatically highlighted when the text is displayed. Graphics appear in a separate window, and not in the main body of the text.

The goals of SuperBook were to develop ways to automatically expose the structure in existing documents, and to give the user tools to explore it in a non-linear fashion.

*HyperTies*

HyperTies is based on the concept of embedded menus, whereby links are represented by words or phrases (targets) appearing in the text itself, and are associated with other entries. When a target is selected, a short description of the referenced entry is provided
in a separate window. If the user elects to follow the link, the full entry replaces the currently displayed one. There is also a selectable index of all the entries in the database, a table of contents, a history of the user’s past route through the database, and a string search facility. It is possible to have more than one card visible at a time, and each article appears in its own window. Shneiderman (1987b) claims that HyperTies:

“Allows authors to create a network of conceptual knowledge in which concepts are linked explicitly and the readers are free to explore pathways based on their needs and interests”.

**Electronic Document System**

The Electronic Document System comprises three subsystems, the Picture Layout System – a structured graphics editor, the Document Layout System – used for constructing the web structure of the document (linking pages by creating buttons), and the Document Presentation System – through which readers traverse the links.

Two forms of maps available to readers. One type of map provides a history of the reader’s path through the document in the form of a ‘timeline’, with selectable miniatures of the pages visited. In the second type of map, a miniature of the current page is displayed in the centre of the ‘neighbourhood view’, on the left are miniatures of all the pages from which the reader could have come, and on the right, of those he could go to next.

**Guide**

Guide was the first popular commercial hypertext system. It began as a research project in 1982 and was released in 1986. In Guide, a document is displayed as a single scroll, with the intention of disguising the underlying data structure. The system uses several types of buttons, which are anchored to text or graphics:

Replacement buttons – these are considered to be the most important type of button in Guide. When selected, the button is replaced in-line by new material. Replacement buttons are typically used to expand a document, and can be ‘refolded’ under the original button.

Reference buttons – permit cross-references between different parts of a document, or between documents.

Note or glossary buttons – out-of-line replacement in a separate window.
**Boxer**

In this system, 'boxes' are used to represent units of information. A box may contain other boxes, text or graphics. Because it is a programming language, cross-reference links are treated in a special way: rather than using icons as links, a specialized box (called a 'port') provides a direct view into the destination. The boxes are nested within each other two-dimensionally, and filtered in order to reduce screen clutter.

**CREF**

In the Cross-Referenced Editing Facility (CREF), chunks of text, called 'segments' constitute the nodes in the system. These are arranged in a linear series, and may have keywords and various kinds of links to other segments. The segments are organized into 'collections', which appear as a continuous length of text with the segment boundaries marked by horizontal lines. A collection can be edited as if it were a single document. Four types of links are supported:

- References – cross-references among segments.
- Summarizes – impose a hierarchy.
- Supercedes – implement versioning.
- Precedes – place a linear ordering on segments.

**SAM**

SAM (Perlman, 1987) is a hypertext interface to Smith and Mosier’s Guidelines, with hierarchical browsing based on an online table of contents. At the beginning of a session, only the main title is shown, this then expands to show the section titles, and so on down the hierarchy. References can be browsed at two levels: expanded in place or by asking a reference for the names of the guidelines which cite it. The guidelines also have cross-references to other guidelines and sections. It is possible to expand only the title of the guideline, dynamically follow the cross-reference, or collect all of the cross-references from a guideline for later study. A keyword browsing facility permits searching across several sections, and guidelines found during a session can be marked and collected for later use. There are eight windows in the system:

(i) a hierarchical browser – shows the hierarchical structure of the guidelines, (ii) a reference list – these can be searched for, dynamically expanded and marked for later reference, (iii) working guidelines – relevant guidelines gathered during a task, (iv) expanded guidelines – a record of all the guidelines which have been expanded, so the user is able to review them, (v) a text reader – guidelines are expanded into this window, and the expanded guidelines window also serves as a searchable history list of guidelines in this window, (vi) a copy buffer – the contents of any window can be copied into this window to permit on-screen comparison of two texts, (vii) an options
window – variables which control the way in which SAM looks and functions, and (viii) a help window – contains one-line descriptions of the commands.

The fisheye views in the table of contents, temporal maps of previously read material, user-defined importance maps and structural maps to inform the reader where a piece of text is in the whole document were all intended to provide context for the reader.

The *Engineering Data Compendium* (Glushko, 1989) is a hypertext version of a multivolume engineering encyclopedia, designed and built on CD-ROM. Glushko describes the philosophy behind the design of the compendium as being in contrast to the technology-driven one frequently encountered. The objectives were:

1. To build upon the experience that users have of printed reference books.
2. To preserve and enhance the organization and user aids of the printed version.
3. To utilize the structure implicit in the printed version which could not be fully exploited due to constraints in the printed form or the process by which it was developed.
4. To devise additional features to enhance the accessibility and usability of the information.

It was considered that the format of the paper version of the Compendium makes it highly suitable for hypertext representation on compact disc because (i) the information is segmented into small, self-contained entries, dealing with well-defined topics, (ii) these are arranged according to a hierarchical table of contents, each having ten explicit, and many implicit, cross-references to other entries, (iii) the entries themselves are highly structured in ten standard parts, and (iv) each entry centres around one or more tables or graphics depicting the key facts.

The emphasis is on hierarchical browsing, which Glushko defines as exploration through the progressive display of detail, rather than a “casual, undirected, serendipitous information-seeking activity” (p.295). The initial display of the table of contents in the browser shows only the main topic areas. When one of these is selected, it is expanded to show the levels below it in the hierarchy, and details of the other parts of the hierarchy are hidden. It is claimed that this implementation of a fisheye view helps to focus the user’s attention on the most recently selected item. Boolean search of the full text is also supported, and users are able to select the next or previous target from the list of candidate entries:

“This function was modeled after the familiar process of sticking your thumb in the Index at the back of the book to hold you place while you go back and forth to view each entry” (p.295).
It is also possible to place bookmarks in the Compendium, and return to them at a later point.

1.8.3.4 General hypertext technology

NoteCards

NoteCards is a semantic network of electronic notecards, interconnected by typed links. It is an idea structuring system, in which tools are provided for displaying, modifying, manipulating and navigating through the network. NoteCards:

"provides an object-orientated, spatial, direct manipulation, navigational interface not only to information stored in the network, but also to the organizational structure of that information" (Halasz, Moran and Trigg, 1987, p.51).

There are four main elements in the system:

1. NoteCards – an analogy to a paper notecard, having a title and containing text or graphics of some form.

2. Links – used to connect cards into networks or structures of related cards. Represented by an icon in the source text, and clicking on the icon displays the destination. May be global-global, global-specific, specific-global or specific-specific.

3. Browser – a notecard containing a structural diagram of the network of cards. The titles of the units are selectable, and the different types of links are represented by different types of lines. Users are also able to create browsers for sub-networks.

4. Fileboxes – specialized cards used to organize or categorize collections of cards. Each card must be filed in one or more boxes, and the filebox structure must form a hierarchy. Fileboxes support the traversal of local links by providing a hierarchical structure.

Intermedia

Intermedia comprises a number of applications: a wordprocessor, a structured graphics editor, a historical timeline editor, a scanned image viewer, an animation editor, a videodisk controller and a viewer which displays and rotates three-dimensional models.

Links are represented by markers embedded in the documents, referred to as 'anchors', and the resulting 'webs' are shown as maps. Each link belongs to one or more webs and is only visible when the web is active. To view a document whose links belong to a
particular web, the web must be activated, then the document. Anchors for individual links range from an insertion point to the entire document. The system provides facilities for generating maps at different levels of detail. A global map shows a high-level view of the web, depicting links at the document level. A tracking map provides a continually updated graphical view of the current document and its links, and can be viewed at four levels of detail (i) document-to-document, (ii) document-to-block, (iii) block-to-document, and (iv) block-to-block. Readers are able to create and traverse paths through selected links, and a history of the session is maintained, so that they are able to step back through it.

*Neptune*
This differs from many other systems in that the destination end of a link is an iconic point in the destination node, rather than the whole node. The interface has several types of browser. These include:

1. **Graph** - provides a pictorial view of a subgraph of nodes and links.
2. **Document** - supports browsing of the hierarchical structure of nodes and links.
3. **Node** - accesses an individual node in the document.

*HAM (Hypertext Abstract Machine)*
HAM is a general purpose, transaction-based, server for a hypertext storage system, providing a general and flexible model that can be used in several different hypertext applications (Campbell and Goodman, 1987). It is based on five objects:

1. The highest level, containing all of the information relating to a particular topic.
2. **Contexts** - these partition the data.
3. **Nodes** - these contain arbitrary data.
4. **Links** - which define a relationship between a source node and a destination node, and can be followed in either direction.
5. **Attributes** - which can be attached to contexts, nodes or links, and give semantics to objects.

The system has automatic versioning and a filtering mechanism permitting subsets of HAM to be extracted.

*HyperCard*
This uses a card metaphor, like NoteCards, but the cards are in stacks rather than fileboxes. The current version (at the time of writing) is constrained to a fixed card size and it is only possible to display the contents of one window at a time. Movement through the hypertext is by means of 'buttons' - active areas on the screen, which may
be attached to text or graphics. Navigation facilities provided include movement to the
next, previous, first and last cards in the network, and a 'Go Recent' command. The
latter produces a selectable display of miniatures of the last forty-two unique cards
viewed by the user. However, no duplicates are shown, so the temporal order of access
may not match the display. The system also supports a search facility.

SuperCard
SuperCard is similar to HyperCard, but the windows are resizeable and it is possible to
display more than one window at a time. However, SuperCard does not support the
'Go Recent' facility of HyperCard.

1.8.4 Advantages

The advantages of hypertext as a vehicle for the presentation of information are
summarized by Conklin (1987):

1. Ease of tracing references – machine support for link tracing means that it is just as
easy to follow a reference forwards to its referent, or backwards to its reference.

2. Ease of creating new references – it is possible to create a new reference or add to
someone else's document.

3. Information structuring – hierarchical and non-hierarchical structuring can be
imposed on unstructured information.

4. Global views – these can be effectively mixed with local (node or page) views.

5. Customized documents – nodes can be linked together in many ways, thus
permitting the same document to serve multiple functions.

6. Modularity of information – ideas can be expressed with less overlap and
duplication.

7. Consistency of information – references are embedded in the text, so that even if the
text is moved, they remain linked to it.

8. Task stacking – users are able to have more than one path of enquiry active and
visible at a time.

9. Collaboration – several authors can work together on one document.
Smith and Weiss (1988) contrast two types of paper documents in terms of the relationship between their logical and physical structures. They propose that in some paper documents, such as novels, the physical and logical structure are closely related. Physically, the document is a linear sequence of words that has been divided into lines and pages for convenience. Logically, it is also linear: words are combined to form sentences, sentences to form paragraphs, paragraphs to form sections, etc. If the document has a hierarchical logical structure, the hierarchy is presented linearly, and readers are encouraged to read linearly, from beginning to end following the same sequence. In other paper documents, such as encyclopedias, the logical and physical structures are separate. Physically, they are linear sequences of independent units, such as articles on specific topics or entries for individual words, but logically, they are more complex. They are rarely read from beginning to end, but are searched in order to locate the article or entry of interest (a form of random access), and this is then read linearly. However, readers often encounter various cross-references to other entries while reading, as well as a list of 'see also's' at the end of an article. To follow these pointers, it is necessary to locate the appropriate volume, find the entry, and then the relevant portion.

"The logical structure of reference and other similar documents is, thus, more complex. They have a sequential structure that aids search, but the logical path of the reader is a network which can criss-cross the entire document or set of documents, from one item to another, etc. Such documents are more flexible, but they are also cumbersome, particularly when they appear in large, multivolume formats" (Smith and Weiss, 1988, p.817).

However, these examples may be said to represent two extremes, and as Collier (1987) notes:

"Printed text has an inherently linear structure. A sentence is made up of words in a certain order. In turn, a paragraph is made up of sentences in a certain order. Chapters follow chapters in a set sequence. Yet text is highly interconnected and multiply linked by the meanings of the terms it uses, its logical structure and the rhetorical relations among its components. These relations are intrinsically non-linear" (p.270).

Conventions for marking relations between units of text in the printed medium include footnotes (from marker to note), reference sections (from text to text), glossaries (from phrases in a text to a defining phrase), and indices (from a topic to a place). But such markers can only provide what Collier (1987) terms 'weak pointers' to interrelated units of text. Hypertext permits us to "break the 'linear straightjacket' of ink on paper" (Collier, 1987, p.271), and show the structure of the document explicitly, through the use of links. Furthermore, while the organizational and cross-reference structure of paper documents is fixed at the time of printing, hypertext links and nodes can be
changed dynamically, new nodes and links can be added and individual nodes may be updated if required (Smith and Weiss, 1988).

Speaking in the context of a dictionary, Raymond and Tompa (1987) also note that hypertext removes some of the restrictions imposed in the paper medium due to space constraints. These include dense typesetting, extensive use of abbreviations and symbols, and very few spatial techniques.

Hypertext has selection benefits for both the reader and the author (Jones, 1987). It is no longer necessary for the author to choose which of several ideas to express next - they can all be linked to the current one. Readers are able to access information more directly and more quickly than is possible in a conventional paper-based system, and

"More importantly, we might expect a selectivity of access such that we can pinpoint the information we need without wading through a mass of irrelevant information" (Jones, 1987, p.1107).

On the other hand,

"Discovery is the major advantage of hypertext database searching. Not only can the user locate specific information on a topic, but can see associations of that information with information from other sources. These associations and connections may be just as valuable as the information itself. Serendipitous results from extensive hypertext browsing by end users can result in just as significant results as a carefully planned search strategy on present online systems" (Kesselman and Trapasso, 1988, p.221).

The advantages of hypertext are therefore that it:

"allows authors or groups of authors to link information together, create paths through related material, annotate existing texts, and create notes that direct readers to either bibliographical data or the body of the referenced text. Using a computer-based hypertext system, students and researchers can quickly follow trails of footnotes and related materials without losing their original context; thus, they are not obliged to search through library stacks to look up referenced books and articles. Explicit connections - links - allow readers to travel from one document to another, effectively automating the process of following references in an encyclopedia" (Yankelovich, Haan, Meyrowitz and Drucker, 1988, p.81).

Although it may also be used for the storage of other forms of electronic information, mention should be made of CD-ROM technology. Oren (1987) suggests that CD-ROM is particularly suited to the storage of hypertext due to (i) its read-only static nature - although it may be possible to annotate and add new nodes, the basic document is immutable, and (ii) its large capacity. As Marchionini (1989b) says:
"The ability to store up to 600 megabytes of data on a single surface twelve centimetres in diameter with seek times under two seconds is clearly cause for attention" (p.55).

The first widely distributed text on CD-ROM was Grolier Electronic Publishing's *The Electronic Encyclopaedia*, whose text occupies approximately 60 megabytes. The encyclopaedia is an interactive network of articles. It is menu-driven, and supports direct look-up and full-text searching, but has no graphical capabilities.

However, it should be noted that the use of CD-ROM does not enable the dynamic nature of Xanadu to be realized.

1.8.5 Problems

Conklin (1987) considers there to be two main classes of problems associated with hypertext: problems with current implementations and those "that seem endemic to hypertext". He suggests that the latter are more challenging, and may ultimately limit the usefulness of hypertext.

In a learning context, Hammond and Allinson (1989) provide a summary of what they believe to be the main difficulties with hypertext:

"First, users get lost. The knowledge base may be large and unfamiliar; the links provided are unlikely to be suitable for all learners and all tasks. In consequence it is all too easy to bogged down. Second, users may find it difficult to gain an overview of the material. They may fail to see how parts of the knowledge base are related and even miss relevant sections entirely. Third, even if users know specific information is present, they may have difficulty finding it. The knowledge base may not be structured in the way they expect, or their lack of knowledge may mislead them. Fourth, readers may ramble through the knowledge base in an unmotivated and instructionally inefficient fashion. The materials may not provide sufficient tutorial guidance for learners to ask themselves the right questions or to help them formulate and attain goals. Finally, coming to grips with the interface for controlling the various facilities may interfere with the primary task of exploring and learning about the materials" (p.294).

Many of these relate to navigation issues, which will be discussed in some detail in section 1.9.

Hardman (1988) notes a number of problems associated with hypertext from the designers point of view:

1. How to present the information to the user, including its structure, in an easily understandable way.
3. How to help readers find what they seek.
4. How to handle personalized trails.

Another proposed problem in hypertext systems is referred to as ‘cognitive overhead’: the necessity to make decisions about which links to follow and which to ignore may impose an additional cognitive load on the reader.

“A problem for users of hypertext systems is deciding how far to browse. How many side branches should a user explore?” (Kesselman and Trapasso, 1988, p.221).

A further problem is that in the paper medium readers are accustomed to ignoring apparently irrelevant or nonsignificant material, but hypertext links may condition the user to expect significant relationships between materials (Landow, 1987). An additional difficulty relates to the lack of context in a hypertext document. As Conklin and Begeman (1988) explain:

“Traditional linear text provides a continuous, unwinding thread of context, as ideas are proposed and discussed, a context in which the writer is directly, if unconsciously, working to guide the reader to the salient points and away from the irrelevant and distracting ones. Indeed, a good writer anticipates the questions and confusions that the reader may encounter and carefully crafts the text to prevent these problems” (p.327).

However, in a document which is not presented sequentially, there can be no “continuous, unwinding thread of context”, because the information is not always accessed in the same order. This may also lead to inappropriate juxtapositions which are not predicted by the author.

Landow (1987) refers to two related problems with hypertext systems: how to indicate the destination of the links and how to welcome the user on arrival.

“Drawing on the analogy of travel, we can say that the first problem concerns exit or departure information and the second, arrival or entrance information” (p.331).

He proposes that hypertext may redefine some of the basic characteristics of the paper medium, but it still depends upon many of the same organizing principles that make page-bound discourse coherent. It has been suggested (DeBeaugrande, 1984) that an important aspect of writing is the transposition of ideas which are related in a complex, multi-dimensional manner into a linear form. Waller (1985) considers this to indicate that many of our techniques of discourse relate to the linearity of language, and that we should therefore approach alternatives to the traditional linear text with caution.
Raskin (1987) proposes that the problems associated with hypertext are so great that:

"In short, hypertext only sounds like a good idea. It tends to evaporate when looked at closely. There are three basic human interface problems: (i) the linkages are often either cumbersome, wrong for your needs, or trivial, (ii) the problem of what aspect of a word, phrase or picture you intend has not been addressed, and (iii) a uniform and excellent human interface specification is both necessary and absent" (p.329).

The author fears that users will spend much of their time in trying to please the system instead of themselves, concluding that:

"It is my guess that the reality will remain tantalizing, and will never fulfil the dreams of hypertext's advocates..." (p.330).

However, the present author does not support this view, considering that although there may be problems, hypertext also has many potential benefits for both readers and writers. The fact that hypertext has both advantages and disadvantages is noted by Jones (1987) in relation to the proposed disorientation problem:

"The malleability/extensibility of hypertext is a double-edged sword. The richness of hypertext's network representational scheme may produce complicated webs that ensnare users on both the sending and receiving end. From the reader's perspective, some selection may be better than none, but too much selection may be much worse. This brings us to the problem of 'getting lost' in hypertext" (Jones, 1987, p.1109).

1.9 NAVIGATION IN HYPERTEXT

"The biggest problem in hypertext systems, which most of us admit to in footnotes towards the end of papers extolling the virtues of our systems, is of getting lost. This applies to both readers who follow links set by others, and, worse, to authors who need to create and modify links. There is thus a pervading need for navigational aids and also for checking aids that verify the validity of links. The need for such aids probably rises proportionally to the square of the document size" (Brown, 1987, p.39).

1.9.1 What do we mean by ‘getting lost’ in hypertext?

According to Elm and Woods (1985),

"Getting lost in a display network means that the user does not have a clear conception of the relationships within the system, does not know his present location in the system relative to the display structure, and finds it difficult to decide where to look next within the system. In this view, getting lost is
defined as a decrease in the ability to extract the information needed to successfully perform domain tasks, rather than by subjective feelings of being lost" (p.927).

Inability to find information which is known to be in the system is also said to be a characteristic of getting lost in a hypertext environment (Mayes, Kibby and Anderson, 1989; Halasz, 1987).

Charney (1988) asks what it means in cognitive terms for readers to “get lost” in a networked text, while Foss (1987) reminds us that there are other aspects of the disorientation issue besides not knowing the spatial layout of the hypertext network. These include:

1. Arriving at a point in the document and forgetting what was to be done there.
2. Not returning from a digression or forgetting to go to a planned one.
3. Not knowing if there are other relevant frames.
4. Forgetting where you have been.
5. Inability to form a coherent summary of which frames have been examined.

McAleese and Duncan (1987) describe the problem in terms of the user being unable to “see the wood for the trees”.

1.9.2 Why might people get lost?

The issue is neatly summarized by Valdez, Chignell and Glenn (1988):

“In many ways, the problems of hypermedia stem from the very flexibility that is its chief advantage and justification. It is difficult to maintain a sense of where things are in a relatively unstructured network of information. While the associative nature of hypermedia increases the availability of large amounts of diverse information, this very diversity makes it easy for information and users to get lost. Hypermedia exacerbates the problem of ‘getting lost in information space’ by providing a complex associative structure that can be traversed, but not fully visualized. Information gets lost because it becomes difficult to organize and tag effectively, while users get lost as they lose sense of where they are in the hypermedia” (p.318).

Halasz (1987) considers that applications in which navigation is problematic are generally characterized by large, unfamiliar, heterogeneously structured networks, but other writers (e.g., Hammond and Allinson, 1987) consider this to be a problem even for moderately sized hypertext systems.

A distinction between disorientation in the physical and conceptual sense is made by Mayes et al. (1989). The former is said to be rooted in the nature of hypertext and
merely a navigational problem, in that the geography of the system may be too complex to understand, even when a map is provided. Although visualization techniques may be used to give the reader a better way of locating information in space (i.e., accessing it, knowing where it is), they do not assist in navigation through conceptual space.

Van Dijk and Kintsch (1983) hypothesize that readers construct hierarchical representations of documents. However, as Charney (1987) describes, the mental mechanism proposed to explain the way in which this hierarchy is constructed (Kintsch and van Dijk, 1978) is dependent upon the order in which propositions are encountered and the degree to which important concepts are repeated in successive sentences. Readers are said to incorporate new propositions into their hierarchies by constructing networks with chains of repeated arguments. Charney considers that hypertext raises a number of issues in relation to this approach to text processing. Perhaps most importantly, the processing model assumes that a relatively stable text base can be derived from a text:

"This assumption seems to depend on a linear reading of a fixed amount of information. Almost by definition, however, hypertext avoids imposing a fixed order on the information" (Charney, 1987, p.113).

Oren (1987) describes how books use print conventions to give the reader a sense of location. These include running headings, section headings, type styles and indentation, all placing the current portion of text within the hierarchical or narrative structure of the book. Many of these navigation cues are lost in the electronic medium “because they are deliberately designed as peripheral cues, only occasionally brought into focus by the reader” (p.296). The situation is made worse when the physical proximity is removed and there are a number of small nodes, each encapsulating a single idea.

In paper documents, the underlying object manipulated by the user has a serial or sequential structure, and, even if the reader does not choose to access the information in this order, its sequence remains stable (Monk et al., 1988). As Conklin (1987) says, the reader only has two options, he can search for the desired information earlier or later in the text. It would therefore appear that:

"The main disadvantages of using hypertext, at present, seem to be consequent of its sheer lack of physical presence and integrity – the very flexibility of reading on screen is disorientating for a user who can’t conceptualize an overview of the structure” (Mahony, 1988, p.4).
1.9.3 Does it matter?

For present purposes, getting lost in a hypertext environment is defined in terms of the reader not knowing:

1. Their present location within the system as a whole – “Where am I?”.
2. Where they have been – “Where have I been?”.
3. Where they have not been – “Where is there new to go?”.

It is considered that the ability to answer such questions is important, because a location contains information. Getting lost therefore needs to be considered in terms of the relationship between the location of the reader in the hypertext structure and that of the desired information within the structure, as Valdez et al. (1988) state, both users and information get lost. Consequently,

1. “Where am I?” involves the question “What is here?”.
2. “Where have I been?” involves the question “What was there?”.
3. “Where is there new to go?” involves the question “What is there?”.

Readers themselves recognise the relationship between these two aspects of location when they ask “Where was I when I saw...?”. Furthermore, if a reader does not know their present location within the document, then they will be unable to plan a route to an intended future destination.

However, in any discussion concerning reading there are three important variables to be considered: the reader, the type of text, and the reader’s purpose in accessing the document – their intended task.

Certain types of task have a well defined goal, and while some may be performed more efficiently using a keyword search facility, this may not support the kind of query necessary to obtain the desired information. In this case, the reader needs to know which parts of the document he has looked at and which he has not. It may be that the reader does not know whether a given document contains any information relevant to the current task; in this case he needs to know whether he has seen all of the document, i.e., visited every location. On the other hand, if the reader is engaged in a browsing type of task, in which the goals may be less clearly defined, knowing his exact location within the document may be less important (although even in these circumstances there is the danger of unintentionally revisiting locations).
It is therefore proposed that the type of task involved has some bearing on the degree to which getting lost in a hypertext document is important. Nevertheless, the reader's subjective feelings must also be considered. The concept of locus of control is useful at this point. If the user feels in control of the system (even though he may not have clearly defined goals), he is more likely to have a positive attitude towards it, but if the system is felt to be in control, it is likely that it will be rejected.

1.9.4 Proposed solutions to the ‘lost in hyperspace’ problem

1.9.4.1 What should designers provide?

Shneiderman (1989) points to a number of facilities which he considers that designers of hypertexts should provide when he says:

"Paper books present a clear vision of their boundaries so readers can know when they have read it all, but in the hypertext world other mechanisms must be created to give readers a sense of scope and closure. The overall structure of articles must make sense to readers so that they can form a mental image of the topics covered. This facilitates traversal and reduces disorientation. Just as important is the reader's understanding of what is not in the database. It can be terribly frustrating if readers think that something of interest is in the database, but they can neither find it nor convince themselves that it is not there”.

Hammond and Allinson (1987) emphasise that navigation facilities must be both suited to the user’s goals and easy to use:

"The poorer the user’s understanding, the greater the likelihood of getting lost: he may mobilise only a subset of the full navigation facilities; his choice of facility may be unsuited to his task; he may find navigation to be demanding. In all these cases, the consequence is likely to be inefficient or ineffective performance” (p.76).

The importance of applying principles from traditional information systems and the results of empirical studies to the design of hypertext systems is stressed by Marchionini and Shneiderman (1988). Key issues are said to include:

1. Finding the appropriate information unit granularity for particular task domains and users.
2. Presenting interfaces with low cognitive load, and reasonable default conditions.
3. Striking a balance between analytical and browsing search strategies.

Most importantly,

"The general problem of maximizing power and flexibility while minimizing complexity of use must always be attacked” (p.79).
Mahony (1988) proposes that the basic requirements of a good hypertext interface are:

1. Facilities for browsing.
2. Good searching and navigation techniques.
3. Clear and consistent information about link types and link labels.
4. Similar information concerning the type, content, author, size and name of objects.

She goes on to say that:

"These needs are, of course, really very interdependent – good browsing facilities should help the user construct the sort of overview of the structure that's essential for navigation, while a clear representation of information about links and objects virtually amounts to the provision of a browsing facility" (p.4).

A number of writers have suggested specific facilities which should be provided in order to assist readers in navigating through a hypertext environment. For example, Wright (1989) considers that readers should:

1. Be permitted to return to some part of the text they have seen earlier.
2. Be given some assistance in planning their way forward – where they can go to from their current position.
3. Be provided with information concerning which parts of the hypertext they have not already seen.

According to Oren (1988), a hypertext system should include facilities that can (i) tell the reader when they have seen everything and how much they have not seen, (ii) show them something new, (iii) show them the path to something they have seen before, and (iv) review the particular paths they have taken to a certain location.

In summary, it would therefore appear that all of the above writers consider that designers of hypertext systems should provide the reader with information concerning:

1. Their current position within the structure.
2. Where they can go from this point.
3. Where they have been.
4. Their previous routes through the information space.

Proposed solutions to the problem of disorientation in a hypertext environment would appear to fall into several classes:
"First, one can create maps or browsers that allow users to determine where they are in terms of the overall network, or regions thereof. Second, one can create tags, markers or milestones which represent familiar locations, much as a lighthouse signals location in the middle of a foggy night" (Valdez et al., 1988, p.318).

A third proposed solution is the provision of predetermined routes through the information structure – often referred to as 'tours' (e.g., Hammond and Allinson, 1988; Trigg, 1988).

1.9.4.2 Maps

A number of hypertext systems provide the user with a graphical representation of the structure of links and nodes in the information space, and it has been suggested that visual cues will both help users to determine their position in the information structure and act as a graphical means for organizing and retrieving material (Yankelovich et al., 1985). According to the latter authors, interactive maps are the optimum method of travelling through an information web.

Billingsley (1982) considers there to be three reasons why the provision of a map could be useful. First, she claims that there is evidence from the verbal learning literature that people take advantage of the spatial structure of hierarchically-organized information when it is made available, and that they recreate the structure on paper when asked to recall all the items in a given hierarchy (Bower, Clark, Lesgold and Winez, 1969; Broadbent, Cooper and Broadbent, 1978). Second, the ease with which data items in a hierarchical structure are comprehended and remembered is due to the inherent structure of the hierarchy itself (Brosey and Shneiderman, 1978). Third, both the semantic and locational attributes of data are encoded in memory regardless of whether subjects are asked to attend to the spatial information (Zechmeister et al., 1975)

Shneiderman (1987c) proposes that a graphical representation of a hypertext's structure is of benefit because:

"Dealing with representations of objects may be more 'natural' and closer to innate human capabilities: action and visual skills emerge well before language in human evolution. Psychologists have long known that spatial relationships and actions are grasped more quickly with visual, rather than linguistic, representations" (p. 202).

McGee (1976) introduced the concept of 'picturability', suggesting that the display of structures in a pictorial form would help users to learn the data structure. Such pictures may not only assist in initial comprehension, but also provide a reference point to which users could return; in other words, acting as a landmark.
Foss (1987) takes a slightly different approach. She describes four types of browser which are intended to alleviate specific problems that users may have, rather than providing a global overview of the network. The two problems addressed are (i) following embedded digressions and (ii) forming a summary of what has been seen. The four types of browser are:

1. Graphical history list
This records and displays in a temporally ordered list the nodes a user has visited during a session. Selecting a node from the list produces a mini-browser centered on this node, with a display level one link away. It is possible to travel through the network by selecting a node from one of the mini-browsers. Cards which have been viewed are marked on the card itself, so readers can see which links have already been followed. They are able to see what cards/topics are related to the main line of investigation by looking at which ones point to the current node.

2. History tree
The history tree also records the cards which have been seen, but they are shown in a selectable hierarchy, rather than a list. Revisited nodes are displayed – this preserves the temporal order but, because it is possible to access cards through a search mechanism, the connectivity may not be shown. Readers can tell which links have been followed by looking to see which link icons on a card have been marked. An alternative structure shows all possible nodes, i.e., the underlying structure. Here cards which have been viewed are marked, and although readers are not able to see the temporal order, they are still able to see the context. Readers are able to take notes by bringing up a ‘twin’ of the current card, which has the same title, but is empty. These twin cards are stored with their originals.

3. Summary boxes
Summary boxes are primarily intended to facilitate note-taking while browsing. A twin card is automatically created beside every card opened, making it easy to copy material of interest from a card to its twin. The originals and twins are both stored in a Summary Box, which is also a history because the cards are dynamically added to the box as they are examined and created. The list is linear and revisited cards are not duplicated, consequently, the exact path the reader has taken through the network cannot always be determined. All cards which have been visited are marked.

4. Summary trees
These are similar to the history tree, but the reader is also able to annotate and add text or diagrams to the summary window tree. The idea is that users are able to build their own conceptual maps – pictorial summaries derived from a set of related cards. These
may not be isomorphic to the structure of the network, because users are able to split apart nodes, place annotations anywhere along a link and make notes anywhere in the graph window.

A number of studies have pointed to the utility of maps in relation to computer systems. For example, in an investigation concerning embedded menus, Billingsley (1982) concluded that:

"The pattern of results provides support for the hypothesis that exposure to a pictorial representation of the structure of a menu system helps subjects to develop a workable mental model of the way data elements interrelate. The spatial/locational information inherent in a map appears to provide enough additional mnemonic assistance so that subjects are able to remember how to find a target (animal) for a considerable time after the map is no longer available" (p.106).

In addition, performance in a post-experiment map drawing task was found to be correlated with the total number of choices made in a search task.

Engel, Andriessen and Schmitz (1983) report a study examining the retrieval of information from a hierarchically structured database. They refer to earlier studies whose results showed that unskilled users easily lost their bearings when searching for information, seeming to be uncertain both about how they arrived at their current position in the structure, and about which way to go in order to find the desired information. The authors note that a similar tendency has been observed by van Ness and van der Heijden, in whose study the number of menu pages accessed was approximately twice the actual number necessary in order to locate a specified item of information.

The system employed in the study by Engel et al. contained two types of display: a 'what' screen containing primary information and a 'where' screen with secondary information. The secondary information was a map of the primary information contained in the database, with the user's current position marked on it. If the 'where' display was too large to fit onto a single screen, then a hierarchical structure of 'where' screens was employed. The user's problem was then in obtaining an internal global representation of the structure. In an attempt to assist in this process, additional navigation information was provided in the form of a stored list of the numbers of the successively selected pages. The user was able to move a pointer backwards and forwards in the list, and to place flags at various locations for future reference.
Although extensive testing was not carried out, the authors concluded that the information provided on the ‘where’ screen did help users navigate through the database and to retrieve the desired information.

A study by Isa, Neal, Evey and McVey (1982) compared the utility of maps and signs for teaching metalanguages for programming. Conventional IBM syntax was compared with a Pascal “railroad tracks” system. After extensive training there was no significant difference in performance, but when subjects were only provided with one page of instructions, performance using the map was found to be superior.

In spite of the proposed benefits, there are several difficulties concerning the use of maps in a hypertext environment. For example, Mahony (1988) points to the differences between maps, in which space and length are meaningful variables, and the links in a hypertext, where these two features are insignificant. She quotes Bertil’s (1983) definition of a network:

“In a network, one can plot the figures on a plane which has no meaning, and then look for the arrangement which produces the minimum number of intersections, or the simplest figure”;

suggesting that a network, rather than a map, is the most appropriate model for a hypertext.

However, as Oren (1987) says, the usual approach to the location problem is to generate a view of the neighbourhood around the current position. A ‘zoom out’ or ‘road map’ diagram of the adjoining nodes is the simplest approach. This neighbourhood view can take many forms, for example, timelines, maps or semantic net type representations. The author notes some difficulty with the latter solution, suggesting there to be problems with screen clutter, complexity of controls to manipulate the view, and the lack of obvious mapping to the documents themselves. Furthermore,

“Any of these views can be overwhelmed by heavy branching at a node or attempts to view at several links distant from the current document” (p.296).

Such an opinion is endorsed by Weiland and Shneiderman (1989), who state that even though a graphical display of a database network can alleviate difficulties such as getting lost, it is not the ultimate solution.

Conklin (1987) proposes that because there is no natural topology for an information space, until one is familiar with a large document, “one is by definition disorientated”
Consequently, it is practically impossible to abolish the disorientation problem with a browser alone.

Further caution is advised by Jones (1987), who considers that maps permit the reader to access relevant units as long as enough information is displayed to permit their relevance to be recognized. However, when there are a large number of units, the recognition of relevance function of such devices is not sufficient, and more direct recall of information units is required.

"It is reasonable to suppose that the representation of a unit in a hypertext map will have to be at least partially symbolic (e.g., a name, description, title or label)" (Jones, 1987, p.1109).

Foss (1987) would not seem to be fully convinced about the utility of maps in a hypertext system. She remarks that a common approach to the problem of disorientation is to give users an overview of some kind "with the hope that looking at a map will help them re-establish context" (p.3). The author notes a number of problems with such a solution, including the fact that due to space limitations on the screen, only part of the browser can be shown at once. She concludes that the main problem with graphical browsers is that of complexity:

"Unlike hierarchies or linear orders, where the location of a node in the structure is enough to imply some relationship with the neighbouring nodes, there are no conventions for the organization of information into a graph structure. In our experience, graphs comprising more than 10 or 15 nodes approached the user's saturation point... The problems of size, manageability, and complexity associated with displaying global representations of large networks limit the effectiveness of global browsers for reducing disorientation" (p.4).

A number of solutions have been proposed, for example, Engel et al. (1983) suggest three possibilities: (i) 'zooming in', (ii) panning across the structure, and (iii) a hierarchical series of screens. Two other solutions are discussed by Oren (1987) - filtering and distorted views.

Filtering is the removal of documents from view based on some simple criterion (Kay, 1983). All filtered views require the user to manipulate the filtering criteria, rather than the system doing this automatically. But,

"Filtering is also antagonistic to serendipity, as it removes the chance of accidental discovery of an unanticipated type of relation" (Oren, 1987, p.297).

Distorted views use more complex criteria for the rejection or inclusion of nodes of information in the display. One example of a distorted view is the 'fisheye view' (Furnas, 1986), in which information is shown according to the distance from the
viewing point, with more and more detail omitted farther away from it. The degree of interest function associated with the fisheye view dictates the type of distortion produced.

Valdez et al. (1988) consider that although the concept of a fisheye view is easy to understand, it is not obvious how it should be implemented. One suggestion they make is that certain nodes in the network should be designated as landmarks, due to their memorability, familiarity or salience. A fisheye view can then be provided of these landmarks, in which a number of landmarks near to the current location are represented, and fewer more distant ones. However, one problem with this approach is that, as the authors note, it relies on there being a spatial representation of the network which permits these distances to be calculated. Other difficulties concern the determination of the appropriate level of detail for each ‘level’ of the display.

Another kind of distorted view is the cluster, where each document is assigned to one or more clusters, and the neighbourhood view from a node shows the adjoining clusters, rather than single documents. This does not solve the general location problem, but it does permit the user to construct a personalized information space (Oren, 1987).

1.9.4.3 Tours

As Trigg (1988) says:

"The ancestry of guided tours dates back to Vannevar Bush’s classic ‘As we may think’ article in which he describes the notion of a trail” (p.399).

The metaphor of tourists and tour guides, called ‘Tourist Artificial Reality’, is described by Fairchild, Meredith and Wexelblat (1989). This metaphor is similar to Bush’s (1945) ‘trails’, and was chosen because:

"it allowed us to draw on users' preconceptions of the physical world, Their expectations will give them clues as to what sort of actions are expected and permitted..." (p.301).

In the Tourist Artificial Reality, the user selects from a collection of predefined paths through the documentation space, referred to as ‘tours’. It is also possible to customize these tours.

Similarly, Allinson and Hammond (1989) propose a Learning Support Environment – tools to support the exploration of knowledge domains. The Learning Support
Environment uses the metaphor of a ‘guided tour’ with ‘conventional’ hypertext navigation being referred to as ‘rambling’. Maps can be used to ‘orienteer’ round the system. These maps indicate the reader’s current position in relation to other frames and also show the links between the frames.

Trigg (1988) describes the implementation of a ‘guided tours’ facility in NoteCards. These tours are intended to support communication between the author of a notefile and future readers. However, they differ from the tours found in other systems in three main ways:

1. The tour is accessed through a graph-based interactive interface, allowing both authors and readers to work from the same overview of the guided tour’s structure.

2. Multiple sources of information can be displayed on the screen at once, in addition to the sequential organization inherent in the tour.

3. The tour itself constitutes a ‘fully-fledged’ node in the hypertext network, referred to as a ‘Tabletop card’.

A Tabletop card is a method of recording those aspects of the layout of a set of cards on the screen which will permit the original arrangement of cards to be recreated. The guided tour facility consists of a graphic interface to a network of tabletop cards:

“Specifically, a guided tour is a graph whose nodes are tabletop cards, and whose edges are ‘guided tour’ links connecting them to other cards” (Trigg, 1988, p.404).

The graph structure displayed on the guided tour card also provides various indicators of the reader’s place in the tour: (i) the node in the graph whose tabletop is currently open is shown in reverse video, (ii) the nodes for tabletops previously visited are drawn with thicker borders, and (iii) the edges corresponding to the links followed are displayed in bold.

Guided tours which provide paths visiting certain landmark cards are discussed by Trigg et al. (1986). The authors envisage future tours being tailored according to various attributes of the reader, such as expertise or time available.

1.9.4.4 Alternatives

Monk (1990) contrasts directed and exploratory navigation. He considers that it is frequently implied that the majority of hypertext use is exploratory, but there may be
times when the user knows which information has to be displayed, because he has been there before, and navigation is therefore directed. Suggested tools for directed navigation include:

1. Commands – e.g., search and GoTo.

2. Contents lists and indexes – in which the names of different sections can be organized alphabetically or according to some meaningful scheme.

3. Maps and browsers – such as those used by Hammond and Allinson (1988), or the network representation in NoteCards.

However, as Monk says, much of the material displayed in a browser is irrelevant to directed navigation, since locations sought by the user must have already been visited. He therefore proposes that a personalized index, or browser, in which the user selects the sections and names to describe them, would be of benefit.

Hardman (1988) suggests that the section and sub-section headings related to a node should be shown on the screen, in addition to the text itself. But this has the disadvantage of taking up a lot of space, thus reducing that available for the display of the text itself. She says that another possibility would be to provide a link to the contents screen for the current subsection, and another to the main contents screen.

An alternative solution was employed in the design of the Guide system (e.g., Brown, 1987). The philosophy behind Guide is that readers should not be aware of the underlying structure of the document. Thus it does not employ the directed graph approach of most hypertext systems, instead, the user sees a single scroll. Brown (1988a) believes that basing a hypertext structure on a ‘strong hierarchical backbone’ may help to reduce the navigation problem. However, he does concede that while the Guide approach is suitable for many applications, it is not so for everything, and that

"Extra mechanisms are therefore still needed to help readers know where they are, and to retrace their steps" (Brown, 1988a, p.6).

1.9.4.5 The role of authoring

As Oren (1987) says:

"Unplanned, unstructured links are not the best use of hypertext; they can produce an 'amorphous blob' database that may be fascinating to explore, but does little to ensure fast access to interrelated ideas. In such an unplanned hypertext, the access problems for links can become as bad as that for paper
documents. The user does not know what links to expect in a node, and navigation from place to place becomes a hit or miss proposition. It is easy to get lost and there is no consistent pattern of knowledge to be found” (p.293).

This points to the importance of the author’s role in hypertext navigation.

“The challenge for hypertext designers is to understand the user’s task, and to support links that follow from some model of the user’s need for information in some particular context. Instead of creating a ‘spaghetti document’ with the resulting disorientation problems that others have noted, it seems more sensible to prevent the disorientation caused by unconstrained linking” (Glushko, 1989, p.297).

Brown (1988a) suggests that users of the Museum Guide (Shneiderman, 1987a) did not experience navigation difficulties because of the unusually careful and skilled authorship. However, he considers that the general standard of hypertext authorship is extremely poor, and

“The reason for the currently conflicting reports on the seriousness of the getting-lost problem is doubtless due to variability in authorship skills” (Brown, 1988a, p.2).

As McKnight, Richardson and Dillon (1989b) state, the skills which have been developed in writing for the paper medium need to be replaced by equivalent skills relevant to the electronic one.

Nonetheless, an improvement in authorship techniques is not the solution to the problem,

“What it will do is raise thresholds: readers should have no trouble in navigating round small to medium hyperdocuments, and the getting-lost problem will only be paramount in largeish documents. Thus we need to continue to provide extra navigation aids for readers” (Brown, 1988a, p.3).

A further point is that navigation difficulties experienced by authors will be reflected in the quality of the hypertexts they produce.

1.9.5 Previous studies

The following section describes those studies which have been conducted involving navigation in a hypertext environment. First, those which have compared performance using paper documents with that using hypertext will be discussed, and second, those which have focussed on hypertext itself.
1.9.5.1 Paper vs. hypertext

McKnight et al. (1990a) examined performance in a question-answering task using the same text presented in four conditions—two hypertext (HyperTies and HyperCard) and two linear (Wordprocessor and Paper).

The authors found that subjects using the linear formats were able to estimate the size of the document (in terms of the number of pages, cards or screens) fairly accurately, but those in the hypertext conditions tended to over-estimate its size. This may have been partly due to the fact that the contents pages in the linear conditions indicated the total number of pages, and the actual page numbers were also displayed. Furthermore, the paper version provided tactile feedback. There was no significant difference in speed of question answering between the four conditions, but answers were more accurate in the linear ones. The greatest differences were between Paper/HyperCard and Paper/HyperTies. When the percentage of time spent in the contents list/index was analysed, significant differences were found between Paper/HyperTies, Wordprocessor/HyperTies, and HyperCard/Paper. It would appear that more time was spent in the contents list/index in the hypertext conditions, but answers to the questions were less accurate. Subjects did not use the links between the cards very much to navigate through the text in the hypertext conditions, preferring to return to the index in order to select a new topic. In the linear conditions, information was found by scanning the text, rather than accessing the contents list/index.

A series of studies using Grolier’s Electronic Encyclopaedia is reported by Marchionini (1989b) and Marchionini and Shneiderman (1988). The encyclopaedia has two search methods: browse (analogous to looking in the print index for a term) and word search (a type of subject search). In addition, the system permits users to jump between articles quickly, page through screens rapidly, use an outline for long articles (enabling them to move to selected sections quickly), and jump to other articles containing a search term.

One study concerned what Marchionini (1989a) refers to as the 'information-seeking framework'. This is said to have five components:

User – including mental models for information-seeking and the search system.
Setting – including stimulus for the search.
Task domain – e.g., type and amount.
Search system – including the database and the interface.
Outcomes – products and the search process.
The database component of a search system influences information-seeking through its content, organization and physical form. In a printed encyclopaedia, the organization (alphabetical ordering and indexes) is critical to the user, while in the electronic encyclopaedia it is less so (it can be made transparent by the interface). The search system is static in the paper medium, and the interface depends entirely on the user. However, an electronic search system offers dynamic features which both extend the capabilities of the user and complicate the information-seeking process. The important question is how the cognitive complexity required to take advantage of these dynamic features will influence users of the system.

Performance on (i) a closed search task, (ii) an open search task, and (iii) a search task involving a topic generated by subjects themselves, was examined using paper and electronic versions of Grolier's Academic American Encyclopaedia. The differences between the two media may be considered at both the conceptual and the physical level, and:

“A fundamental problem is whether the conceptual physical differences between print and electronic encyclopaedias are so great that using print metaphors for interfaces and instruction severely limits eventual performance with electronic systems” (Marchionini, 1989a, p.594).

The research was therefore intended to examine how mental models developed for a print encyclopaedia were adapted to mental models for an electronic one.

There was found to be no significant difference in success rate, or in the number of articles examined, between the two media. It was concluded that users spent over 25% of their time engaged in “fruitful activity” in the print medium, and almost 50% in the electronic medium. More queries were posed and more articles were examined during electronic searches. Search times were also slower using the electronic encyclopaedia. It was suggested that this may have been due to an interaction between novelty effect and the interface. In print medium, a quarter of the subjects used the index, and most simply read the articles in a linear manner, rather than scanning section headings and text. In the electronic medium, subjects did not appear to take advantage of the full-text search capabilities of the system.

Manifestations of the ‘lost in space’ effect were noted, with subjects repeatedly pressing the ‘up’ and ‘down’ page arrows, when they were already at the beginning or end of an article. Marchionini also mentions the effect of the highlighted query terms in the text – this feature may facilitate the scanning of the text, but it may cause relevant information to be missed, because only the exact query terms are highlighted.
Most subjects demonstrated highly developed mental models for the print encyclopaedia, and the results of the study suggested that they found it easy to augment these models to include the electronic system. Consequently, many did not examine and use the unique features of the electronic medium, failing to assimilate these into their model. It seemed that all subjects transferred their mental model of the print encyclopaedia to the electronic one: the difference was in the level of detail transferred. Those who transferred a high level of detail were unable to accommodate the new features into their model. It was concluded that:

"Selection and use of metaphors are clearly important issues for designers of new systems and for those who train and assist users of such systems. Metaphors and instruction that highlight similarities between traditional and electronic systems must be augmented by instruction that focuses on the unique characteristics of the electronic system" (Marchionini, 1989a, p.615).

The results of a study by Carroll and Thomas (1982) have some relevance to the above findings. In their study, it was found that novices used a paging procedure in preference to a scrolling one for displaying new information on the screen. Elkerton and Williges (1984) consider this to imply that the development of search procedures which exploit the hard-copy metaphor may be beneficial for novice users, because this permits the extension of an existing cognitive structure.

Egan, Remde, Landauer, Lochbaum and Gomez (1989) describe an experiment in which readers were asked to perform two tasks using SuperBook and a paper version of the same document. The first task was a structured search (e.g., finding the answer to a specific question), while the second resembled an open-book essay question. The measures employed were performance on the tasks, incidental learning and subjective ratings. It was hypothesized that search performance with a conventional book would be dependant upon users’ knowing the appropriate topic headings, whereas that using SuperBook would not be so. In conventional books the author’s topic headings are listed in the table of contents and are frequently emphasized in the text.

The results of the study indicated that for both the search and open-book tasks, overall performance was superior using SuperBook as compared to conventional documentation. In addition, users rated the former as being easier to use than the paper version. The authors concluded that:

"For most kinds of search questions, SuperBook produced advantages over conventional documentation that are statistically reliable and practically significant" (p.209).
The greatest advantage appeared to be when questions were not anticipated by the author's organization of a document.

1.9.5.2 Hypertext systems

Two studies by Wright and Lickorish (1990) examined the influence of separating navigation decisions from the display of the text itself on readers' performance in a variety of tasks. It was proposed that readers of electronic documents may find it beneficial to have a navigation system which is based on familiar procedures for searching for information within documents (e.g., contents lists and indexes). Although hypertext systems permit readers to jump about within a document, such a navigation method may only be necessary for cross-reference type links.

The text used for the first study was in five chapters, each divided into sections. Two navigation methods were employed: Page navigation and Index navigation. In the Page navigation condition (which supported jumps between cards), the five chapters were listed at the bottom of the screen, and the section headings of the current chapter were listed down the right-hand side. The reader's current location was indicated by showing the chapter and section in reverse video. In the Index navigation condition, neither the chapters nor sections were shown when the text was visible. Readers were able to jump directly to the index card (which was not alphabetical, but a detailed contents list, preserving the groupings of the chapters and headings) from any card, and movement through the document was only possible by selecting a section from the index. The chapter and section the reader had just come from were shown in reverse video in the index.

For the second study, the text was structured in a three-level hierarchy, and it gave the price of a number of items in five different shops. In the Page condition, clicking on a 'hop' button took the reader directly from a product category in one store to the corresponding category in another one. In the Index condition, the information was obtained by clicking in the appropriate position on the index card. Readers were able to take notes in both conditions.

Subjects were required to answer multiple-choice questions for the first study, and for the second, they were required to answer three types of questions, referred to as 'GoTo', 'Compare' and 'Compute'.

In the first study, navigation system was not found to influence error rates or the time taken to answer questions. The Index was rated as being significantly easier to use, and the more 'novel' aspects of the hypertext system (e.g., pop-up displays and reverse
video) were better liked by subjects in the Index condition than by those in the Page condition. When shown both displays, subjects stated a preference for the Index condition.

Error rates were not influenced by navigation system in the second study either. None of the subjects took notes for the GoTo questions, but, for the Compare questions, those in the Index condition took more notes than those in the Page condition. It was concluded that the jump facility in the latter condition was of particular advantage for this type of question. For the Compute questions, navigation system had no significant effect on the degree of note-taking. There were more clicks made in the Page condition for the easiest questions, but fewer for the harder ones. For this second study, the Page navigation system was rated as being preferable to the Index one.

Wright and Lickorish concluded that different navigation systems are the most suitable in different circumstances. The first study showed that separating navigation options from the display may have the advantage of coupling navigation decisions with an overview of the text structure. However, the second study (in which decisions about where to go were not involved) indicated that as tasks made more demand on readers' working memory, separation of the navigation from the display further increased this load, and readers sought to reduce it by taking notes. Furthermore, when movement to 'corresponding points' was required, the ability to jump directly from a page was of benefit.

The application of a 'travel holiday' metaphor to a Learning Support Environment (LSE) for cognition is described by Hammond and Allinson (1987; 1988). An LSE does not aim to model either the learning process or the user's understanding of the knowledge domain, but instead attempts to provide suitable conditions under which learning processes may take place.

"A key issue in the design of LSEs, then, is the provision of tools for accessing the knowledge base: not only should users be prevented from getting bogged down in the morass of information, but the nature of the tools should encourage optimal learning strategies for a given set of educational or training requirements" (Hammond and Allinson, 1988, p.269).

The travel metaphor was selected because:

"It is common to think about structured information in spatial terms, and many systems use a spatial analogy for representing a database. Travel therefore seems a promising metaphor for accessing structured information" (p.270).

The LSE comprises an authoring component (for generating material) and a presentation one (concerned with the interaction between the user and the system). The
authoring component permits the teacher to generate inter-linked frames in a hypertext structure. Each frame has a main display area, which includes a number of mouse-sensitive areas, and a line at the bottom of the screen containing several selectable boxes. These boxes provide the travel facilities and help information, allow users to trace their steps, restart and end the session, and select the next frame. Each frame represents a place to visit. Four forms of navigation are available:

1. ‘Go-it-alone’ travel, referred to as ‘rambling’, where users are free to travel through the network as they choose.

2. The guided tour, – which is the main tutorial mechanism used by the system. Users are guided through a sequence of screens and can also branch out or go on embedded tours (referred to as ‘excursions’).

3. Orienteering – a graphical representation of the local part of the network is available from any screen, and it has selectable arrows at the four edges, leading to further maps. It was intended that the user could gain an overview of the information by navigating around these maps. The maps are selectable, providing direct access to the material represented on them, and they show the user which frames they have seen and from which frame the map was invoked.

4. Navigation through an index, or ‘guide book’, containing a list of keywords. Selecting one of these keywords displays the relevant information on the screen.

Performance was examined in a variety of tasks, which were defined by the users themselves. Tasks included ‘browsing’, ‘information search’, ‘revision’, ‘integration with other teaching’ and ‘seeking references’. It was found that all four navigation methods were used by 57% of the subjects, 29% used all three, and 14% used only two methods. All of the subjects rambled, 91% toured, 79% used the guidebook and 74% orienteered. Self-reported data from users indicated that different methods of travel were employed according to the task currently being performed, and that the method selected was the most appropriate for the task.

The system was found easy to use and subjects did not get lost. Furthermore, the extension to the metaphor (the arrows on the edges of the maps), was easily comprehended. Hammond and Allinson suggest that there is a danger that a metaphor may be too restrictive – the system should improve upon the metaphor rather than be constrained by it. It was concluded that the provision of conventional hypertext access (rambling) is not sufficient in a learning environment in which there are variations in both the content of the material and the user’s needs and abilities.
In a later study, Hammond and Allinson (1989), the LSE was used for a database of the history of the city of York. This study was intended to examine the influence of restricting the available access tools, on the grounds that the ability to use a particular facility does not necessarily mean that it is worthwhile. Performance was measured on an exploratory task (where subjects were tested to see how much they had learnt) and a directed task (where they were given a set of questions). The database mainly comprised screen-sized units, although cross-referencing was permitted. Travel facilities were provided in five different conditions:

1. Hypertext (Rambling).
2. Hypertext, Map.
3. Hypertext, Index.
4. Hypertext, Tours.
5. Hypertext, Map, Index, Tours.

The results suggested that although hypertext was the main navigation method, the additional forms of navigation were called upon substantially, with the method of navigation used being task-dependent, and again the most appropriate for the task being performed.

The provision of different navigation facilities significantly influenced the number of screens viewed. Subjects in the hypertext condition viewed least screens, in terms of both the total number of screens and the number of different screens. When navigation was examined in terms of the ratio of new screens seen to total screens, subjects in this condition showed less efficient exposure to new information than those in the other conditions. It would therefore appear that the addition of other navigation facilities resulted in more efficient access to new information.

Subjective measures indicated that the system was considered easy to use, and 'better than a book'. Getting lost was not perceived to be a problem. A comparison of estimates of how much of the information had been seen with the actual amount seen indicated that the greatest divergence was in the hypertext-only condition, with the amount of material seen being over-estimated.

Nielsen and Lyngbaek (1990) describe a study using NorDATA ‘87, which is presented in Guide. One of the subjects is reported as saying that "I soon realized that if I did not read something when I stumbled across it, then I would not be able to find it later" (p.65). Nielsen and Lyngbaek also discuss difficulties encountered by readers of an interactive fiction entitled "Inigo gets out", arising from the use of two different
navigational metaphors in the document. The authors propose that this emphasises the importance of consistent navigational metaphors in a hypertext system.

In the first experiment of a study by Monk et al. (1988), subjects' ability to perform a problem-solving task was compared using (i) a hypertext browser, (ii) a scrolling browser and (iii) a folding browser. The underlying model for the scrolling and folding browsers was of a single sequential document, while for the hypertext browser, it was units of information. Performance was found to be inferior in hypertext browser condition. In a second experiment, subjects were provided with a non-interactive overview of the structure, in the form of a printed map displayed to one side of the screen. To control for the possible influence of the availability of section titles in the map, a list of section titles was also available in an additional condition. It was found that the provision of a map significantly improved performance using the hypertext browser, but the list of section titles had little effect. The authors conclude that:

"It would seem that providing a map or 'overview', to use the terminology of the Notecards system, is of crucial importance" (p.433).

They further consider that if no overview is available, then the cognitive effort required to navigate through the structure may outweigh the benefits provided by a non-linear text structure matching the demands of the task.

The hypertext used in these studies contained only 12 sections, and the addition of a map produced a 25% improvement in performance. Monk et al. propose that greater improvements may be found with a larger hypertext, although they do recognize that there will be a point at which the amount of information is such that a map will be too complex to be of benefit. They also suggest that an interactive map may be of greater utility than the non-interactive one employed in their investigation.

A series of studies involving the identification of landmarks in a hypertext network was conducted by Valdez et al. (1988). It was concluded that landmarks appeared to be important, even in the absence of cognitive structures that were strongly spatial in nature. Connectivity was found to be a good predictor of landmark quality, and the authors suggest that this is not surprising in view of the fact that "in normal human commerce", places where paths cross often become landmarks.

Shneiderman (1987b) describes two studies using HyperTies. In the first study, subjects were required to traverse the database in order to answer questions posed by the experimenter, and performance using embedded menus was compared with that using explicit menus. More questions were completed, and both fewer screens and
articles were visited by subjects using the embedded menus. This type of menu was also considered preferable to the explicit one.

The second study compared performance using a database presented on paper and in HyperTies. Subjects were required to answer three types of questions, (i) locating a simple fact at the beginning of an article, (iii) locating a simple fact in the body of an article, and (iii) questions which required information to be obtained from two articles. Performance was significantly faster on paper for the first type of questions, but there was no significant difference between the media for the less simple types of questions. However, the majority of subjects preferred the HyperTies version of the database.

An investigation by Edwards and Hardman (1989) examined the effect of three different representations on users' perceptions of the structure of a hierarchical hypertext document:

Hierarchy  —  Movement was only possible by traversing the hierarchy. Travel through the database was via buttons embedded within the text.

Index  —  Movement was through an alphabetical index, in which the screen titles were selectable. This index was available from all of the other screens. Subjects were not able to traverse the hierarchy, but it was unfortunately still in evidence because the screen titles were highlighted.

Mixed  —  Both the index and hierarchy method of travel were available to readers.

The measures employed were (i) latency and the number of screens selected in a question-answering task, (iii) subjective opinion, (iii) a questionnaire concerning various aspects of feeling lost, and (iv) scores in a 'map construction' task. For the map construction task, subjects were asked to lay out miniature paper copies of the screens on a board as they were thought to be arranged in the document, drawing lines to represent the links. The titles on these cards were enlarged in relation to the body of the text, so that the text itself was not legible.

The main findings were as follows:

1. For the question-answering task, latency decreased during the task in the hierarchy condition. Fewer screens were visited in the index condition, and most in the mixed one. There was no significant difference between the conditions in the number of
questions correctly answered.

2. Scores for the map construction task were highest in the hierarchy condition and lowest in the mixed condition.

3. There was no significant difference in overall feelings of ‘lostness’ (although the highest score was in the mixed condition).

4. Satisfaction was highest for the hierarchy condition and lowest for the index condition (The latter finding was possibly due to frustration caused by the visible, but redundant, hierarchy).

5. Significant correlations were found between (i) scores in the map construction task and feelings of being lost, (ii) scores in the map construction task and satisfaction ratings, and (iii) satisfaction ratings and feelings of being lost.

Overall, the results of the study were said to indicate that subjects in the mixed condition had greater difficulty using the hypertext than those in the other two conditions. Edwards and Hardman concluded that people do form cognitive representations of documents they read, and that accurate structural knowledge is important if readers are to locate information from a hypertext efficiently. The authors proposed that designers should provide spatially-based orientating/navigating devices, which present the information in a two or three-dimensional form, rather than just maintaining a record of the units which have been viewed.

An investigation concerning the user’s model of a hypertext interface is reported by Teshiba and Chignell (1988). The interface to Project Jefferson, which is an online information retrieval hypertext system to help students perform research, was used for the studies. The interface is based on the metaphor of a notebook, and it provides:

1. A ‘scratch pad’ to record notes.
2. Background information related to the user’s current assignment.
3. A citation facility in the form of a card catalogue, which permits students to access a database of books and articles related to their current topic.
4. A function to record what is on the screen at a given moment for later review.
5. A ‘locator’ device which provides links and background information on terms related to the chosen topic.
The ‘locator’ is a hierarchical search tool which presents the user with five categories of topics, each linked into the lower levels: the underlying model of Project Jefferson is that of hierarchies superimposed on networks.

The studies were intended to assess the users’ models of the hierarchical part of the interface in relation to its actual structure. Subjects were first asked to form hierarchies of the thirty topic titles from the system, which were printed on index cards. They were then required to use the system to search for specific topics in the index hierarchy and, finally, to perform the sorting task again.

The results indicated that the accuracy of pre-search hierarchies was positively correlated with performance in the search task — those subjects who performed better in the sorting task also did so in the search task. There was also a tendency for the hierarchies produced in the second sorting task to be more similar to the actual structure of the system than those produced in the first sorting task, thus suggesting that some learning occurred during the search task.

Marchionini and Shneiderman (1988) speak of a mismatch between the system and the user’s conception of it, claiming that usage patterns will be determined by the user’s mental model of the system. The authors suggest that the embedded menus in HyperTies are examples of specialized indexing for systems which emphasize understanding rather than retrieval, highlighting semantic relationships, rather than physical ones. This implies that embedded menus may be more suitable for certain types of tasks than others.

It was found that when subjects were asked to search for specific information in a HyperTies database, the predominant strategy (14 of 16 subjects) was to use the alphabetical index. Marchionini and Shneiderman consider this points to the importance both of the type of task and the user’s mental model for the task. It would seem that the subjects in this study used a familiar strategy, not that which the system was designed to promote.

However, a usage log of a HyperTies system in three museums (Shneiderman, Brethauer, Plaisant and Potter, 1989) indicated that more than two-thirds of selections were made through the embedded menus, as opposed to the index. This demonstrated an orientation towards a browsing strategy in a museum setting, and also indicated that people used the appropriate strategy for such a task. It was concluded that:

“For hypertext and electronic information systems to be effective, designers must understand how users find specific facts, locate fragments of text that satisfy information queries, or just browse” (p.70).
McKnight, Richardson and Dillon (1990b) describe a hypertext database of academic journal articles in which the ‘front-end’ is based on a library shelf metaphor. This approach was employed on the grounds that because it was based on the existing structure of paper journals and issues, it would be both readily understood by readers and easy to implement.

The ‘front end’ of the database (the library level) is presented in HyperCard, and the articles are placed within a hierarchical structure of journal title, volume and issue number. The journal articles themselves are presented hierarchically in Guide, with the sections of the paper journal article being preserved. If an article references another article in the database, it is possible to jump directly to that article if desired. In addition, full details of a referenced article may be viewed in a pop-up window.

There has as yet been no formal evaluation of the system, but one potential problem would appear to be that there is no navigation support for jumping between articles within the database. In addition, the authors acknowledge that the library shelf metaphor would be inappropriate for larger databases, and, perhaps more importantly:

“Such a representation ignores the content of the articles. It is the content which is of primary interest to the users – knowing which shelf the journal sits on only aids access at the global level” (McKnight, 1990, p.297).

The importance of the ‘front end’ is stressed by Raskin (1987), who suggests that it may even be more important than the central part of the system, because if the front-end puts people off, then they will never go any further.

1.10 SUMMARY

This chapter commenced with a discussion of the problems faced by the present paper-based journal system, the way in which it is used, and its perceived advantages and disadvantages. Previous electronic journal systems were described, both the philosophy underlying their design and the lessons they have taught us in relation to the design of future electronic journals. The main area in which further work would seem to be required is in permitting readers to browse through, search and retrieve information more easily from an electronic journal.

It was suggested that there is no inherent difficulty in reading electronically presented text, particularly from the high quality equipment typically required for hypertext systems. The use of metaphors in relation to computer systems has been examined, and
it was concluded that the application of a navigation metaphor to the hypertext environment may be of benefit to readers.

The role of location as an incidental cue for the relocation of information from sequentially presented documents in both the paper and electronic media was discussed. It was suggested that location may act as an important navigation cue, and that alternative methods of introducing location into hypertext documents are required. Various approaches to the design of electronic documents were described, and an approach which merely attempts to imitate the paper medium was rejected.

After a discussion of the numerous definitions of the term 'hypertext' which have been proposed, it was decided to adopt the simple definition of hypertext as being units of information linked together in a network. Existing hypertext systems were described, with particular emphasis on the navigation facilities provided in each. The proposed advantages and disadvantages of hypertext were examined, and it was concluded that while there may be difficulties, there are also many potential advantages for both readers and writers.

The concept of getting 'lost in hyperspace' was discussed, together with possible solutions to the problem. Finally, previous studies concerning the use of hypertext systems for a variety of tasks were described.

1.11 THE THESIS

The present research commenced by interviewing academics from four different university departments concerning their usage of the paper-based journal system and attitudes towards the concept of an electronic journal. Earlier investigations (e.g., Haarala, 1983; Martyn, 1987) had provided some information in the former category, but there is now a greater awareness of the capabilities of the electronic medium and, furthermore, these have improved considerably since the previous studies. The aim of the present interviews was to gather information concerning (i) the problems encountered in the present journal system, which might be alleviated by the use of the electronic medium, (ii) how the system was used, indicating those features which should either be retained or provided by an alternative method electronically, and (iii) to gain some insight into probable attitudes towards an electronic journal. The interviews also provided a context in which to place the experimental part of the thesis.

The starting point for the experimental work itself was the importance of location as an incidental cue for readers of documents. Previous studies (e.g., Lovelace and Southall,
1983; Haas and Hayes, 1985a) had indicated that, both in the paper and electronic media, location acts as a cue for the retrieval and recall of information from within a text. One of the cues which is available in the paper medium but not (generally) in the electronic one is whether a certain piece of information is presented on a left or right hand page. The first aim of the second study was to determine if such a cue was incidentally encoded in the same way as within-page and text-sequence cues have been found to be. Previous studies have used fairly short texts (typically comprising less than 2,000 words) and with an average of approximately 24 lines per page or screen. The second aim of this study, therefore, was to investigate the incidental recall of text location using a longer text, and with more lines per page/screen. The study examined incidental memory for the location of text presented in four different forms: continuous scroll, single page, preview (two pages displayed simultaneously, but no left/right-page cues) and in a book form.

It has been suggested that, for a number of reasons, readers of electronically presented text have difficulty in relocating information from within the document (e.g., Wright, 1987). A major problem would appear to be due to the loss of tactile cues in the paper medium – those cues associated with the physical nature of the text, thus making it difficult for readers to form an overview of the document. Other problems lie in the fact that some of the location cues used in the paper medium are not available in the electronic one. One possible solution is to introduce other kinds of cues into an electronically presented document. Tombaugh et al. (1987) have demonstrated that the use of a multi-windowing technique may be of benefit in the relocation of information. However, the study did not determine which features of the technique were responsible for the enhanced performance compared to a single window display. The authors suggested that a tiled display (as compared to the overlapping one used in the study) may be of even greater utility, in that it enhances the spatial separation between the windows. In an attempt to answer such questions, the third study compared performance in an information relocation task using the reverting stack technique employed by Tombaugh et al. with one in which the windows did not revert to their correct order, and a fully tiled (non-overlapping) display.

The previous two studies in this thesis employed text presented in a sequential manner, but hypertext systems permit the use of alternative structures, containing active pointers between the units of text. It has been proposed that people form mental maps of documents that they read (Waller, 1985; Edwards and Hardman, 1989), but the flexible access permitted in hypertext systems makes the formation of such maps more difficult. Readers therefore need to be provided with facilities which aid in this process if they are to be able to navigate through the document efficiently, and not become 'lost in hyperspace'.
In view of this, the next series of studies examined the possible benefit of a number of facilities in helping readers to navigate through a hypertext document. The relationship between the ability to form a mental map of a document's structure and navigation performance was also investigated. The first three of these studies used hierarchically structured documents, and the variables examined were as follows:

1. An alphabetical index vs. a hierarchical contents list.
2. Typographical cues to the document's structure.
3. The provision of a 'footprint' in the the index or contents list, showing readers which text card they had just come from.
4. A graphical vs. a textual representation of the hierarchy.
5. Interactive vs. non-interactive representations of the hierarchy.
6. Providing readers with a record of the cards which they had visited.
7. Indicating the order in which these cards were visited.

A hierarchical structure may not be the optimum for all types of documents and databases and, furthermore, precludes some types of links. In view of these factors, the next two studies investigated the effect of various navigation cues using a non-hierarchically structured hypertext. With the exception of the hierarchical contents list and typographical cues, the same variables were examined as for the hierarchical documents. An additional variable investigated was the possible benefit of showing readers the direction of the links between the cards.

It was intended that a set of features which assisted readers to navigate through hypertext documents of different structures could be derived from the results of these studies. The aim of the next study was to apply these to the interface for an academic journal article, comparing performance with that using a contents list taken from the paper medium.

The final experiment examined readers' ability to navigate through, and retrieve information from within, a database of interlinked journal articles. The interfaces for the individual articles contained the features found to be of benefit to subjects in the earlier studies. Performance was compared using two interfaces to the database itself: one contained the same features as the interface for the individual articles, and the other was a chronological list of the articles in the database.

Some more general points should be made here concerning the thesis. First, the type of electronic journal discussed is intended to be presented on CD-ROM, rather than in an online format such as that employed in the EIES and BLEND systems. Second, although the main focus of the research is on the electronic journal, other sorts of texts
are also used in the studies. There are several reasons for this: (i) limited copyright permission was available, (ii) it is difficult to find journal articles that are intelligible and interesting to a wide range of users, and (iii) the inclusion of other types of texts enabled a larger number of subjects to be used than would otherwise have been possible. Third, some of the location tasks that subjects were required to perform would have been more easily carried out using a string-search mechanism. However, such a facility was not provided because one of the main aims of the studies was to examine subjects’ ability to navigate through the documents. Finally, throughout the thesis, the emphasis is on the location and relocation of information, rather than on comprehension measures. This decision was made because there are a number of problems associated with the use of comprehension as a performance measure. The main difficulty would appear to be that there is no generally agreed measure of comprehension. For example, in the study by Richardson, Dillon, McKnight and Saadat-Sarmadi (1988), two measures were employed, and a different pattern of results was obtained for each. Furthermore, the present author agrees with Wright (1987), who says that:

"There is little advantage in knowing that readers can understand the information, if in practice they cannot find it" (p.51).
CHAPTER TWO

READERS' USE OF THE PAPER JOURNAL SYSTEM

2.1 INTRODUCTION

The study described in this chapter examines the way in which the existing paper-based journal system is used, in order to provide information which may assist in the design of an electronic journal system.

2.1.1 Problems with the paper journal system

The academic journal is the main vehicle for the dissemination of scientific research, and has played a major role in the research process for over three hundred years. However, the future of traditional procedures in academic referred papers journals would now appear to be in question. There are several reasons for this. First, the ever-increasing costs of printing and associated processes. The economics of the publisher/library system are already finely balanced, and the rising cost of conventional journal production has resulted in many libraries being forced to make cuts in the number of serials to which they subscribe. The expanding volume of information available is also an important factor, and the storage problem is exacerbated by the need for libraries to store materials such as records and films, as well as printed materials.

In addition to the problems encountered by libraries, users also face difficulties. For example, material may be already on loan, at the binders, missing, unshelved, vandalized or even stolen. In addition, library hours are limited, buildings may be inconveniently situated, and the working conditions are often not conducive to study. The library may not have the desired material, in which case interlibrary loans are slow for the user and expensive for the library.

A further reason why the future of the paper journal may be in question is that, for a long time, paper has remained unchallenged as the only viable presentation medium for journals. Recent advances in computer-based technology now make it possible to present journals electronically, and the considerable advantages of the electronic storage and retrieval of information have also been demonstrated.

However, if the use of the electronic medium is to resolve problems faced by readers of paper journals, it is necessary to determine what users’ requirements of a journal system may be. It was considered that an examination of the way in which the existing
paper-based journal system is used could provide information that would help to answer this question.

2.1.2 Previous studies

Previous investigations have addressed some of the issues examined in the study described in this chapter, and the findings of these are briefly discussed below.

The most extensive study of readers' usage of the paper journal system is that reported by Line (1971). This wide-ranging study was intended to gather data which could be used to improve existing information systems and to design new ones. The subjects were social scientists, the majority of whom were researchers. Three main methods of data collection were used in the investigation (i) a questionnaire, (ii) interviews, and (iii) day-to-day observation. The topics examined included sources and types of information, methods of article location, use of abstract and indexing journals, library catalogues and bibliographies, and the perceived importance of informal channels of communication.

The most frequently used and most highly rated method of locating information employed by subjects was following up references in books and periodicals. This method was used by 94% of respondents, and rated as being the most useful by 95% of them. Library catalogues were only used by 61% of the subjects, but 41% used special bibliographies. Sixty-five percent of the sample mentioned one abstracting or indexing journal that they used regularly, with an overall mean of 1.7 such journals. Expressing concepts in appropriate terms for abstracting and indexing journals was considered to be a problem by 30% of the sample, while 33% were often unable to find the term used by the indexer. The majority of subjects indicated that a delay of one to three months between the publication of an article and its appearance in an abstracting or indexing journal was acceptable.

Eighty-four percent of those surveyed considered it important to keep up-to-date with new publications, and the most common method of doing so was through personal and informal contacts. Many spoke of difficulties in obtaining information concerning current research, and 78% claimed that information was frequently found too late to be of use. The accidental discovery of relevant material was reported by almost all subjects, with 46% claiming that this was usually through scanning periodicals. A large proportion of the sample (72%) said that they never delegated searching for information. Reasons for this included the loss of serendipity and the opinion that no-one else was competent to carry out the search.
Interestingly, 3% of the subjects claimed that they never used libraries, although 11% used six or more. Only 4% considered that the material held by their local library was adequate for all of their requirements.

The use of the paper journal system for a specific purpose has been examined in several studies. For example, Cooper (1985) sought to determine how authors locate material when conducting a literature search for review-writing purposes. Three aspects of reviewers' strategies were investigated (i) sources of information accessed, (ii) how useful these were considered to be, and (iii) how 'central' to the review they were thought to be. The average number of search strategies used by those authors surveyed was seven. The most commonly employed strategy was, not surprisingly, references provided by previous reviewers. Journal articles were the most frequently used type of documentation, accounting for 53% of all citations. Cooper notes that computer searches of abstracts appear to be increasing in popularity, and that authors employing this search technique found it to be extremely useful.

Three distinct approaches to searching the literature were identified in the study:

1. Bibliographic – emphasis on the use of searches compiled by other reviewers.
2. Personal contact – relying on information provided by others in the field.

In a later investigation, Martyn (1987) examined the information-seeking practices of a group of scientists from various backgrounds in relation to their current research. The main emphasis of the study was on the possible causes and costs of late-found information. This study was a follow-up of an investigation conducted in 1964, in which 23.3% of those scientists surveyed reported finding relevant information too late to be of use. It was considered that the changes in behaviour and attitudes that had occurred within the information environment since the earlier study would have influenced the number and causes of late finds made. The results of the 1987 survey are summarized below.

Following up references in relevant papers was the most frequently used information searching strategy, cited by 96% of respondents. The second most frequently used strategy was keeping up with the literature by reading current publications (cited by 95%). These two sources of information were also considered to be the most useful.

Late finds were reported by 25.6% of academic researchers, 21.5% of industrial and 30.4% of government scientists (an overall mean of 26.8%). Martyn also suggests that relevant information existed in the literature in many more cases than were actually
reported. The number of late finds was not related to the facilities available to respondents, and the author considers that all of them had access to a satisfactory level of basic information facilities. The most common method of discovering late found information was through another person pointing it out (29% of late finds). Twenty-seven percent of late finds were made by chance when looking through publications, while 23% were cited as references in other documents. The searching strategies employed by subjects had no significant influence on the number of late finds reported.

A study by Sabine and Sabine (1986) compared the way in which books and journals were used by members of university, special and public libraries. Sixty-nine percent of the respondents worked in the physical sciences, 21% were social scientists, and the remainder were from a wide variety of occupations. Subjects were asked questions relating to the type of material accessed, how it was located and used, and the amount of information contained in a book or journal which was relevant to their needs. The survey also included questions concerning the availability and use of computers.

The physical scientists reported reading very small portions of books and journals, with 60% reading 10% or less. Half of the interviewees took notes or photocopies of material. Eighty percent of the sample had access to a computer, but only 5% had ever used one to call up information from a book, rather than merely a citation. The problems encountered in dealing with information were specifically noted by respondents. For example, one subject remarked that:

"It's not organized in such a manner that you can capture just that part of it you need. Books are still organized as books, and the table of contents is put in the way the author intends; the index is organized the way the author intends. These data are not organized necessarily for easy browsing, and one cannot get at just that information one wants... We're quite frankly overloaded with books and reports, and it's hard to find one's way around and through them" (Sabine and Sabine, 1986, p.408).

In an investigation by Pullinger (1983), a sample of researchers in the field of Computer Human Factors (computer scientists, human factors engineers and psychologists) were questioned with respect to their reading and writing habits, and opinions of the present publishing system.

Responses to the interviews indicated that 65% of browsing and 85% of reading papers took place out of office hours, either at home or whilst travelling. Three main strategies for approaching a journal article were reported (i) filtering through the sections of the article in their correct order, (ii) a preliminary filter of the title and abstract, and (iii) skimming through the article looking for new ideas.
Sixty-three percent of the sample wrote mainly in the evenings, with a large number claiming that they would like to write more papers than circumstances permitted. Little communication between readers and authors was reported: only 19% of those interviewed said that they asked for reprints from authors, and the number of requests received for reprints of their own papers was considered to be declining. Subjects expressed a strong dislike of delays in the present publication process. Sixty-eight percent of respondents considered that the maximum acceptable time for initial editorial processing was three months or less. Refereeing was viewed as a mechanism for maintaining the quality of journals, but a number of those interviewed complained about occasional arbitrary and unhelpful refereeing.

Finally, in perhaps the most similar study to that reported here, Dillon et al. (1988) interviewed fifteen human factors researchers concerning their use of the paper journal system. It is of particular interest that the present study was conducted very soon after this, so that answers to those questions that are common to the two investigations may be compared for the different samples studied.

The department in which the interviews by Dillon et al. were conducted is a distance of two miles from the main campus, and has its own library. However, this does not hold the full range of the journals in which respondents may find relevant material. Of the 15 subjects interviewed in the study, only one said that he visited the main campus library regularly, six did so occasionally, seven seldom, and one never. Reasons for not using the superior facilities on campus included the physical distance involved and, a related factor, lack of time. Five of the interviewees mentioned using the interlibrary loan service (based in the main campus library) in order to obtain material. None of the subjects reported that they did any reading in the library, three of them (20%) expressing a strong dislike of libraries as a place in which to work.

None of those interviewed felt that they covered all of the journal material relevant to their needs, 20% considering that it was likely they missed a lot of relevant material. The majority (54%) felt that they missed some material, while a third were satisfied that they covered most of it. All of the interviewees reported that relevant material was pointed out to them by colleagues. Subjects distinguished between two types of journal accesses. The first was occasioned by work demands, and the second by personal interests. It is difficult to give an access rate for the former type of usage, as this obviously depends upon the individual’s current work. However, 60% of interviewees claimed that they accessed a journal at least once a week for personal interests. The lowest rate was once every two months (one subject), and the highest was twice per week (four subjects). Seven subjects had a subscription to one or more journals,
although the authors note that subscription to a journal is obligatory for membership of the Ergonomics Society.

Journal articles were photocopied regularly by all of those interviewed, and a number of reasons were given for doing so. First, not wanting to remove a journal in case another person wanted it. Second, a photocopy can be read in detail at the user's convenience. Third, it is possible to annotate and highlight photocopies. Finally, they can be stored for easy retrieval at a later date. However, eight of the fifteen subjects admitted to photocopying articles that were never read.

When asked how they selected the articles to be read from a new issue of a journal, subjects reported that they primarily used the titles and authors as selection criteria. However, it should be noted that several of the sample considered that titles alone could be misleading, and said that they would often scan the rest of the article before deciding whether or not it was relevant.

In the second part of Dillon et al.'s study, observations of the way in which readers interacted with a journal article were conducted. When an article of interest had been identified, the abstract was examined first, followed by a quick scan of the remainder of the article. The majority of subjects browsed the beginning of the introduction, then scanned the section headings. The conclusions were also frequently browsed at this stage and sometimes the references. By this point, the reader had decided whether the article was relevant to his current purpose. In cases where it was so, the authors identified three reading strategies:

1. A rapid scanning of the abstract and/or introduction, then section headings and occasional paragraphs within sections, figures and tables. Subjects also noted the level of mathematical content and the length of the article at this stage. Browsing the conclusions was often used as a method of extracting the main ideas from an article.

2. The article was read in a non-serial manner, reading some sections fully and skimming or even omitting others. Usually the introduction and discussion were read fully, while the method and results were just skimmed.

3. A detailed serial read of the article.

However, Dillon et al. consider it to be unlikely that any of these strategies are rigidly adhered to, and the majority of subjects reported that an article would eventually be read serially, in a fairly detailed manner. An important point to emerge from these
observations is that readers would seem to overlook a large proportion of the material in journal articles.

Subjects were also asked questions relating to the provision of an electronic journal database. Physical access was seen to be very important, with the majority stating that they would like such a database to be available from their own desk.

2.1.3 The present investigation

The aim of the study described in this chapter was to gather information concerning the way in which the present paper-based journal system is used, in order that an electronic system may be designed which is able to satisfy the needs of its users.

The study differed from those described in the previous section in two main ways. First, although earlier investigations had provided answers to some questions, as Martyn (1987) says, changes in the information environment may influence both usage and attitudes. In view of the recent improvements in, and greater awareness of, the capabilities of computer-based technology, one particular area in which it was thought that attitudes may have altered was in relation to the electronic presentation of documents. Second, there were differences in the nature of the sample population studied, or their purpose for accessing information.

The focus of the present investigation was on those aspects of the information system which were considered to have some relevance for the design and provision of an electronic journal.

2.2 METHOD

2.2.1 Subjects

Twenty academics were interviewed, five from each of the following departments: Chemistry (C), Economics (E), Human Sciences (HS) and Library and Information Studies (LIS). All of the interviewees were involved in both teaching and research activities within the university.

2.2.2 Interview format

The format of the interviews was determined as follows. A list of possible questions was compiled, and an interview based on these questions was given to one subject
from each of the four departments included in the study. Modifications indicated by these pilot interviews were incorporated into the questions, and the process was repeated until it appeared that no further modifications were necessary. Subjects used in these pilot interviews did not participate in the main study. The interviews were semi-structured: the interviewer attempted to retain the same question order for each subject but, due to the nature of their responses, this was not always possible.

2.2.3 Procedure

Each subject was interviewed individually, usually in their own office. Unfortunately this did mean that some interruptions (e.g., telephone calls) were unavoidable during the interview sessions. The interviews were tape-recorded (subjects' permission having been obtained) and transcribed by the interviewer. Transcription was in several stages. The first transcriptions were verbatim, the next stage eliminated all 'extraneous' words (such as those due to interruptions) and the final stage reduced the transcriptions to subjects' responses to the original questions asked.

2.3 RESULTS

2.3.1 The number of journals subscribed to by interviewees

The number of journals taken personally by respondents ranged between one journal (C and HS) and 20 journals (LIS), with a mean of 6.20 per subject. As can be seen from table 2.1, the mean number of journals taken was lowest for subjects in the Human Sciences department and highest for those in the Economics department. Several of the respondents admitted that they did not actually subscribe to all of the journals mentioned, but that some were received as a consequence of membership of Editorial Boards or certain societies.

<table>
<thead>
<tr>
<th>Department</th>
<th>Mean</th>
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<tbody>
<tr>
<td>Chemistry</td>
<td>mean = 4.60</td>
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<tr>
<td>Human Sciences</td>
<td>mean = 3.80</td>
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<tr>
<td>Library and Information Studies</td>
<td>mean = 7.60</td>
</tr>
<tr>
<td>Economics</td>
<td>mean = 8.80</td>
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Table 2.1. Mean number of journals taken by subjects in each department

2.3.2 Coverage of journal material

Twelve of the interviewees (60%) claimed that they read all of those journal articles considered to be related to their own field of interest. However, 25% of subjects said that constraints of time influenced their reading habits, e.g.,
“I would like to read more, but I haven’t the time” (LIS).

2.3.3 The number of abstract journals taken

There was a large variation in the number of abstract journals taken by members of the four departments studied (see table 2.2). For example, 60% of the Chemists interviewed subscribed to an abstract journal, whereas none of the LIS interviewees did so. Thirty percent of the total sample took an abstract journal.

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<th>Department</th>
<th>Number</th>
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<tr>
<td>Chemistry</td>
<td>3</td>
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<tr>
<td>Human Sciences</td>
<td>1</td>
</tr>
<tr>
<td>Library and Information</td>
<td>0</td>
</tr>
<tr>
<td>Economics</td>
<td>2</td>
</tr>
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Table 2.2. Mean number of subjects in each department taking an abstract journal

2.3.4 Sources of references

Subjects were asked how they obtained references to their reading material. Reported sources of references included citations in journal articles (mentioned by eight subjects), those provided by research students (seven subjects), references from colleagues (six subjects) and those from books (three subjects). The high reliance on students was perhaps surprising, although shortage of time may be an influential factor:

“I rely on research students; I’ve got no choice what with everything else I’m trying to do” (C).

The relatively low usage of books as a source of references may be due to readers’ requirements for up-to-date references:

“Research level books – less, I think, that route, because of the time-lag involved” (C).

However, opinions concerning the utility of references obtained from colleagues were high, e.g.,

“The best references always come from colleagues” (HS).

Similar comments were made by 40% of the sample.
2.3.5 Obtaining articles

If the interviewee did not possess a particular article required and it was not in the university library, then it was obtained by one or more of a number of methods. The various methods cited, and the number of subjects mentioning each of them, were as follows:

- Interlibrary loans (13 subjects)
- Reprints from authors (3 subjects)
- Travel to another library (3 subjects)
- Research students (3 subjects)
- Friends in other institutions (1 subject)

As can be seen, the interlibrary loan service was used to a considerable extent, although opinions as to its efficiency varied:

"The interlibrary loan service is very good" (HS).

On the other hand:

"I would travel to a library that holds a journal – it's quicker than an interlibrary loan" (C).

2.3.6 Article selection

Subjects were asked how they selected the articles to be read from a new issue of a journal. There was little variation between the four departments in the strategies employed for the selection of articles. All of those interviewed examined the contents page first, 80% were concentrating on the subject/title, and 45% also used authors' names as a criterion for selection. A quarter of the respondents specifically mentioned keywords. An example of a response illustrating all of these strategies is as follows:

"Contents page – I'd look for both title and author. Keywords. There's a certain curiosity to see what colleagues have been writing" (HS).

Two subjects also said that the place where the reported research had been carried out was an influential factor, because they knew which departments were doing research closely related to their own.
It is interesting to note that several of the sample reported that, after looking at the abstract, they would scan the rest of the article, remarking that neither the title or abstract told them whether the article was relevant.

2.3.7 Time and location of reading

Sixty-five percent of interviewees said that all of their reading was done at home in the evenings, one subject offering the interesting opinion that:

“I do my reading at home – it’s an alternative to the television!” (LIS).

The most common reason for reading at home was that there were too many interruptions in the office. Three subjects claimed that the majority of their reading was carried out whilst travelling,

“On train journeys – at peaceful times of the day” (LIS).

(It is an interesting reflection on an academic’s life that a train journey is considered to be more ‘peaceful’ than their office!).

2.3.8 Reading strategies

Half of those interviewed reported that they read the abstract of an article first (see table 2.3), and four mentioned some kind of skimming/scanning strategy, e.g.,

“The abstract, then skim the rest, looking for important points” (LIS).

“Only in the extreme would I actually read the middle part of the article” (HS).

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<td>Chemistry</td>
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<td>Human Sciences</td>
<td>2</td>
</tr>
<tr>
<td>Library and Information Studies</td>
<td>3</td>
</tr>
<tr>
<td>Economics</td>
<td>2</td>
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</tbody>
</table>

Table 2.3. Number of subjects in each department who read the abstract first

A number of subjects said that they would vary their reading strategy according to the article’s proximity to their own field of research:

“Main research: beginning to end. Others: data only, or I might look at the methods used” (HS),
"Read the abstract, then it depends what it is. If it's mainline, then I'll start at the beginning with the intention of reading straight through, then I'll probably jump bits. If it's a bit offline, then I'll skip through it, maybe look at the figures" (HS).

Others claimed that recency of publication influenced the way in which an article was approached, e.g.,

"Current papers: I never read the experimental part. Past papers: I rarely read the discussion or summary" (C).

Time was again mentioned as being an important factor:

"Pressure of time is the problem. I try to read as little as possible, but get the main gist of the paper" (C).

2.3.9 Citations in the text

When asked if they read the full details of references cited in the text, 60% of those interviewed claimed that they always did so straight away:

"I go to the end immediately. One of the reasons for looking at an article is to find out about other work you don't know about" (HS).

Several subjects remarked that the different methods employed for giving details of citations influenced their strategy:

"At the foot, I will invariably glance down. At the end, it's frequently a case of what level do I think the reference is in terms of importance" (C).

Only two subjects (LIS and E) said that they never turned to the references section of an article immediately, claiming that this disrupted the reading task.

2.3.10 How articles are used

Once an article had been selected as being relevant to the reader's interests, a number of approaches were used: taking a photocopy, making notes, or writing a brief abstract. Several interviewees mentioned more than one method, e.g.,

"If I think the paper is of low priority, then I make a few notes. If it's of considerable importance, then I take a photocopy. There are a lot of places where I just annotate" (C).

The most common way in which articles were used was to take a photocopy, (mentioned by 65% of subjects). Forty percent of those interviewed wrote an abstract
card, while only 30% made notes on the articles they read. Opinions as to the relative utility of taking notes or making photocopies varied:

"It depends, if I were writing a paper, then I would take a photocopy. If it was just for lecture purposes, then I would probably just remove a few notes" (HS).

However,

"If I were just browsing and I found it, then I would take a photocopy. If I were doing a literature search I would take notes" (LIS).

It would therefore appear that whether or not a photocopy is taken depends to some extent upon the intended use of the article. Reasons given for taking photocopies included (i) the ability to annotate, (ii) for use in a personal filing system, and (iii) time constraints.

2.3.11 Reprint requests

Seventeen subjects claimed to have received requests for reprints, with all subjects in the Chemistry and Human Sciences departments having done so. The majority of these requests were said to come from other academics, but only three of the interviewees said that they wrote to authors for reprints themselves.

2.3.12 Writing journal papers

Forty percent of the interviewees said that they wrote exclusively at home, while 25% only did so in the office. The place of writing was to some extent linked to the method of writing. Eighty percent of the sample used a wordprocessor at some stage of the writing process, and if they had no access to such equipment at home, then they would obviously have to write in the office, and vice versa. There was considerable variation between departments in the extent to which word-processors were used. None of the subjects from the LIS department used one, but all of those from the HS department did so.

Fifty percent of the sample engaged in the writing of joint papers. There was again a marked difference between the departments: all of the subjects from the Chemistry department engaged in collaborative authoring, but only one from the LIS department.
2.3.13 Conference attendance

All of the interviewees considered that the main benefits of attending conferences were social, e.g.,

"I find conferences are less useful for providing me with up-to-date information in my field. Their main use is making personal contact with scientists I only know as names on paper" (C).

Informal discussions were thought to be more beneficial than the formal papers:

"The main benefit is that in talking to others in the field, you get to know about current thought. Not necessarily about current work, but about the way people think about things now. That is important" (LIS).

2.3.14 Electronic communication

The extent to which electronic communication was used by subjects was considerably influenced by the availability of equipment. For example, in the Chemistry department, none of those interviewed had a terminal linked to the university’s electronic mail system (and from there to the Joint Academic Network) in their own office. In the Human Sciences department, however, all of the subjects had such facilities. This is reflected in the results of the interviews – none of the Chemists had used electronic mail, whereas all of those in the Human Sciences department had done so. Indeed, access to equipment was mentioned by several subjects, e.g.,

"I would have to walk to a terminal, and that’s just too inconvenient. If I was connected here it would be a different matter. If I thought it would go straight to their desks I would use it" (C).

Of those who did not at present use electronic mail, four expressed an interest in the system, e.g.,

"No, nothing more than the telephone I’m afraid. It’s inertia; I’m interested in electronic communication, very interested, but a substantial inertia" (LIS).

Many subject’s responses resembled the following:

"I did use electronic mail for the first time last week. I think it’s partly a question of, firstly, being aware that it’s there, and secondly, getting into the habit of using it" (E).
2.4 DISCUSSION

2.4.1 Comparison with previous findings

One aim of the present study was to determine whether there had been any changes in journal usage patterns since the earlier investigations discussed in section 1.2.2. In the following section, responses to those questions which had been addressed in these studies will be compared with those obtained in the present one.

2.4.1.1 The number of journals subscribed to by interviewees

The mean number of journals subscribed to by subjects in the present investigation was 6.2. The subjects in Pullinger’s (1983) study took a mean of 2.8 journals each, while those in a later study (Pullinger, 1984) took a mean of 4.2 journals. However, there was considerable variation in the number of journals subscribed to by members of the four departments surveyed in the present study. The mean number for the Human Sciences department, that perhaps most closely resembling the sample used in Pullinger’s studies, was 3.8. As can be seen, this figure is similar to that obtained in the second of Pullinger’s investigations. Taken together, the findings from the three studies may indicate a trend towards subscribing to a higher number of journals. One explanation for this is that the rapid expansion in the amount of information available, combined with the economic and storage problems faced by libraries, means that libraries are now unable to satisfy the needs of users adequately.

In Dillon et al.’s (1988) study, seven subjects subscribed to at least one journal, meaning that over half of the sample did not subscribe to any journals. As mentioned previously, subjects in this investigation had access to a specialized on-site library, and it is possible that the low subscription rates reported indicate that many of the subjects were satisfied with the facilities provided by this library.

2.4.1.2 Coverage of journal material

None of those interviewed in the study by Dillon et al. considered that they covered all of the relevant material satisfactorily through their use of journals, and 20% felt they missed a lot of relevant material. However, twelve (60%) of the subjects in the present study claimed that they read all of the articles related to their own area. One possible reason for the difference in these findings is that respondents in Dillon et al.’s study were all full-time researchers, whereas those interviewed in the study reported in this chapter were also involved in teaching activities. It is suggested that the former group...
of respondents would have a greater need for up-to-date journal material than the latter, and so would be more aware of failure to obtain this.

2.4.1.3 Sources of references

The commonest source of references to new material reported by subjects in the present study was citations in journal articles – 40% of the sample used this method the most frequently. This finding is supported by those of the study by Line (1971), in which social scientists obtained the majority of their references from journals and books, and also considered these to be the most useful sources of references. Similar data is reported by Sabine and Sabine (1986), the results of whose investigation indicated that half of the material read by subjects was located from a reference in another publication. Martyn (1987) again found that following up references cited in relevant papers was both the most popular, and most useful, method of obtaining references.

In contrast, the most frequent strategy employed by subjects in Cooper's (1985) study was examining references provided by previous reviewers (used by 53%). In addition, the source considered to be the most useful was comments from reviewers/researchers of past work. In view of the fact that the focus of the investigation was on locating material for writing a review, these findings are not particularly surprising. However, it is of interest to note that the source considered to yield the most central references was browsing through library shelves.

2.4.1.4 Obtaining articles

A number of methods of obtaining articles not held by the university library were reported in the present investigation. These included interlibrary loans (13 subjects), reprints from authors (3 subjects), travelling to another library (3 subjects), via research students (3 subjects) and from friends in other institutions (1 subject). The majority of subjects used more than one of these methods.

A higher percentage (65%) of the sample employed in the present investigation used the interlibrary loan service than in the study reported by Dillon et al. (33%). This finding may be a reflection of the way in which those in the department in which the latter interviews were conducted work. They are all members of project teams, and it frequently falls to the most junior members of a team to collect references. It may be that the majority of the sample comprised more senior members of staff, who would delegate much of the required literature searching to others in the team. The reported differences in the use of the interlibrary loan service could also be due to varying levels of provision by the subjects' libraries in relation to their own specialist fields.
2.4.1.5 Article selection

When asked how they selected the articles to be read from a new issue of a journal, all of those interviewed in the present study reported that they examined the contents page first. This finding is supported by observations made in the study by Dillon et al. (1988). Subjects in the latter investigation said that they primarily used the titles and authors of articles as selection criteria. The high reliance upon the title of an article was also mentioned by subjects in the present study, 80% claimed to be concentrating on the subject/title, while 45% also used authors’ names as a criterion for selection. In addition, a quarter of the respondents in the study reported in this chapter specifically mentioned the use of keyword scanning as a method of article selection.

It is of interest to note that in both investigations, several subjects said that titles alone could be misleading, and that they would often scan the rest of the article before deciding whether or not it was relevant.

2.4.1.6 Time and location of reading

In Pullinger’s (1983) investigation, subjects reported that 65% of browsing and 85% of reading whole papers took place out of office hours, either at home or whilst travelling. When the data for the two types of reading activity are combined, the results of the study show that 75% of reading was done out of the office. This figure is similar to that obtained in the present interviews, where 80% of reading was said to be carried out at home in the evenings, or whilst travelling. None of the subjects in either of these two investigations, or that by Dillon et al. (1988), mentioned reading in the library. Furthermore, three of the interviewees (20%) in the latter study expressed a strong dislike of libraries as a place in which to work.

2.4.1.7 Reading strategies

Half of those interviewed in the present investigation reported that they read the abstract of an article first, with four subjects (20%) mentioning some kind of skimming or scanning strategy. In the study by Pullinger (1983), three main reading strategies were reported by subjects (i) filtering through the sections of an article in their correct order, (ii) a preliminary filter of the title and abstract, and (iii) skimming through the article looking for new ideas. Dillon et al. observed that if an article was judged to be relevant to the current task, then three reading strategies were employed (i) rapid scanning of particular parts of the article, (ii) non-serial reading at varying levels of detail, and (iii) a detailed serial read (see section 1.2.2).
Finally, an important point to emerge from the study by Dillon et al. is that readers overlooked a large amount of the material in a journal article. This observation is supported by the findings of the investigation by Sabine and Sabine (1986), in which 60% of the hard scientists surveyed read 10% or less of an article.

2.4.1.8 How articles are used

Sixty percent of the present sample always took a photocopy of an article, while a slightly lower proportion (47%) of the sample interviewed in the study by Sabine and Sabine (1986) claimed that they took photocopies. However, all of those interviewed by Dillon et al. said that they made photocopies regularly. In the survey by Pullinger (1983), those subjects who filtered through the sections of an article in order sometimes took a photocopy, and those who only filtered through its title and abstract always did so. It is possible that access to photocopying facilities has some influence upon the frequency with which photocopies of articles are made. For example, although not reported, it is known that subjects in the study by Dillon et al. had much freer access to such facilities than those in the present investigation.

Forty percent of those interviewed in the study reported in this chapter wrote an abstract card of articles they read, and 30% made notes. A similar degree of note-taking (27%) was reported by subjects in Sabine and Sabine's (1986) investigation. Interestingly, 26% of the latter sample said that they merely read articles, but noted that the study included the use of public libraries, and so some of the accesses would have been for non-work related purposes.

2.4.1.9 Reprint requests

A slightly lower percentage of subjects in the present sample than in that surveyed by Pullinger (1983) wrote to authors requesting reprints of papers (15% and 19% respectively). This may reflect the increased availability of photocopiers since the earlier study was conducted. The majority of requests received by subjects in the present investigation were from other academics, whereas those in the earlier study were considered to come mainly from students. An accurate comparison is not possible, however, as not all subjects in the present study indicated the source of the requests received. The desire for a greater amount of communication between authors was expressed by participants in both studies.
2.4.1.10 Writing journal papers

Forty percent of those interviewed in the present study said that they wrote exclusively at home, while 25% only did so in the office. As mentioned previously, the place of writing was to some extent linked to the method of writing. Eighty percent of interviewees used a word-processor at some stage of the writing process. Sixty-three percent of the subjects in Pullinger's (1983) study wrote mainly in the evenings, with a large number claiming that they would like to write more papers than circumstances permitted. The author remarks upon the lack of secretarial support for writing, proposing that this is why most of those surveyed were unable to write as many papers as they would like. However, it is suggested that time constraints are a more influential factor than lack of secretarial support. The finding that higher percentage of the sample studied in the present investigation used a word-processor or typewriter (80%) than in that by Pullinger (51%) is almost certainly due to developments in computer-based technology. It is suggested that as the cost of microcomputers falls, and they become more widely used, a greater amount of writing may be carried out at home.

2.4.1.11 Conferences

Subjects in the present study considered that informal discussions were more beneficial than the formal papers presented at conferences. In addition, those interviewed by Cooper (1985) ranked informal conversations at conferences as being the fourth most useful of the 15 searching strategies reported for gathering references for literature reviews.

However, Line (1971) reports that formal papers were thought to be as useful as informal discussions, although he does suggest that these responses may be coloured by subjects feeling a need to justify expenses for conference attendance!

2.4.2 Implications for an electronic journal

The findings of the present investigation, and those reported in section 2.1.2 of this chapter, have a number of implications for the design and provision of an electronic journal, at both the article and database level. Studies of the way in which readers interact with the paper-based system indicate those features which should either be preserved, or alternatives provided, in the electronic medium. Furthermore, it may be possible for an electronic journal to provide better support for the tasks for which these features are used. Subjects' responses also point to some disadvantages of the paper journal system, which may be alleviated in an electronic one. Issues relating to these areas will be discussed in the following sections.
2.4.2.1 Facilities that an electronic journal must provide

Subjects in the present investigation and in previous studies (Line, 1971; Sabine and Sabine, 1986; Martyn, 1987) indicated that the most frequently used and highly rated sources of references to new material are citations in journal articles. An electronic journal article must be presented in such a way that the full details of citations are readily available to readers, but without disrupting the reading process. Two of the questions often discussed in relation to an electronic journal are (i) whether articles should be 'published' under journal titles or individually, and (ii) whether they should be 'published' as single articles, or in issues (as in the present system). However, a more important consideration is whether an electronic journal should provide a more precise method of referencing, in order to facilitate the retrieval of articles – such a process may be better supported by the electronic medium than by the paper one.

In the study by Line (1971), 72% of the interviewees said that they never delegated searching for information, one of the reasons being the loss of serendipity. The Royal Society report (1981) emphasises the importance of browsing, concluding that the majority of users obtained information for current awareness by browsing through primary journals. This activity also leads to the accidental discovery of relevant information (Martyn, 1987). An electronic journal system must therefore support browsing both between and within articles.

It would appear that a number of criteria are used by readers for the selection of articles from an issue of a journal. All of the subjects in the present investigation and that by Dillon et al. accessed the contents page first, looking at both the titles of the articles and their authors. Several readers in the present study said that the location at which the research was carried out was also a deciding factor. Once an article had been selected for closer inspection, the majority of subjects read the abstract first, followed by a scan of the section headings. Some readers also looked through the beginning of the introduction, the conclusion or the references, before deciding whether an article was relevant to their needs (Dillon et al., 1988). These findings indicate that information concerning the title and author of an article, and also the location at which the research was conducted, must all be readily accessible to readers of an electronic journal. In addition, facilities should be provided enabling them to access both the abstract and constituent sections of a journal article easily.

The data obtained in the present study, and those by Pullinger (1983) and Dillon et al. (1988), indicate that a number of different strategies are employed by readers of paper journal articles. Furthermore, it would appear that they only require a small proportion of the available material (Sabine and Sabine, 1986; Dillon et al., 1988). Consequently,
an electronic journal must be capable of supporting a variety of selective reading strategies.

In the electronic medium, it is possible to present documents in ways that permit readers to access them in a more flexible manner than in the paper medium. For example, readers may be permitted to access sections of text directly from a 'contents page' for an article, rather than having to move through the article in a linear fashion. The provision of more flexible access facilities would enable readers to select both articles, and material from within them, more efficiently than in the paper medium.

The most common method of using a journal article is to make a photocopy. Two of the reasons that subjects gave for doing so were ability to annotate and for use in a personal filing system (Dillon et al., 1988). An electronic journal journal system should therefore enable readers to make notes either on an article, or in such a way that they are linked to the original article. It is possible to design an electronic journal in which users are able to construct personal databases comprising a subset of the main one, and to structure this in their own way. This point will also be discussed in more detail in chapter eight.

The majority of subjects in the present investigation, and those by Pullinger (1983) and Dillon et al. (1988), considered that if an electronic journal was to be acceptable, then a terminal on their own desk was essential. However, the results of these three studies also indicated that a high proportion of reading is carried out either at home or while travelling — little reading is done in the office or in the library. These findings imply that it must either be possible to obtain hard copies of material, or the necessary equipment for reading journals electronically must be available when and where desired.

However, an increasing number of people have access to a microcomputer at home, and it would seem likely that portable machines of a sufficient standard will be available in the near future.

2.4.2.2 Disadvantages of the paper system

In the study by Line (1971), only 4% of the sample considered that the stock held by their own library was adequate for their needs. Rising costs limit the number of journals to which libraries are able to subscribe, and space problems impose restrictions on the number and proportion of available volumes they are able to shelve (see Kilgour, 1987). The use of the electronic medium (especially CD-ROM) would permit the effective storage of vast amounts of information and, provided that it is well indexed, in an easily accessible form.
The ever-increasing amount of information now available caused problems for many of
the subjects in the studies reported in this chapter. For example, none of those
interviewed by Dillon et al. considered that they covered all of the relevant information
available. In accessing information relevant to a particular purpose or task, there are
selection decisions to be made at two levels – the database level and the article level. As
discussed in the previous section, it is possible to provide facilities in the electronic
medium which may enable readers to select both articles and the information from
within them more efficiently than in the paper medium.

In the survey by Pullinger (1983), delays in the publication procedure were particularly
disliked by respondents. Seller and Raben (1981) propose that these delays, combined
with low acceptance rates, constitutes serious impediments to the flow of scientific
information. In an electronic journal system it would be possible to ‘publish’ accepted
articles as soon as the next issue of the journal was due, because there would be no
printing queues. Furthermore, there need be no restrictions on the number of articles in
an issue, or their length, as there are in the paper-based system.

Problems in identifying the terms that indexers use for concepts were mentioned by
subjects in Line’s (1971) study. These difficulties are similar to those encountered by
users of search systems (see Richardson et al., 1988). More flexible search and
retrieval facilities than are available in the paper medium could be developed for an
electronic journal system. This issue will be discussed more fully in chapter eight.

2.5 CONCLUSION

In all of the studies described in this chapter, two of the factors most frequently
mentioned by subjects were shortage of time and the importance of obtaining material
quickly. Readers claimed that their coverage of relevant material was limited by the time
available, and the various skimming and scanning strategies employed represent
attempts to assess the relevance of an article, and extract information from it, as rapidly
as possible. A number of subjects suggested that interlibrary loans were too slow, and
delays in the publication process were considered to be unsatisfactory.

A third factor frequently mentioned was the value of serendipity, with browsing
through current publications being the most common method of discovering relevant
material by chance. The perceived value of serendipity was also acknowledged by those
interviewees who said that its loss was one of the reasons why they did not delegate
searching for information.
It is suggested that the main benefit of an electronic journal may lie in the provision of facilities which permit readers to access articles in a more flexible manner than in the paper medium, thus facilitating the selection of relevant information at both the journal and article level. Seiler and Raben (1981) describe two types of information users—those who do not have access to large libraries, and those who are inundated with information. An electronic journal may assist both types of user, making a greater volume of information available, but also helping them to deal with this efficiently.
3.1 INTRODUCTION

As discussed in section 1.6, there are two aspects of location involved in navigating through documents — the location of the reader and that of the information which he may be seeking. Some previous studies have examined the role of location in a reading context (see section 1.5.4), but several questions have been left unanswered. Furthermore, few investigations have been conducted in the electronic medium. The first study reported in the present chapter therefore sought to provide additional information concerning the role of location, in both the paper and electronic media.

There is evidence to suggest that readers of sequential documents presented on screen have difficulty in navigating through them (e.g., Wright, 1987). The electronic medium permits alternative document structures to be explored, but a number of location cues will then be unavailable, and it is likely that readers will therefore have even greater difficulty in navigating through documents. Tombaugh et al. (1987) examined one method of introducing other location cues into electronically presented texts, and the second study reported in the present chapter is a continuation of their work.

3.2 MEMORY FOR SPATIAL LOCATION

Kahneman (1973) describes a capacity model of attention, in which the amount of energy available for performing mental operations is limited, but may be allocated flexibly to different stages of processing. A fundamental aspect of this model is that mental operations differ in the amount of processing that they require. Hasher and Zacks (1979) refer to a continuum of attentional requirements, from automatic to non-automatic:

"Automatic and nonautomatic operations either have been found, or are presumed, to differ in their correlation with awareness and intention, in their susceptibility to inhibition, in the effects of stimulus load, in practice effects, or in other characteristics" (p.358).

Automatic process do not require either awareness or intention, and they use a very limited amount of attentional capacity. However, the knowledge gained by automatic
processes is accessible to consciousness and can then be used in a number of ways (Hasher and Zacks, 1979).

Many writers (e.g., Brown and McNeill, 1966; Wickens, 1970) have argued that memory for textual material comprises a constellation of attributes (Underwood, 1969), of which spatial location is a major component (e.g., McCormack, 1976; Underwood, 1983). It has been proposed that spatial location is one of the attributes which are processed automatically, and relating events to be memorized to a spatial-temporal dimension is claimed to be a fundamental aspect of encoding (Zimmerman and Underwood, 1968). Spatial location is considered to have a mainly discriminative function (Underwood, 1969), and may therefore act as an extremely efficient retrieval system (Bower, 1970; Yates, 1966).

Zechmeister and McKillip (1972) propose that spatial recall is related to the strength of a memory experience. Consequently, correct information retrieval with correct spatial recall will lead to greater confidence of memory than only content recall. The feeling-of-knowing experience (Hart, 1965) and the tip-of-the-tongue state (Brown and McNeill, 1966) may be both precipitated by spatial recall.

3.3 PREVIOUS STUDIES

3.3.1 The paper medium

Several studies have examined incidental memory for the location of text. Location is referred to as incidental in these studies because memory tests for prose are typically concerned with content, rather than location, recall.

In an investigation by Rothkopf (1971), incidental memory for two types of location was examined: within-page and text-sequence. An additional measure of interest was the possible relationship between accuracy of location and content recall. Subjects were required to complete an answer-completion test, and to indicate from which eighth of the page and quarter of the text the answers came. They were not told that they would be asked location questions, just to read the text through and learn as much as they could. The results of the study indicated that both within-page and text-sequence location recall were significantly more accurate than by chance. Accuracy of content and within-page location recall were correlated, but text-sequence location recall was not significantly different for correct and incorrect content recall.
The text employed in the previous investigation was typed on single sheets of paper. In a later study by Zechmeister and McKillip (1972) the pages were divided into four blocks of text, each block comprising approximately 150 words. There were four different conditions, differentiated by the quadrant of the page on which the text commenced. In the first experiment of the study, subjects were required to answer 20 fill-in-the-blank questions, and to indicate from which quadrant of the page the answers came. The mean recall rate for the location questions was found to be significantly more accurate than by chance. Spatial recall was more likely to be correct when content recall was so, but confidence ratings for the content answers were not influenced by accuracy of location recall.

In a second experiment, using a slightly shorter text, performance in the content recall task was compared when subjects were provided with within-page location and when they were not so. In addition, a set of multiple-choice questions was administered after the content and location questions, location information again being provided in the first condition. The results of this second experiment indicated that the provision of spatial information did not significantly influence accuracy of content recall for the fill-in questions. The absolute level of spatial recall, for both correct and incorrect content recall, was very near to that obtained in the first experiment. Spatial recall was again more likely for correct content recall than for incorrect recall, but there was no significant difference in the confidence ratings for correct and incorrect spatial recall. The provision of spatial information did not influence performance in the multiple-choice questions.

The results of these two experiments would seem to indicate that spatial recall is not a necessary correlate of item retrieval: over two-thirds of correct fill-responses were not accompanied by knowledge of the item's location on the page. Zechmeister and McKillip suggest that one explanation for the difference in spatial recall obtained for correct and incorrect content recall is the potential cue value of the correct item for spatial recall. It is may be that a spatial attribute is a correlate of other attributes (e.g., context) that are part of correct information recall. However,

"It is possible that both retrieval and confidence of responses are mediated by more dominant attributes, specifically associative or semantic characteristics. A spatial attribute may suggest a retrieval cue when these more dominant attributes fail to recover an item from memory. Therefore, recall of place on the page suggests a shift in the subject's attribute hierarchy to a less dominant attribute" (Zechmeister and McKillip, 1972, p.452).

The authors conclude that, on the assumption that content retrieval is mainly associatively mediated, it is possible that imagery of the text page provides a secondary attribute which carries spatial information.
Zechmeister et al. (1975) would appear to have employed the same text, and in the same four conditions, as that used in the second experiment reported above. Subjects were asked to complete fill-in questions, indicate the quadrant of the page on which the answer appeared, answer multiple-choice questions, and to give confidence ratings. One group of subjects were informed that they would be asked for location information as well as content, and the other group were not. The results of the investigation indicated that cuing subjects to a subsequent test for location did not influence accuracy of either spatial or content recall. Spatial recall was significantly more accurate than by chance, and more likely to be correct when content recall was so. The proportion of correct content and location recall increased directly with the degree of reported knowledge. As in the studies by Zechmeister and McKillip, location recall was significantly poorer for those items in the lower right portion of the page, for both cued and non-cued recall.

The authors consider that the finding that spatial memory is superior for correct content recall provides evidence that spatial recall aids item retrieval. Two possible explanations are proposed. First, the presence of a correct information answer serves as an additional and salient cue for location recall. Second, item and spatial recall may both benefit because that particular portion of the text was attended to more fully. Zechmeister et al. describe a later study, in which one group of subjects were provided with the correct fill-in answers prior to completing a test of spatial recall. If the fill-in answers were cuing spatial recall, then the provision of these should have resulted in superior performance. However, this was not found to be the case, and the first of the proposed explanations is not therefore supported. The second suggestion, that conditions which fail to produce content recall also fail to produce spatial retention is not supported by the negative finding for instructions in the main study reported by Zechmeister et al. Neither is it supported by the fact that different levels of spatial recall were found for the four positions on the page, but item recall was as accurate for all of them. Zechmeister et al. therefore concluded that:

"It appears appropriate to characterize spatial retention as mediated by visual imagery of the text page" (p.51).

Finally, the data obtained for the multiple-choice questions would seem to provide evidence in support of the hypothesis that spatial recall may aid in differentiation among similar memory experiences.

Christie and Just (1976) suggest two alternative explanations for the finding that accuracy of within-page location is correlated with that of content recall. First, that readers are able to deduce locative information from their knowledge of the text’s content and second, that they may unintentionally encode the location of a specific piece
of information. The former hypothesis is concerned with deductions based on content information retrieved from long-term memory, and the latter is concerned with initial comprehension and decoding processes.

The two experiments reported by these authors differed from those by Rothkopf (1971) and Zechmeister and McKillip (1972) in that the texts were shorter, location memory was intentional and the main measure was response latency. The texts were only 150-200 words in length, each comprising 11 sentences, and the pages were divided into three blocks. Two versions of the text were employed in the first experiment (i) a coherent text (organized), and (ii) a version in which the sentences were scrambled (disorganized). One of the aims of this investigation was to determine how the organization of a text affects content and location recall:

"While locative information can be deduced from the logical structure of a coherent passage, it cannot be deduced from the logical structure of a disorganized passage" (p.702).

The same 11 questions were used as both content and within-page location probes, and subjects were informed that they would be asked for both types of information. The questions were asked orally, and subjects were permitted to search through the text for the answers. Latencies for content questions were found to be similar for organized and disorganized texts. Those for location questions were shorter in the organized texts than those in the disorganized ones. Mean latencies for the content questions were significantly longer than for the location questions. As the same probes were employed for both question types, this could not be attributed to the time taken to read the questions. There were almost twice as many location errors for the disorganized texts than for the organized ones, both being lower than by chance. Subjects made more "Don't know" responses than incorrect ones for content questions, and vice versa for the location questions. It would seem that subjects knew when they could not recall content information, but tended to guess location information. This was probably due to the fact that there were only three location alternatives, but the content responses were open-ended.

Christie and Just consider the finding that latencies for the content questions were similar for the organized and disorganized texts to suggest that readers may represent the two in a similar way, perhaps by reorganizing the information from the latter type of text (Kintsch and Monk, 1972):

"The passage content may be stored as an interconnected network structure, whose nodes are single propositions, and the links are interpropositional connectives denoting relations such as causality or temporal sequence" (p.706).
Internal reorganization of a disorganized text destroys some of the locative information in the passage, meaning the subjects have difficulty in recalling from which part of the text a sentence came.

In a second experiment memory for location was measured unobtrusively, by recording subjects' eye fixations as they scanned a previously read passage for answers to content questions. The texts employed were similar to those used in the first experiment, but without the location boundaries marked. They were presented electronically, on a 'standard video monitor'. It was suggested that visual search in disorganized passages could take longer due to either lack or inaccuracy of locative information. The results indicated that initial fixations were at the correct sentence 31% of the time for organized passages, and 19% for disorganized ones – chance level was 9%. Even if the first fixation was not at the correct location, it was generally very close to it. However, when this initial fixation was inaccurate, subsequent search was more efficient for the organized passage. The results further suggested that the internal search processes used for location questions in the first experiment resembled the external ones used in the second experiment.

If the initial fixation in an organized passage is accurate, subsequent fixations may be guided by two possible sources of knowledge (Christie and Just, 1976). First, what the subject read at the initial location may provide a cue to the location of the desired information. Second, the subject may use his previous memory of the passage: if he could recall the order in which the events were presented, this could be used as a cue to the relative position of the target information in relation to the initial fixation.

"When a passage is coherent, as most passages we read are, then people internalize the structure of that passage. That is, they encode how the various propositions in the passage are related to each other. In a coherent passage, the temporal sequence in which the sentences occur generally corresponds to the logical sequence that relates the sentences" (Christie and Just, 1976, p.709).

However, as mentioned previously, when passages are disorganized, subjects may reorganize them in order to remember them, or at least store them in an organization that is independent of their sequence in the passage. This means that the internal sequence of propositions is different from the presented sequence of corresponding sentences, and so location information is not preserved.

Lovelace and Southall (1983) list three possible explanations which have been proposed by previous authors for the correlation between content and location recall.
1. Fluctuations of attention – for parts of the text to which they have attended carefully, readers are able to recall both the content and its location, but for those parts of the text for which reading has become mechanical, neither can be recalled.

2. Recall of the answer to one question may, by providing more material, enhance the cue value of the content question, thus facilitating access to the spatial attribute.

3. Recall of a spatial attribute may provide more of the constellation of features, therefore improving performance in answering content questions.

However, Lovelace and Southall emphasise that these are not mutually exclusive, and all three may contribute to the correlation between content and location recall. They consider that the first explanation is not consistent with Zechmeister et al.’s (1975) observation that content recall was not differentially related to quadrant of the page, but location recall was.

The other two explanations are both implied by any model of memory assuming that (i) a coded memory representation for an event is a constellation of attributes and (ii) the greater the number of attributes retrieved, the greater the cueing value for accessing individual attributes. The most important question would seem to be whether certain attributes are fundamentally independent in their activation at the time of attempted recall, or whether they interact, so that each may facilitate activation of, or access to, the other.

In the first experiment of the study by Lovelace and Southall, performance in a location recall task and an answer-completion task was compared using a text presented in three different forms (i) on a continuous paper scroll, (ii) on a scroll with pages marked, and (iii) in a book form (control condition). It was hypothesized that depriving readers of within-page location cues would produce poorer content recall, since these cues would not be available to facilitate content recall. Subjects were not told that they would be asked for location information until they had read the text. There was no significant difference between the two ‘paged’ conditions in the accuracy of either substantive content or within-page location recall. However, the availability of within-page location information did have a significant effect on the accuracy of substantive content recall, this being poorer in the ‘no pages’ condition. In addition, in the paged conditions, content recall for those questions for which location could not be recalled was approximately the same as for the continuous scroll condition.

The second experiment in the study examined two hypotheses (i) that reinstating location cues at the time of test would enhance content recall, and (ii) that reinstating...
content would improve location recall. The results of the study by Zechmeister and McKillip (1972) did not support the first hypothesis, but Lovelace and Southall propose that the procedure employed to reinstate location information may have been inadequate. Although Zechmeister et al. (1975) failed to find support for the second hypothesis, they did not provide procedural information. The text and presentation conditions employed in Lovelace and Southall's second experiment were the same as those in the first one, except that half of the subjects were provided with content information in the test booklet, and the other half were given location information. They were all told which type of information would be provided, and which type would be required. Content recall was significantly more accurate when location information was provided, and location recall was significantly more accurate when content information was provided.

Although previous studies had demonstrated a relationship between memory for location and content, none of these had shown a causal link. However, Lovelace and Southall proposed that their study made it clear that the recall of within-page spatial location and content information are not functionally independent – manipulating the availability of one at the time of test had a significant effect on recall of the other. Furthermore, it would appear that the provision of location cues aids content recall more than the provision of content answers assists in the recall of location.

"In summary, the present results are consistent with a general memory model in which the within-page spatial location of words is treated as one of several attributes that the reader of a prose passage stores in memory and in which the recall of a given attribute is facilitated by the recall of other attributes that are components of some constellation of attributed constituting the memory for that prose passage" (Lovelace and Southall, 1983, p.434).

3.3.2 The electronic medium

With the exception of the second experiment reported by Christie and Just, all of the studies described so far have presented texts in the paper medium.

The first experiment in a study by Haas and Hayes (1985a) compared performance using paged text presented on paper and on a standard (24 line x 88 character) CRT screen. Subjects were required to read the article, and then to give the text-sequence and within-page location of a number of sentences from within it. Recall of the vertical location of the text was significantly more accurate in the paper medium, but neither horizontal or text-sequence location accuracy were influenced by presentation medium. In a second experiment, subjects were asked to relocate information from within a text presented on paper or in one of two screen conditions. In the first condition, the display was the same as that used in the first experiment. In the second condition, each screen
comprised 50 lines of 94-character, dark-on-white text. A further difference between the two screen conditions was that the second was a scrolling display, controlled by a mouse, whereas the first used an Emacs text editor. The results of this second experiment indicated that performance was slower using the ‘standard’ CRT display, but there was no significant difference between the other two conditions. However, as the authors point out, it is not clear which of the display and text-editor variables were responsible for the observed differences between the two screen conditions.

A follow-up study (Haas and Hayes, 1985b) was intended to answer this question. The task employed for the first experiment in this investigation was the re-organization of a disordered passage, which is a comprehension task with a strong spatial component. Performance was compared using text presented on paper and in four screen conditions. The latter differed in the size of the display (46 lines or 22 lines) and in the method of advancing the text (scroll bar or function keys). Subjects reading from the 22-line display completed the re-organization task significantly more slowly than those using either the 46-line display or the paper version of the text, but there was no significant difference in performance between the latter two conditions. The method of advancing the text was not found to have any influence on performance.

Wright and Lickorish (1988) speak of difficulties encountered by readers of lengthy texts displayed in the electronic medium (e.g., Pullinger, 1984), proposing that one problem yet to be resolved is that of relocating information from within the text. There is some evidence that using larger screen reduces such problems, because more of the text is visible simultaneously (Haas and Hayes, 1985b). However, Richardson et al. (1989) found that increasing the size of the window in which a text was displayed had no significant influence on performance in a location task. Furthermore, even if a larger screen is used, part of it may be required for other activities, so that the window in which the document is read may be smaller than the hardware would permit. Wright and Lickorish suggest that an alternative is to introduce other visual cues into the document. Two types of visual cue are ‘landmarks’ (Wailer, 1982) and incidental cues, such as spatial location (e.g., Rothkopf, 1971). It is proposed that both kinds of cue could reduce the number of screens to be searched when attempting to relocate information.

Colour is commonly used to differentiate topics or sections in the paper medium, and the aim of the first experiment reported in the study by Wright and Lickorish was to determine whether it could act as an incidental cue for the relocation of information. The texts were articles from Computer Human Factors (see Pullinger, 1983), and these were printed on coloured sheets of paper, a different colour being used for each section. For the second experimental condition, texts were printed in each of the single
colours. Subjects were asked to read the text, and then locate the answers to ten questions from within the document. They were told that location information would be required. The results indicated that although the effect of the colour cues was not apparent after a single reading of the text, it did occur during the question answering task.

A second experiment examined the influence of colour cues in the electronic medium. The texts, conditions and procedure were identical to those employed in the previous experiment, that but colour of the text itself was varied, rather than the background. Performance using the multi-colour display was found to be inferior to that using a single colour one. Readers were slower, made more errors, and turned more additional pages in the former condition. Wright and Lickorish suggest three possible explanations for this result (i) salience - in view of the fact that the whole background was varied, changes may have been more salient in the paper medium, (ii) memory for order - a visual reminder of the order of the colours was available in the paper version, but not in the electronic one, and (iii) cognitive load - it may be that the cognitive resources required to read the text were greater in the electronic medium.

In order to test the last of these hypotheses, a third experiment employed texts which were conceptually simpler than those used in the first two experiments. The data obtained confirmed the findings of the previous experiment, that introducing variation in the colour of the typeface appears to hinder, rather than help, readers to relocate information from an electronically presented text.

A final experiment was intended to test the suggestion that the critical factor was the reminder of the order in which the colours were presented. The procedure used for this experiment was identical to that in the other three, except that coloured pieces of card, in the same order as the colours were used for the sections of text, were stuck just above the screen. The provision of order information removed the performance decrement observed for the multi-colour display in the previous experiments, but did not assist readers to relocate information.

The authors conclude that there is no evidence that variations in the colour of the typeface can be used to assist in the relocation of information from CRT screens, and caution against transferring design recommendations from one medium to another. However, in the paper medium, the colour of the background itself was varied, but in the electronic one, the text was displayed in different colours. It is therefore suggested that this conclusion is not justified on the basis of the study reported by Wright and Lickorish.
Tombaugh et al. (1987) consider that although advances in hardware and software will resolve some of the difficulties involved in manipulating lengthy texts presented on screen,

“One problem will remain for readers, because it is rooted in certain fundamental differences between the physical properties of multiple sheets of paper and a single CRT display. This problem concerns readers’ attempts to retrieve information they had in front of them just a few minutes ago” (p.598).

They suggest that one solution may be employ a method of presentation that brings incidental spatial cues into readers’ interactions with the text, and may therefore help them to relocate information from within it.

Subjects’ performance in a relocation task was compared using a single window and a ‘reverting stack’. The two special features of the latter were referred to as ‘perceptual’ and ‘procedural’ stacking. The first of these terms meant that when all of the windows were closed they formed a perceptual overlapping stack, each window having a heading which was visible when the stack was tidied. The second term meant that whenever a window was closed, it returned to its correct position within the stack. Consequently, at any one time, the only window not in its correct sequential order was the window at the front of the stack (i.e., the one currently being read). This produced a situation in which the windows retained a permanent location relative to each other within the stack. The single window was the same size as each of those in the multi-window condition, and it was possible to select a section of text directly from the contents ‘page’. The texts employed in the study were essentially the same as those used in the study described above, with each section being presented in a different window for the multi-window condition. Subjects were required to read the text, and then to search through it in order to locate the answers to a number of questions.

In the first experiment in the study, the text was read significantly faster using the single window display than the multi-window one. However, there was no significant difference in the times taken to answer the questions. One proposed explanation for these finding was that the search task had three components, each requiring a different kind of knowledge (i) textual memory is required (knowing where to go), (ii) a conceptual model of the display dynamics is required (knowing how to get there), and (iii) motor co-ordination to turn that understanding into an adequately executed plan is required. The authors suggest that the two displays may have made different cognitive demands on readers’ understanding of how to get to a specific location and, furthermore, their mousing skills may have been inadequate.
A second experiment was therefore conducted, in which subjects were trained in mousing techniques and the use of a multi-window display. The results indicated that display condition had no significant influence on the accuracy of question answering. Questions tended to be answered faster by subjects using the multi-window display, and this difference was significant for one of the two texts employed in the investigation. Tombaugh et al. consider that readers' greater understanding of how to get to a specific location was the critical factor accounting for the difference in these results as compared with those of the first experiment.

The authors concluded that once a certain minimal ability to understand and manipulate the display has been acquired, multi-windows help readers to relocate information from within a text. However, as Tombaugh et al. themselves point out, their study did not ascertain which characteristic of the reverting stack was responsible for the superior performance. They also suggest that the use of a fully tiled display, as would be possible on a larger bit-mapped screen than that used in their study, may be of even greater benefit to readers, because it enhances the spatial separation between the sections.

3.4 LOCATION CUES ON PAPER AND SCREEN

3.4.1 Introduction

As described in section 3.3.1, the results of previous investigations have indicated that when paper documents are presented sequentially, incidental recall for the location of the text is more accurate than by chance, and accuracy of location recall is correlated with that of content recall. The first aim of the experiment reported in this section was therefore to determine whether these findings are supported when texts are presented in the electronic medium.

The second aim of the present experiment was to examine performance in location and content recall tasks using a longer text than those employed in previous studies. These ranged from only 150-200 words (Christie and Just, 1976) to 4,000 words in length (Zechmeister and McKillip, 1972; Zechmeister et al., 1975).

The third aim was to examine incidental memory for the location of text presented on pages or screens with a display area of the same size as an A4 page, containing approximately the same number of lines, and in a 'conventional' format. An A4 page normally contains about 45 lines of text, but those in many of the earlier studies contained fewer. For example, the pages in Lovelace and Southall's investigation only
contained 24 lines of text. Although the pages used by Zechmeister and McKillip (1972) and Zechmeister et al. (1975) would appear to have been of a similar size to an A4 page, the text was not displayed in a conventional format, but each page comprised four separate blocks of text. The pages in Lovelace and Southall’s study were also of A4 size, but here the text was double-spaced. Pages containing 50 lines of text were displayed in one of the screen conditions in Haas and Hayes’ (1985a) investigation, and those in the first experiment of the follow-up study (Haas and Hayes, 1985b) contained 46 lines of text. However, the texts used in these two investigations were fairly short – 1,800 words and 1,200 words respectively. Furthermore, the relationship between accuracy of content and location recall was not examined in either of the studies.

Readers of documents presented in the paper medium frequently have more location cues available than readers of documents presented on screen, in that text may appear on a left or right-hand page. In view of this, the final aim of the present study was to determine whether recall of left versus right-hand page information was more accurate than by chance, and if it had any influence on the recall of substantive content, within-page location or text-sequence location.

In order to examine these questions, the text employed in the present investigation was presented both on paper and screen, and in four different forms. Lovelace and Southall had found that there was no significant difference in the accuracy of either content or location recall when a text was presented on a scroll with page breaks marked or in a book form, but content recall was significantly less accurate when no within-page location cues were available. In order to test these conclusion in the electronic medium, the first presentation form used was a continuous scroll with no page breaks marked. In consideration of the fact that many VDUs display one ‘page’ of text at a time, the second presentation form was single pages of text (replacing Lovelace and Southall’s scroll with page breaks marked). The third form of presentation was as a conventional book (i.e., readers saw two consecutive pages, side-by-side, with the lowest numbered one on the left, and when the display was changed, these were replaced by two new pages). For the fourth presentation form, two pages were again displayed simultaneously, but readers saw each page both on the left and right sides of the display area. This was referred to as the preview form. Comparing performance in the third and fourth conditions permitted the influence of left/right-hand page location information to be examined.

The hypotheses tested were as follows:
1. Recall of substantive content would be significantly influenced by the form in which
the text was presented. Specifically, that the ‘no pages’ condition would produce the
poorest recall, while there would be no significant difference in performance between
the ‘paged’ conditions.

2. Recall of within-page location, text-sequence location, and left/right-hand page
location would be more accurate than by chance.

3. Presentation medium would significantly influence performance, this being inferior
in the screen conditions.

4. Text-sequence recall would be influenced by presentation form, being significantly
poorer in the continuous scroll condition.

5. Within-page location recall would not be influenced by presentation form.

6. There would be significant positive correlations between:
   – Accuracy of text-sequence and substantive content recall.
   – Accuracy of within-page and substantive content recall.
   – Accuracy of within-page and text-sequence location recall.

7. The availability of left/right-hand page location information would influence accuracy
of substantive content, page location and text sequence recall.

3.4.2 Method

3.4.2.1 Design

The design was a completely randomized 2 x 4 ANOVA. The two levels of factor A
(presentation medium) were paper and screen. The four levels of Factor B (presentation
form) were a continuous scroll with no pages marked (C), single pages (S), preview
(P) and book (B).

3.4.2.2 Subjects

The 16 subjects used in the study comprised members of staff from the HUSAT
Research Institute. Their ages ranged between approximately 20 - 40 years. All subjects
had some experience in using a Macintosh computer, and were therefore familiar with
manipulating a mouse and operating the paging and scrolling mechanisms employed in
the study. Equal numbers of subjects were randomly allocated to each of the four experimental conditions.

3.4.2.3 Equipment

In the screen conditions, the text was displayed on a MegaScreen™ driven by a Macintosh Plus computer. It was presented using Microsoft Word.

3.4.2.4 Stimuli

The text was a 12-page encyclopaedia style article (containing approximately 7,500 words) describing various aspects of the Sahara desert. It was selected because (i) subjects were unlikely to be familiar with its content, and (ii) there was no obvious logical order for the various sections of the text. Each of the pages, whether presented on screen or paper, contained 45 lines of text and measured 23 cm. in length and 19 cm. in width. The text was displayed in Geneva font, this producing optimal legibility in the screen conditions. The font size was 14-point in the screen conditions which, when presented from within the Microsoft Word preview mode, appeared equivalent in size to the 10-point font used in the paper conditions.

The paper medium

For the scroll condition, the pages were joined into a single length. The pages were stapled together in the top left-hand corner for the single page condition. For the preview condition, the pages were placed in a stack and subjects were instructed to place the previously read page to the left of the stack, face upwards. The pages were formed into a conventional book, stapled together down the centre, for the book condition.

The electronic medium

The text was placed in a file with no page breaks marked for the scroll condition. It was advanced by clicking the mouse on a small arrow in the scroll bar down the right-hand side of the text window, the distance by which the text advanced at each move being controlled by the subject. For the single page condition, the text was displayed a page at a time in the centre of the screen, and a click in the scroll bar itself replaced the contents of the screen with those of the next page. The size of the window was adjusted so that it corresponded to that of a single page in the preview and book conditions. In the preview and book conditions, the screen was in effect bisected vertically, so that two pages of text were visible simultaneously. For the preview condition, a click in the scroll bar moved the page last read from the right-hand section of the screen to the left.
and placed a new page of text in the right-hand section. Finally, for the book condition, a click in the scroll bar replaced the contents of the screen with two new pages of text.

### 3.4.2.5 Questionnaires

Subjects were required to answer a number of questions relating to each of 32 sentences taken from the text. The number of questions per sentence was dictated by the form in which the article was presented. In all conditions, subjects answered both a substantive content and text-sequence question for each of the 32 sentences. Those reading the text in the single page, book and preview forms were also required to answer a page location question for each sentence. Subjects reading the text in the book form were asked to answer a content, text-sequence, page location and Left/Right-hand page question for each sentence.

Eight of the 32 target sentences were taken from each quarter of a page, and eight from each quarter of the whole text. In addition, the locations of the sentences were equally distributed between left and right-hand pages when the text was displayed in the book form. For the content questions, the target sentences were reproduced, but with a blank space substituted for one keyword from each sentence (e.g., "Most of the —— in the plain have temperatures of more than 35 degrees centigrade.") and subjects were required to fill in the missing word.

For the text-sequence questions, subjects were asked to indicate from which quarter of the text the sentence was taken by writing down the appropriate number (1-4) in the space indicated on the questionnaire. In order to answer the page location questions, subjects were presented with a diagram of a page divided into a matrix, each section being marked with a letter (A-D), and they were required to write down the letter corresponding to the quarter of the page in which the target sentence had been displayed. Subjects in the book conditions were also asked to indicate whether the sentence came from a left or right-hand page by putting the letter L or R after the page location code.

All subjects answered questions relating to the same 32 target sentences, and these always appeared in the same order. Questionnaires were presented on typed sheets of paper, regardless of the medium in which the subject had read the original text.
3.4.2.6 Procedure

Pilot study
Prior to the main experiment, a pilot study was conducted in order to ascertain that the answers to the content questions did not constitute common world knowledge. The 32 questions were given to four members of the same population from which the main sample was drawn, and these subjects were asked to fill in the missing words without having read the text itself. Only one question was answered correctly by one subject, and it was therefore concluded that the answers did not constitute prior world knowledge for this particular sample population.

Main study
All subjects received the same instructions, which were typed on a sheet of paper. Subjects were told that they would be asked some simple questions concerning the information in the article, and that their reading would not be timed. They were required to read the text straight through, and not to go back and re-read whole passages. It may be argued that the latter instruction forced subjects to read in an unnatural manner, but they were asked to read in this way for two reasons. First, subjects in previous studies were given similar instructions (e.g., Zechmeister et al., 1975; Zechmeister and McKillip, 1972). Second, Lovelace and Southall (1983) found the same pattern of results regardless of whether subjects were told to read the passage as for study purposes or not to go back and re-read sections.

When subjects were satisfied that they understood the instructions, they read the article in the presentation medium and form for the condition to which they had been allocated. On notifying the experimenter that they had finished this task, subjects were given the appropriate questionnaire for the form in which they had read the article.

3.4.3 Results

3.4.3.1 Presentation medium and form

Content recall
The first hypothesis was that accuracy of substantive content recall would be significantly influenced by the form in which the text was presented. A 2 x 4 ANOVA on the number of missing words correctly recalled indicated there to be a main effect of presentation form on this measure (F [3,15] = 8.67, p < 0.01) (see table 3.1).

A Tukey test revealed there to be significant differences between scores for the Continuous and Single forms (T 0.01 = 6.20, p < 0.01) and the Book and Single forms
(T_{0.05} = 4.07, p < 0.05), with superior performance being obtained in the single condition in both cases. Neither presentation medium nor the interaction between this variable and presentation form reached significance (both p > 0.05).

<table>
<thead>
<tr>
<th>Presentation Medium</th>
<th>Paper</th>
<th>Screen</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continuous</td>
<td>8.50</td>
<td>8.50</td>
<td>8.50</td>
<td>1.29</td>
</tr>
<tr>
<td>Single</td>
<td>14.00</td>
<td>15.50</td>
<td>14.75</td>
<td>1.50</td>
</tr>
<tr>
<td>Preview</td>
<td>11.00</td>
<td>13.50</td>
<td>12.25</td>
<td>2.63</td>
</tr>
<tr>
<td>Book</td>
<td>13.00</td>
<td>8.80</td>
<td>10.50</td>
<td>3.00</td>
</tr>
<tr>
<td>Mean</td>
<td>11.63</td>
<td>11.38</td>
<td>11.50</td>
<td></td>
</tr>
<tr>
<td>SD</td>
<td>2.45</td>
<td>3.81</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3.1. Mean number of correct content words in each condition (max = 32)

Text-sequence location

It was proposed that text-sequence recall would be influenced by presentation medium and form. A 2 x 4 ANOVA showed there to be both a main effect of presentation form on the accuracy of text-sequence recall (F{[3,15]} = 23.92, p < 0.001), and an interaction between presentation form and presentation medium (F{[3,15]} = 6.56, p < 0.05) (see table 3.2). Significant differences were found between scores in the following pairs of conditions:

Paper C / Paper S, Paper C / Paper B, Paper C / Screen S, Paper B / Screen S, Screen C / Screen S (all p < 0.01).

Paper S / Screen C, Paper P / Screen S, Screen C / Screen P (all p < 0.05).

<table>
<thead>
<tr>
<th>Presentation Medium</th>
<th>Paper</th>
<th>Screen</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continuous</td>
<td>12.50</td>
<td>13.00</td>
<td>21.75</td>
<td>0.96</td>
</tr>
<tr>
<td>Single</td>
<td>20.00</td>
<td>21.50</td>
<td>20.75</td>
<td>1.71</td>
</tr>
<tr>
<td>Preview</td>
<td>15.00</td>
<td>19.00</td>
<td>17.00</td>
<td>2.58</td>
</tr>
<tr>
<td>Book</td>
<td>21.00</td>
<td>16.50</td>
<td>18.75</td>
<td>2.75</td>
</tr>
<tr>
<td>Mean</td>
<td>17.13</td>
<td>17.50</td>
<td>17.32</td>
<td></td>
</tr>
<tr>
<td>SD</td>
<td>3.87</td>
<td>3.55</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3.2. Mean number of correct text-sequence recalls in each condition

Within-page location

The third hypothesis stated that within-page location recall would be influenced by presentation medium, but not form. An analysis of the data obtained indicated that the accuracy of within-page location recall was not influenced by presentation form, presentation medium, nor the interaction between these two variables (all p > 0.05) (see table 3.3).
Table 3.3. Mean number of correct within-page recalls in each condition

<table>
<thead>
<tr>
<th></th>
<th>Paper</th>
<th>Screen</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single</td>
<td>14.00</td>
<td>17.00</td>
<td>15.50</td>
<td>2.52</td>
</tr>
<tr>
<td>Preview</td>
<td>12.00</td>
<td>14.50</td>
<td>13.25</td>
<td>4.03</td>
</tr>
<tr>
<td>Book</td>
<td>16.00</td>
<td>11.00</td>
<td>13.50</td>
<td>3.11</td>
</tr>
<tr>
<td>Mean</td>
<td>14.00</td>
<td>14.17</td>
<td>14.08</td>
<td></td>
</tr>
<tr>
<td>SD</td>
<td>2.37</td>
<td>4.02</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Left/Right-hand page location*

It was hypothesized that accuracy of Left/Right-hand page location recall would be influenced by the medium in which the text was presented, but this was not found to be the case \((p > 0.005)\). The mean numbers of correctly recalled locations were 18.00 for the paper medium and 23.00 for the electronic one (an overall mean of 20.5 correct responses).

3.4.3.2 Chance

The second hypothesis was that performance levels for all three location measures would be higher than by chance. Within-page location recall was found to be significantly more accurate than by chance for all scores combined \((\chi^2[1df] = 54.75, p < 0.001)\), for each presentation medium and for each of the three 'paged' forms of presentation. Paper: \(\chi^2[1df] = 26.26\), Screen: \(\chi^2[1df] = 27.76\), Single: \(\chi^2[1df] = 48.76\), Preview: \(\chi^2[1df] = 13.13\), Book: \(\chi^2[1df] = 14.45\) (all \(p < 0.001\)). Text-sequence recall was also more accurate than by chance, for all scores combined \((\chi^2[1df] = 339.38, p < 0.001)\), each presentation medium, and each of the four presentation forms. Paper: \(\chi^2[1df] = 170.63\), Screen: \(\chi^2[1df] = 166.88\), Continuous: \(\chi^2[1df] = 10.70\), Single: \(\chi^2[1df] = 79.70\), Preview: \(\chi^2[1df] = 39.38\), Book: \(\chi^2[1df] = 56.45\) (all \(p < 0.001\)).

In addition, accuracy of Left/Right-hand page location recall was found to be significantly more accurate than by chance \((\chi^2[1df] = 4.79, p < 0.05)\). The level of recall was also above that of chance for both of the presentation media separately.

3.4.3.3 Correlations

*Text-sequence location and content recall*

A significant positive correlation was found between individual subjects' ability to retain substantive content information and to retain its text-sequence location \((r = 0.77, p < 0.001)\). Consequently, the number of correct and incorrect content recall responses were compared for correct text-sequence responses only for individual subjects (see Rothkopf, 1971). When text-sequence location recall was correct, there were a mean of
10.38 correct content recall responses, and 6.94 incorrect responses. The difference between these two means was significant \((t_{15d1} = 5.44, p < 0.001)\).

The means for correct and incorrect content responses when text-sequence recall was correct were also significantly different for the two presentation media separately, and for the continuous, single page and preview forms separately (see tables 3.4 and 3.5).

**Within-page location and content recall**

A significant positive correlation was found between individual subjects' retention of substantive content and within-page location \((r = 0.81, p < 0.01)\). Consequently, the number of correct and incorrect content responses were compared for accurate within-page location recall.

<table>
<thead>
<tr>
<th></th>
<th>Content correct</th>
<th>Content incorrect</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Paper</td>
<td>10.13</td>
<td>3.18</td>
</tr>
<tr>
<td>Screen</td>
<td>10.63</td>
<td>2.13</td>
</tr>
<tr>
<td>Total</td>
<td>10.38</td>
<td>2.64</td>
</tr>
</tbody>
</table>

Table 3.4. Mean number of correct text-sequence location responses for correct and incorrect content recall in each presentation medium

<table>
<thead>
<tr>
<th></th>
<th>Content correct</th>
<th>Content incorrect</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Continuous</td>
<td>7.75</td>
<td>0.50</td>
</tr>
<tr>
<td>Single</td>
<td>12.50</td>
<td>0.58</td>
</tr>
<tr>
<td>Preview</td>
<td>10.00</td>
<td>3.56</td>
</tr>
<tr>
<td>Book</td>
<td>11.25</td>
<td>6.18</td>
</tr>
<tr>
<td>Total</td>
<td>10.38</td>
<td>2.73</td>
</tr>
</tbody>
</table>

Table 3.5. Mean number of correct text-sequence location responses for correct and incorrect content recall in each presentation form

When the scores for all of the conditions were taken together, a significant difference was found between the two means \((t_{11d1} = 5.44, p < 0.001)\). The means for scores in the two presentation media were significantly different (Paper: \(t_{5d1} = 4.91, p < 0.01\); Screen: \(t_{5d1} = 3.09, p < 0.05\)). There were also significant differences between the mean scores in the single and book presentation forms (Single: \(t_{3d1} = 5.74, p < 0.05\); Book: \(t_{3d1} = 8.52, p < 0.05\)) (see tables 3.6 and 3.7).

<table>
<thead>
<tr>
<th></th>
<th>Content correct</th>
<th>Content incorrect</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Paper</td>
<td>9.17</td>
<td>2.04</td>
</tr>
<tr>
<td>Screen</td>
<td>9.33</td>
<td>3.44</td>
</tr>
<tr>
<td>Total</td>
<td>9.25</td>
<td>2.70</td>
</tr>
</tbody>
</table>

Table 3.6. Mean number of correct within-page location responses for correct and incorrect content recall in each presentation medium
Table 3.7. Mean number of correct within-page location responses for correct and incorrect content recall in each presentation form

<table>
<thead>
<tr>
<th></th>
<th>Content correct</th>
<th></th>
<th>Content incorrect</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Single</td>
<td>10.49</td>
<td>2.08</td>
<td>5.00</td>
<td>0.82</td>
</tr>
<tr>
<td>Preview</td>
<td>7.75</td>
<td>3.78</td>
<td>5.50</td>
<td>1.00</td>
</tr>
<tr>
<td>Book</td>
<td>9.50</td>
<td>1.73</td>
<td>4.00</td>
<td>1.63</td>
</tr>
<tr>
<td>Total</td>
<td>9.25</td>
<td>2.59</td>
<td>4.83</td>
<td>1.11</td>
</tr>
</tbody>
</table>

Within-page location and text-sequence location recall

It was also hypothesized that accuracy of within-page location and text-sequence location recall would be correlated. When within-page location was correct, there were significantly more correct text-sequence location responses than incorrect responses ($t_{[11d]} = 6.63, p < 0.001$). The differences between the two means were also significant for each presentation medium separately (Paper: $t_{[5d]} = 4.72, p < 0.01$; Screen: $t_{[5d]} = 4.35, p < 0.01$) (see table 3.8).

Table 3.8. Mean number of correct within-page location responses for correct and incorrect text-sequence recall in each presentation medium

<table>
<thead>
<tr>
<th></th>
<th>Text-sequence correct</th>
<th></th>
<th>Text-sequence incorrect</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Paper</td>
<td>11.33</td>
<td>2.34</td>
<td>7.00</td>
<td>1.79</td>
</tr>
<tr>
<td>Screen</td>
<td>11.33</td>
<td>1.51</td>
<td>7.67</td>
<td>1.75</td>
</tr>
<tr>
<td>Total</td>
<td>11.33</td>
<td>2.34</td>
<td>7.33</td>
<td>1.79</td>
</tr>
</tbody>
</table>

When the scores for each presentation form were analysed separately, significant differences between the number of correct and incorrect text-sequence responses were found in the single page, preview and book forms (Single: $t_{[3d]} = 3.66, p < 0.05$; Preview: $t_{[3d]} = 3.66, p < 0.05$; Book: $t_{[3d]} = 6.79, p < 0.01$) (see table 3.9).

Table 3.9. Mean number of correct within-page location responses for correct and incorrect text-sequence recall in each presentation form

<table>
<thead>
<tr>
<th></th>
<th>Text-sequence correct</th>
<th></th>
<th>Text-sequence incorrect</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Single</td>
<td>13.00</td>
<td>0.82</td>
<td>7.75</td>
<td>2.22</td>
</tr>
<tr>
<td>Preview</td>
<td>7.70</td>
<td>3.11</td>
<td>6.50</td>
<td>1.29</td>
</tr>
<tr>
<td>Book</td>
<td>11.00</td>
<td>1.15</td>
<td>7.75</td>
<td>1.71</td>
</tr>
<tr>
<td>Total</td>
<td>10.57</td>
<td>2.85</td>
<td>7.33</td>
<td>1.98</td>
</tr>
</tbody>
</table>

Left/Right page location

The relationship between the accuracy of Left/Right-hand page recall and that of the other performance measures was also examined. There was no significant difference between the number of correctly and incorrectly recalled Left/Right-hand page locations.
when content recall was correct (means = 8.00 and 2.50 respectively), or when within-page location was correct (means = 9.75 and 2.75). However, when text-sequence recall was correct, the correct number of Left/Right-page location responses was 13.00, and the number of incorrect responses was 5.75. The difference between these two means was significant (t[d1f] = 3.28, p < 0.05).

3.4.4 Discussion

3.4.4.1 Within-page location

The data obtained from the present study indicated that within-page location recall was significantly more accurate than by chance. This finding is in agreement with those obtained by Rothkopf (1971), Zechmeister and McKillip (1972) and Zechmeister et al. (1975). Accuracy of within-page location recall was not significantly influenced by presentation medium, presentation form, or the interaction between these two variables. However, scores were highest in the screen / single page condition (mean = 17.0), and lowest in the screen / book condition (mean = 11.0).

The mean level of within-page location recall found in the study reported here was 44%. In the investigation by Zechmeister and McKillip (1972), the mean percentages of accurate within-page location recall were 44.40% and 43.56% for the two experiments, and a correct recall rate of 38.50% was found in the study by Zechmeister et al. It would therefore appear that the level of accuracy obtained in the present investigation was similar to that obtained in previous ones, regardless of the presentation medium employed.

As Schulman (1983) says, words on a page are much more difficult to encode spatially than many other objects, and successive pages appear to have very similar outlines. Consequently, although the absolute levels of performance found in these studies have been 'modest',

"the effect is particularly noteworthy because the conditions are not those that should promote the most effective use of imagery" (Lovelace and Southall, 1983, p.434).

The fact that there was no significant difference in performance between the three ‘paged’ forms of presentation employed in the present study (single pages, book and preview) is in agreement with the results of the investigation by Lovelace and Southall (1983). In their experiment, no significant difference in the accuracy of within-page location recall was found when the text was presented on a scroll with page breaks marked or in a book form.
The finding that within-page location recall was as accurate when the text was presented on screen as when it was presented on paper is consistent with the results of the second experiment reported in the study by Haas and Hayes (1985a) and the first experiment in the follow-up study (Haas and Hayes, 1985b). The results of the earlier study indicated that when the text was displayed on a 'standard' 24-line CRT screen, performance levels were inferior to those obtained in the paper medium, but when an 'advanced' display was used, levels were comparable to those for the paper medium.

The 'advanced' screen condition had many features in common with the screen condition used in the present study. For example, the number of lines per page was approximately the same, text was dark-on-light, and both systems were window-based and mouse-driven. The data obtained in the later study suggested that the important variable was the size of the display. The findings of the investigation reported in this chapter, and those of Haas and Hayes, would therefore appear to support Gould et al.'s (1987) conclusion that, given an adequate display quality, performance using text presented on screen may be equivalent to that in the paper medium.

3.4.4.2 Text-sequence location

The results of the study reported here indicated that text-sequence recall was more accurate than by chance. Rothkopf (1971), in the only previous study to investigate incidental memory for text-sequence recall, also found this to be so, and at the same level of significance. In the present experiment, text-sequence recall was significantly influenced by both presentation form and the interaction between the form and medium of presentation. It was most accurate in the screen / single page condition, and least accurate in the paper / continuous condition.

As stated in section 3.4.3.1, there were eight pairs of conditions whose mean text-sequence location scores differed significantly. Seven of these pairs of conditions contrasted performance in a continuous scroll condition with that in one of the other forms of presentation, and in each case performance was least accurate in the continuous scroll condition. Furthermore, in all cases but one, performance in the continuous scroll condition was contrasted with that in either the single page or book condition.

These findings support the hypothesis that the lack of page markers in the continuous scroll conditions impaired readers’ incidental memory for the sequence in which the text was presented. It would seem that if readers are provided with a means of dividing a document into smaller units, they are able to allocate a particular section of text to one of these units, thus facilitating recall of the sequence of the information contained
within the document. One possible explanation for the fact that text-sequence recall for the preview form was not significantly better than that for the continuous scroll form is that the preview form was unfamiliar to readers. Conventionally, when two pages of text are displayed simultaneously they are presented as in a book, but in the preview condition, text could be read on either the left or right side of the display, thus contradicting readers' previous experiences and expectations.

Previous experiences may also account for the finding that text-sequence recall was most accurate in the book form in the paper medium, and in the single page form in the electronic one – these two forms are the most frequently used in the respective media.

3.4.4.3 Left/Right page location

The fourth measure employed in the present study was accuracy of left/right-hand page location recall. This has not, to the author's knowledge, been examined in any of the previous studies concerning incidental memory for the location of text. Incidental memory for the left/right-hand page location of text was significantly more accurate than by chance, and there was a significant association between scores for this measure and accuracy of text-sequence recall. Although the difference between the scores did not reach significance, when Left/Right-hand page location was accurately recalled, there were more correct content responses than incorrect ones, and more correct within-page location responses than incorrect ones. As reported in section 3.4.3.3, a significant positive association was also found between the accuracy of text-sequence and within-page location recall. It is therefore suggested that all aspects of the location of text within a display are incidentally encoded, and that access to one type of location cue may facilitate access to another type.

3.4.4.4 Substantive content

The mean percentage of content words accurately recalled by each subject in the present experiment was 35.94%, and in the paper medium it was 36.34%. Zechmeister and McKillip (1972) report mean percentages of 41.37% and 34.38% for documents presented on paper, while in the experiment by Zechmeister et al. (1975), a mean accuracy of 25.75% was obtained. The absolute degree of content recall obtained in the present study would therefore appear to be similar to that obtained in previous investigations.

Lovelace and Southall (1983) found content recall to be poorer when text was presented on a continuous scroll, as compared to either a scroll with pages marked, or single pages. The data obtained from the present experiment indicated there to be a main effect
of presentation form – with content recall being significantly more accurate in the single page conditions than in either the continuous scroll or the book conditions. As was the case for the within-page and text-sequence location measures, performance was superior in the screen / single page condition. The finding that scores were significantly higher in the single page form than in the continuous one is in agreement with the results of Lovelace and Southall’s (1983) investigation. However, the fact that performance was significantly more accurate in the single page form than in the book form is somewhat surprising. If this had only been so in the electronic medium, it may have been argued that lack of familiarity with the book presentation form on screen was responsible, but content recall was also more accurate in the single page form in the paper medium.

Previous studies have concluded there to be relationship between accuracy of content recall and accuracy of within-page location recall (e.g., Rothkopf, 1971; Zechmeister and McKillip, 1972 and Zechmeister et al., 1975; Christie and Just, 1976), and these findings were supported by those of the present experiment.

The data obtained in the study by Rothkopf (1971) indicated that accuracy of content and text-sequence recall were unrelated, but the findings of the present experiment indicated there to be a strong positive relationship between these two measures. The significance level for the paper presentation medium (as used in Rothkopf’s study) was 0.05, and that for the screen medium was 0.001. The finding that the relationship between these two measures was stronger in the screen medium than in the paper one is noteworthy. One explanation for the differential findings in the two studies may be that, although both texts comprised twelve pages, the pages in Rothkopf’s experiment only contained 28 lines of text, while those in the present investigation each comprised 45 lines of text. There were therefore differences between the two experiments both in the number of lines per page, and in the total number of words that each text contained. It may also be that the nature of the texts employed influenced these results, with the text used in the present study perhaps being in more discrete sections than used in the earlier investigation. In view of the fact that the text was accessed sequentially in the experiment reported here, text-sequence location had a temporal component. The finding that incidental memory for text-sequence location was correlated with accuracy of content recall may therefore be evidence in support of Zimmerman and Underwood’s (1968) proposition, that spatial-temporal information is a fundamental aspect of encoding.
3.4.5 Conclusion

The first aim of the present experiment was to determine whether the findings of previous investigations, that incidental memory for the location of text was more accurate than by chance, were replicated in the electronic medium. The data obtained indicated that there was no significant difference in the levels of within-page, text-sequence, or left/right-hand page location recall when a document was presented on paper or screen. As in the earlier studies, accuracy of substantive content recall was related to that of incidental memory for the location of the text within the document, and the loss of within-page location cues resulted in inferior performance in the content recall task.

It would therefore appear that the findings of the experiment reported in this section are consistent with the hypothesis that spatial location is one of the fundamental attributes comprising the constellation involved in an episodic memory (e.g., Underwood, 1983).

3.5 LOCATION CUES IN MULTI-WINDOW DISPLAYS

3.5.1 Introduction

The results of the study described in the previous section indicated that the position of text within a document, whether presented on paper or screen, was incidentally encoded by readers. Previous investigations have shown that such information may act as a cue for the relocation of information from a text (e.g., Christie and Just, 1976). However, in the electronic medium, the characteristics of the display frequently lead to the loss of some spatial cues. Wright and Lickorish (1984) describe how, when asked to perform a refereeing task in the electronic medium, subjects had difficulty in moving between sections of text:

"When the text was on the screen they appeared to lose some of the incidental location cues which they normally pick up when reading a wad of paper sheets. That is to say, people felt less certain whereabouts certain information was after they had read it" (Wright and Lickorish, 1984, p.202).

There is some evidence that using a screen with a display larger than 80 x 24 lines is beneficial, because more of the text is visible at once, and so there are fewer screens to be searched (e.g., Haas and Hayes, 1985a, 1985b). However, as Wright and Lickorish (1988) point out, part of the available screen space may be occupied for another purpose, thus reducing the size of the window available for the document.
Furthermore, the use of a larger display area does not solve difficulties relating to loss of incidental spatial cues in the electronic medium.

It has been proposed that other types of incidentally encoded information may assist in the relocation of text. For example, Wright and Lickorish (1988) examined the use of colour coding to differentiate between the sections of a document, on the grounds that such cues are often used in the paper medium (see section 3.3.2). However, although performance levels equivalent to those in the latter medium were achieved, the addition of colour cues to electronically presented texts did not improve performance. The authors therefore suggested that a method of introducing alternative spatial cues into the text should be explored. One method of introducing spatial cues into a document is by the use of multi-windowing techniques:

"Multiple windows could bring incidental spatial cues into readers' interactions with the text" (Tombaugh et al., 1987, p.598).

As described in section 3.3.2, a study was conducted by Tombaugh et al. (1987) which examined the influence of one particular multi-windowing technique on performance in a relocation task. The authors concluded that, given sufficient levels of attainment in the constituent manipulation skills, such a technique was of benefit to readers in relocating text from within a document. Information was relocated more quickly, and fewer sections of the text were inspected, than when using a single window display. Tombaugh et al. acknowledged that their study did not determine which features of the multi-window display employed were responsible for the observed benefit, and suggested that this question could partly be answered by comparing performance using a 'conventional' stack of windows, which remain in the reverse order of access. The authors further suggest that a fully tiled display may be of even greater benefit to readers than the reverting stack employed in their investigation, because such a windowing technique enhances the spatial separation between the sections of the document.

The main experiment reported here sought to address these questions, by comparing performance using three different windowing techniques. The first was the reverting stack used by Tombaugh et al., the second was a 'conventional', or non-reverting, stack, and the third was a fully tiled (non-overlapping) display. Subjects were required to relocate information from within the text, and to answer content questions. Previous studies had shown there to be a positive correlation between incidental memory for the location of text and recall of its content, and so an additional measure of interest was the possible relationship between performance in a relocation and a content recall task.

The hypotheses tested were that:
1. Efficiency of information relocation would be significantly influenced by windowing technique. Specifically, that performance would be most efficient when the text was presented in tiled windows and least efficient when it was presented in a non-reverting stack of windows.

2. Content recall would be significantly influenced by windowing technique, being most accurate in the tiled condition and least accurate in the non-reverting stack condition.

3. There would be a positive correlation between performance in the relocation and content recall tasks.

Norman, Weldon and Shneiderman (1986) have suggested that the way in which users view and process information presented in multiple windows or screens may have an important influence on performance. They claim that

"users adopt a cognitive representation or layout of the type of information to be presented and the relationships among the windows or screens and the information they contain" (p.229).

The order in which the contents of tiled windows are processed was the primary focus of a pilot study conducted prior to the main study described in this section.

3.5.2 Pilot study

The aims of this study were to examine the possible influence of screen layout on (i) the order in which tiled windows are read and (ii) accuracy of incidental memory for the location of information from within a text. Two different layouts were employed: 4 rows of 2 windows (Design A) and 2 rows of 4 windows (Design B). The hypotheses tested were that:

1. Screen layout would influence reading strategy. Specifically, that Design A would elicit a strategy consistent with reading a newspaper, and Design B would be read in a horizontal manner.

2. Screen layout would influence incidental memory for the location of text.
3.5.2.1 Method

Subjects
The 20 subjects comprised members of staff from the HUSAT Research Institute. Their ages ranged between approximately 20-40 years, and all had some experience in using a Macintosh computer. None of the subjects had participated in the previous study, and none of them took part in the main experiment reported here. Equal numbers of subjects were randomly allocated to each of the experimental conditions.

Equipment
The text was displayed on a MegaScreen, controlled by a Macintosh Plus computer, and the software was written in 'Lightspeed'™ Pascal.

Materials
The text employed comprised ‘facts’ from “The ‘Odd Fact’ Computer Book” (Maguire and Modlen, 1985). The book contains ‘odd facts’ about a number of different countries, each ‘fact’ comprising one sentence (e.g., “The Trans-Siberian railway is 4500 miles long.”), and the information relating to each country occupying one screen. The facts concerning a particular country would make sense when read in any order. In the present study, eight facts were taken from the descriptions of eight countries, producing a total of 64 different facts. For each country, the eight facts were each placed in one of the eight windows on a screen. Thus the stimuli comprised eight sets of eight facts, each set relating to a different country, and constituting one screen display. The contents of the windows were randomized, so that for any particular country, the same ‘fact’ only appeared once in each position on the screen.

The windows for Design A were 17.5 cm. wide and 6 cm. tall, and for Design B, they were 7.8 cm. wide and 12 cm. tall. The text was displayed in 10-point Geneva font.

Procedure
Each subject was presented with the facts relating to all eight countries, and the presentation order of the countries was randomized between subjects. Half of the subjects were shown screen design A, and the other half were shown design B.

The study was in two parts. In the first part, subjects were shown four screens of information (i.e., four sets of eight facts) and asked to read the contents of each screen aloud. When subjects had finished reading a screen, they pressed the mouse button to clear the it and display the next set of windows. Responses were tape-recorded by the experimenter for later transcription and analysis.
For the second part of the study subjects were shown facts relating to the remaining four countries. They were required both to read the text out loud and to answer a location question for each country. For the location questions, subjects were given a piece of paper containing two words from the screen of information (each taken from of a different window) and a diagram of the window layout. They were asked to indicate on this diagram the position in which the two words had appeared on the screen. Subjects were not informed of this requirement until they had finished reading a set of facts and pressed the mouse button in order to clear the screen.

3.5.2.2 Results

Reading strategies
All subjects commenced reading in the top left window of the screen. For screen design A (4 rows by 2 columns), six subjects read the windows from top to bottom in columns, as when reading a newspaper, and four subjects read from left to right in four rows. These results indicated there to be no preferred reading order for Design A ($\chi^2 [1df] = 0.05, p > 0.05$). For Design B (2 rows by 4 columns), all ten subjects read from left to right across the two rows of windows. When the data for the two designs was combined, a significant preference for a horizontal reading strategy was found ($\chi^2 [1df] = 4.90, p < 0.05$).

Location
The data obtained for the first location question for each subject was analysed. This was because subjects had no expectation that location information would be required for this first question, and so any such information would be encoded incidentally. It was found that screen design did not influence accuracy of incidental location recall ($\chi^2 [1df] = 0.46, p > 0.05$). Out of a maximum score of 20 for each design, there were 12 correctly recalled sentence locations for Design A, and 15 for Design B.

3.5.2.3 Discussion

It was hypothesized that a 2 column by 4 row screen layout (Design A) would elicit a reading strategy similar to that used when reading a newspaper. However, this was not found to be the case – only 60% of subjects using Design A read in this way. As predicted, all subjects using Design B read the contents of the windows in a horizontal manner. The results of this pilot study therefore suggest that a horizontal strategy is predominant when reading text contained within windows on a screen.

On the basis of these results, it was decided to employ screen design B for the main study, and to sequence the windows from left-to-right row by row.
3.5.3 Main study

3.5.3.1 Design

The design was a completely randomized one-way ANOVA. The three windowing techniques were Tiled (see figure 3.1), Non-reverting Stack (see figure 3.2), and Reverting Stack (see figure 3.3).

3.5.3.2 Subjects

The 12 subjects comprised members of the HUSAT staff and students from the Department of Human Sciences at Loughborough University of Technology. Their ages ranged between approximately 20-40 years, and all of them had some experience in using a Macintosh computer. Equal numbers of subjects were randomly allocated to each of the experimental conditions.

3.5.3.3 Equipment

The windows were displayed on a MegaScreen, controlled by a Macintosh Plus computer. The software was written in ‘Lightspeed™ Pascal. Subjects’ interactions with the system were videotaped using a JVC video recorder.

3.5.3.4 Materials

The text

The text employed in this study was an academic journal article, and the particular article used was selected for several reasons. First, it was divided into distinct sections (Abstract, Introduction, Method, Results, Discussion, Acknowledgements and References). Second, it did not contain graphics: the constraints of the software employed did not make the inclusion of these possible. Third, the article did not contain complex mathematical formulae. Finally, it was considered to be of interest to the population sample used in the study.
ABSTRACT

The experiment reported in this paper examined the influence of three windowing techniques on readers' ability to recall the content of, and relocate information from within, a document. The three windowing techniques employed were (1) tiled windows, (2) a reversing stack of windows (see Tombs et al. 1987), and (3) a non-reversing stack of windows.

RESULTS

Initial reading
A one-way ANOVA on the three windowing techniques indicated there was no significant effect of the windowing technique on the time taken for the initial reading of the text. An analysis of variance (ANOVA) showed that the time taken for the initial reading of the text did not significantly differ between the three windowing techniques (F(2, 30) = 0.09, p = 0.92).

Content questions
A similar analysis of the number of missing words correctly recalled indicated that windowing technique had a significant influence on the number of missing words recalled. Tukey tests revealed that the significant differences were between the non-reversing stack and each of the other two conditions.

DISCUSSION

Windowing technique was not found to have any significant influence on the time taken for the initial reading of the text. In view of the fact that the method of manipulating the displays varied very slightly for the three windowing techniques, this may be taken to indicate that any effect of windowing technique on performance is directly attributed to the characteristics of the display, rather than to the method of manipulation.

ACKNOWLEDGMENTS

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REFERENCES


Windows
Each of the seven sections of the journal article were displayed in a separate window, and an eighth window contained a contents list. The text occupied 48 window ‘pages’, which were left-justified and numbered sequentially throughout the entire article. The windows were all of the same size, regardless of the windowing technique employed – this was determined by the maximum possible size in the tiled condition. Each window measured 12.0 cm. by 7.8 cm., and contained 25 lines of text, a maximum of 30 characters in width, in 10-point Geneva font.

The windows were of standard Macintosh type, having a title bar at the top and a scroll bar down the right-hand side. None of the windows contained a size box, and only the first window (i.e., that containing the contents list) had a close box. Subjects terminated a session by clicking on this close box. Paging forwards was by means of clicking the mouse below the ‘thumb’ in the scroll bar, and paging backwards by clicking above it.

A window could be selected by clicking the mouse anywhere within the chosen window. If the click was in the scroll bar in a position that would normally initiate a paging operation, then this was also performed. In the two stacked conditions the selected window was brought to the front of the stack. In the reverting stack condition, the other windows remained in their correct front to back sequence behind the active
The twenty subjects comprised members of staff from the HUGAT Research Institute. Their ages ranged between approximately 20-40 years, and all had some experience in using a Macintosh computer. None of the subjects had participated in the previous study, and none of them took part in the main experiment reported here.

For all three windowing techniques, a click in the grey area of the screen returned the windows to their opening condition (i.e., with the first page of each window visible, and the windows in the correct order in the non-reverting stack condition). In the location task, subjects were required to carry out this procedure between questions, so that the search for target sentences always commenced from the same display state.

Content questions
For the content questions, eight sentences were taken from the article, two from each of the following sections: Introduction, Method, Results and Discussion. These sentences were each printed on separate pieces of paper, with a blank substituted for one keyword from every sentence (e.g., "It seems likely that skilled readers used all of these ——, from letters to meaning, some of the time, and different ones at different times."), and subjects were required to fill in the missing words. All subjects were presented with the same eight questions, each receiving them in a different randomized order.
Location questions
The same eight questions were used as for the content questions, but without the missing words. These were again presented on separate pieces of paper, and in a different randomized order for each subject.

3.5.3.5 Procedure

Subjects were informed that they would be required to perform three tasks (i) read the article, (ii) fill in the missing word from eight sentences, and (iii) relocate these target sentences.

Subjects were first given a short practice text to familiarize them with the procedures for manipulating the windows and their contents. They were then asked to read the journal article, this initial reading being timed with a stop-watch. The screen was cleared while subjects completed the content questions. Finally, they were shown the article again in order to answer the location questions. Subjects indicated when they had found a target sentence by drawing the cursor along the appropriate line of text. This third task was videotaped and later analysed by the experimenter.

The following measures were recorded: initial reading – time taken; content questions – number of missing words correctly recalled; relocation task – number of windows selected, number of windows interacted with, number of windows selected but not interacted with, and time taken to locate each target sentence.

3.5.4 Results

3.5.4.1 Initial reading

A one-way ANOVA on the three windowing techniques indicated there to be no significant influence of this variable on the time taken for the initial reading of the text ($F_{[2,9]} = 0.29, p > 0.05$) (see table 3.10).

<table>
<thead>
<tr>
<th></th>
<th>Tiled windows</th>
<th>Non-reverting stack</th>
<th>Reverting stack</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>27.74</td>
<td>27.98</td>
<td>28.76</td>
</tr>
<tr>
<td>SD</td>
<td>1.53</td>
<td>0.58</td>
<td>0.57</td>
</tr>
</tbody>
</table>

Table 3.10. Mean reading times in each condition (in minutes)
3.5.4.2 Content questions

A similar analysis of the number of missing words correctly recalled indicated that windowing technique had a significant influence on this measure (F[2,9] = 18.20, p < 0.01) (see table 3.11). A Tukey test revealed that the significant differences were between the non-reverting stack and each of the other two conditions (T[0.05] = 1.28).

<table>
<thead>
<tr>
<th>Tiled windows</th>
<th>Non-reverting stack</th>
<th>Reverting stack</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>5.50</td>
<td>3.00</td>
</tr>
<tr>
<td>SD</td>
<td>0.29</td>
<td>0.41</td>
</tr>
</tbody>
</table>

Table 3.11. Mean number of missing content words correctly recalled in each condition

3.5.4.3 Relocation task

Windowing technique had a significant effect on the number of windows selected during the location task (F[2,9] = 4.88, p < 0.05) (see table 3.12). Further analysis showed that the significant differences were again between the non-reverting stack condition and each of the other two conditions (T[0.05] = 7.74).

<table>
<thead>
<tr>
<th>Tiled windows</th>
<th>Non-reverting stack</th>
<th>Reverting stack</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>2.75</td>
<td>10.25</td>
</tr>
<tr>
<td>SD</td>
<td>0.85</td>
<td>3.20</td>
</tr>
</tbody>
</table>

Table 3.12. Mean number of windows selected per question in the relocation task

A one-way ANOVA was also performed on the number of windows interacted with during the location task. This was in an attempt to distinguish between occasions when subjects operating in the non-reverting stack condition selected a window because they were not sure whereabouts in the stack a desired window was, and occasions when a window was selected because subjects thought that it contained relevant material. The analysis indicated that windowing technique did have a significant influence on the number of windows interacted with (F[2,9] = 8.67, p < 0.01), with more windows interacted with in the non-reverting stack condition than the tiled condition or the reverting stack one (T[0.05] = 2.23) (see table 3.13).

<table>
<thead>
<tr>
<th>Tiled windows</th>
<th>Non-reverting stack</th>
<th>Reverting stack</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>2.00</td>
<td>4.75</td>
</tr>
<tr>
<td>SD</td>
<td>0.41</td>
<td>0.85</td>
</tr>
</tbody>
</table>

Table 3.13. Mean number of windows interacted with per question in the relocation task
Windowing technique had no significant influence on the number of windows selected but not interacted with during the relocation task ($F_{[2,9]} = 3.15, \ p > 0.05$) (see table 3.14).

<table>
<thead>
<tr>
<th></th>
<th>Tiled windows</th>
<th>Non-reverting stack</th>
<th>Reverting stack</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>0.75</td>
<td>5.50</td>
<td>1.00</td>
</tr>
<tr>
<td>SD</td>
<td>0.75</td>
<td>2.40</td>
<td>0.71</td>
</tr>
</tbody>
</table>

Table 3.14. Mean number of windows selected but not interacted with per question in the relocation task

An analysis of the times taken to locate target sentences indicated that windowing technique had a significant effect on this measure ($F_{[2,9]} = 9.21, \ p > 0.01$) (see table 3.15). A Tukey test revealed that the significant differences were between the non-reverting stack and each of the other two conditions ($T_{0.05} = 1.99$).

<table>
<thead>
<tr>
<th></th>
<th>Tiled windows</th>
<th>Non-reverting stack</th>
<th>Reverting stack</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>2.71</td>
<td>5.65</td>
<td>3.52</td>
</tr>
<tr>
<td>SD</td>
<td>0.57</td>
<td>1.32</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Table 3.15. Mean location time per sentence (in minutes)

3.5.4.4 Correlations

A significant negative correlation was found between accuracy of content recall and the mean number of windows selected during the relocation task ($r = -0.88, \ p < 0.001$). There was also significant negative correlation between accuracy of content recall and the mean number of windows interacted with ($r = -0.67, \ p < 0.02$), and between accuracy of content recall and the mean number of windows selected but not interacted with ($r = -0.80, \ p < 0.01$). In addition, a significant negative correlation was found between accuracy of content recall and mean location times ($r = -0.60, \ p < 0.05$).

3.5.5 Discussion

3.5.5.1 Initial reading times

Windowing technique was not found to have any significant influence on the time taken for the initial reading of the text. In view of the fact that the method for manipulating the displays varied very slightly for the three techniques, this indicates that any effect of windowing technique on performance in the relocation task may be directly attributed to the characteristics of the display, rather than to the method of manipulation.
3.5.5.2 Relocation task

It was hypothesized that efficiency of information relocation would be significantly influenced by the windowing technique used to present the text.

The first measure of relocation efficiency was the time taken to find the target sentences from within the document, and the data obtained do suggest that windowing technique had a significant influence on this variable. However, it was also proposed that performance would be most efficient using the tiled display, and least efficient using the non-reverting stack of windows. Sentences were located significantly more slowly in the non-reverting stack condition than in either of the other two conditions, but there was no significant difference between the location times for the tiled and reverting stack conditions.

The other measures of location efficiency were (i) the number of windows selected by subjects when searching for target sentences, (ii) the number of windows interacted with when searching for target sentences, and (iii) the number of windows selected, but not interacted with, when searching for target sentences. It was found that windowing technique had an influence on the first two of these measures, with significant differences again being found between the non-reverting stack and the other two conditions. Windowing technique did not, however, have any significant effect on the number of windows selected, but not interacted with, while searching for target sentences.

The findings that (a) significantly more windows were interacted with in the non-reverting stack condition than in either of the other two conditions, and (b) that windowing technique had no significant influence on the number of windows selected but not interacted with, suggest that subjects in the non-reverting stack condition did not merely select more windows than subjects in the other two conditions because they were not always able to see the titles of the windows. If this had been the case, then significantly more windows would have been selected, but not interacted with, in the non-reverting stack condition than in either of the other two conditions.

The results of the investigation reported in this section therefore indicate that the enhanced spatial cues provided in the tiled display were of no greater benefit to readers than those provided by the reverting stack of windows, when attempting to relocate information from within a text.

The important difference between the two stacked conditions would seem to be that, in the reverting stack condition, the windows always returned to, and were retrieved
from, a unique place within the stack. It was this fixed location relative to other the windows within the display which provided the spatial cues that readers used to relocate information. The fact that there were more 'pages' fully visible in the tiled display, as compared to the reverting stack, again suggests that the ability to actually see the text is not important, but that it is sufficient for it to belong to a window which has a permanent location. It would appear that readers were not only able to associate the title of a window with a particular location, but also the contents of the window. The target sentences were specially selected so that it would not be immediately obvious which section of the article they came from without having read the text, and an exploratory study using subjects from the same population sample as used in the main study confirmed this. Performance in the relocation task was not, therefore, confounded by prior expectations of the window in which sentences would appear.

3.5.3.3 Content recall

The second hypothesis was that accuracy of content recall would be significantly influenced by windowing technique. This hypothesis was supported, with performance in the non-reverting stack condition being inferior to that in the other two conditions. Tombaugh et al. (1987) used a different measure of content recall to that employed in the present study – subjects in their study were asked to write down the contents list of the article. The data from this earlier investigation suggested that recall of the main headings of the article was superior in the multi-window, as compared to the single window, condition. These two results are consistent with the finding that accuracy of content and spatial recall were correlated. When windows had a unique location within the display, readers were able to use this information as a cue for the recall of both their titles and their contents.

3.5.6 Conclusion

In conclusion, the results of the present experiment indicated that performance in both a relocation and a content recall task was inferior when a text was presented in a non-reverting stack of windows. However, the enhanced spatial cues provided by a tiled display did not significantly improve performance as compared to a reverting stack of windows. The finding that accuracy of content recall was correlated with efficiency of information relocation again supports the hypothesis that memory for textual material comprises a constellation of attributes, in which recall of one attribute may facilitate recall of another.
3.6 GENERAL CONCLUSION

The data obtained from the study reported in section 3.3 suggested that spatial location may be used as an incidental cue by readers of sequentially presented documents. The multi-windowing techniques employed in the investigation described in section 3.4 permitted readers to access the constituent sections of the document in a non-sequential manner, and it would therefore appear that spatial location may act as an incidental cue for both sequential and non-sequential documents. This point will be returned to again in the next chapter.
4.1 INTRODUCTION

In section 1.8, it was proposed that, rather than merely attempt to imitate the paper medium, designers of electronic documents should employ methods which take advantage of the facilities offered by the new one. The conclusions drawn from the BLEND project (see section 1.3.3) suggested that future work should be focussed on providing readers with methods enabling them to retrieve information from an electronic journal more easily, and the data obtained from the usage studies reported in section 1.2.2 indicated that readers employ a variety of strategies when using a journal article. Taken together, these findings suggest that hypertext may provide an appropriate environment for the presentation of an electronic journal. As discussed in section 1.8.4, one of the main benefits of hypertext is that it permits information to be both structured and accessed in a flexible manner - thus supporting a wide range of reading strategies. In addition, hypertext systems allow the capabilities of the electronic medium to be exploited, permitting readers to do things that they would find useful, but which are not possible in the paper medium. However, it would appear that the flexibility of access which hypertext provides may cause some problems for readers, in that they are unable to form a mental map of a document's structure, and so have difficulty in navigating through it.

The present chapter commences with a brief discussion of the relationship between mental maps and navigation, in both sequentially presented and hypertext documents. The main part of the chapter describes a series of studies examining the utility of a number of facilities which may help readers to navigate through hypertexts more easily.

4.1.1 Navigation and mental maps

It has been proposed that people form mental maps of the physical environment in which they live (e.g., Lynch, 1960), which are used for navigating through it. Canter et al. (1986) remark upon the number of researchers who have referred to 'navigation' in relation to computers (e.g., Billingsley, 1982; Spence and Apperley, 1982; Deheffe and Hennenbert, 1976), and a navigation metaphor has been applied to both computer systems and databases. In the former context, Fitter (1979) uses a navigation metaphor when he proposes that in order for the user to feel in control of a system, he needs to have an adequate knowledge of it. The latter is defined as knowing (i) where he has
been, (ii) where he is, and (iii) where he can go from his present position. Carroll and Carrithers (1984) compared the new user of a word-processor to a stranger in an unfamiliar city with an inadequate map, speaking of him being unaware that he has taken a wrong turning.

As Canter et al. (1985) point out, it is common to speak of databases as not only being searched – they are browsed, explored and scanned, and it is also recognized that people can get 'lost' in them. The authors propose that:

"...it is fruitful to recognize the direct parallels between navigating concrete environments, such as cities or buildings, and navigating data. After all, such parallels are implicit in the navigation metaphor, so it is worth establishing whether or not there is a fruitful analogy between the psychological processes involved" (p.93).

A place in the physical environment may be thought of as a node of data in a database, and a journey between two places as a path or link between two nodes.

"Selecting and arriving at a destination on a journey can serve as an analogy for asking and answering a question (or posing and solving a problem); planning a trip and navigating a course are similar to describing and locating areas in the information terrain" (Weyer, 1982, p.88).

A document and a database have some similarity in that they both provide information and cues for the selection of further information (Marchionini and Shneiderman, 1988).

4.1.2 Navigation in sequential documents

In the paper medium a number of well-established conventions provide readers with cues to both the structure and contents of documents, and navigation within them is a well-learned skill. However, when documents are presented in the electronic medium, readers may encounter problems, for example Wright (1984) found that referees had difficulty in relocating information from within a document.

One of the reasons why readers may have difficulty in navigating through electronically presented texts is that many of the spatial cues which have been shown to be of assistance to readers of both paper and electronic documents (see section 3.4) are frequently lost in the electronic medium. As discussed in section 3.5, the introduction of other spatial cues into the document, such as by using multi-windowing techniques, may help readers of electronically presented documents to relocate information from within the text.
4.1.3 The design of electronic documents

Although the multi-windowing technique used in the study reported in section 3.4 did permit readers to access the constituent components of the document non-sequentially, the structure was essentially the same as that of a paper document.

However, imitating paper documents (e.g., Benest et al., 1987) is only one approach to the electronic presentation of documents, and there are several arguments against this. First, it would appear that, for a number of reasons, people often dislike reading from screens. Consequently, if electronic documents only imitate paper ones, people will prefer the paper version. If they are to prefer electronically presented documents, then people must be given facilities to do things that they would find useful, but which are not possible with paper documents. Second, some of the features of the paper medium are difficult to imitate in the electronic one (e.g., rapid page flicking), and so alternatives are required. Third, techniques in the paper medium have evolved as a consequence of developments in the paper-making and print industries, and there is no a priori reason for assuming that they will be optimum in the electronic medium. Finally, merely imitating paper documents does not take advantage of the facilities that the new medium can offer.

Presenting documents in hypertext both permits the information contained within them to be accessed in a more flexible manner than in the paper medium and allows the facilities of the electronic medium to be exploited more fully.

4.1.4 Navigation in hypertext documents

The physical structure of a paper document is serial or sequential and, even if the reader does not choose to access the information in this order, its sequence remains stable. Readers only have two options – they can search for the information they desire either before or after their present location within the document (Conklin, 1987). Waller (1985) proposes that active reading strategies (initial browsing and skimming to preview the text, frequent looks-back and re-reading) help readers to build a ‘cognitive map’ of the text as a physical object, in which features such as headings and illustrations serve as landmarks.

However, as Monk et al. (1988) state, hypertext provides mechanisms for physically realizing the conceptual links between related sections of material:
"Hypertext permits the use of hierarchies or any other form of connected network to access related material within the system. Further, if the links between screens can be of different types, then it is possible to impose alternative structures on an object” (p.422).

The increased flexibility of access that hypertext provides makes it more difficult for readers to form a mental map of the document's structure and, as a consequence, they are more likely to become lost. The problem is summarized by Valdez et al. (1988),

“In many ways, the problems of hypermedia stem from the very flexibility that is its chief advantage and justification. It is difficult to maintain a sense of where things are in a relatively unstructured network of information. While the associative nature of hypermedia increases the availability of large amounts of diverse information, this very diversity makes it easy for information and users to get lost. Hypermedia exacerbates the problem of ‘getting lost in information space’ by providing a complex associative structure that can be traversed, but not fully visualized. Information gets lost because it becomes difficult to organize and tag effectively, while users get lost as they lose sense of where they are in the hypermedia” (p.318).

Halasz (1987) proposes that applications in which navigation is problematic are generally characterized by large, unfamiliar, heterogeneously structured networks, but other writers (e.g., Hammond and Allinson, 1987) consider there to be navigation difficulties even for moderately sized hypertext systems.

The data obtained in the investigations by Marchionini (1989a) and Nielsen and Lyngbaek (1990) would appear to support the hypothesis that readers of hypertexts do experience navigation difficulties. Manifestations of the 'lost in space' effect were said to be found in the former study, with subjects repeatedly pressing the 'page up' and 'page down' arrows when they were already at the beginning or end of an article. In the study reported by Nielsen and Lyngbaek, 40% of the readers of a hypertext conference report considered that they did not find all the information that would be of interest, 56% said that they were often unsure of their position within the document, and 44% claimed that they were frequently confused about how to get back to a particular location, e.g.,

“I soon realized that if I did not read something when I stumbled across it, then I would not be able to find it later” (p.65).

According to Elm and Woods (1985),

“Getting lost in a display network means that the user does not have a clear conception of the relationships within the system, does not know his present location in the system relative to the display structure, and finds it difficult to decide where to look next within the system” (p.927).
The inability to form an accurate overview of the structure of a document means that readers are unable to answer questions such as “Where was I when I saw...?”, “Where am I?”, “Where have I been?”, and “Have I seen everything?” (Wright, 1988).

4.1.5 Previous studies

Although, as Monk et al. (1988) point out, empirical studies are the most effective way of gaining knowledge to assist in the design of systems, few investigations have examined the facilities which may help users of hypertext systems to answer these questions. The three studies having most relevance to the experiments reported in this and the following chapters are those by Monk et al. (1988), Edwards and Hardman (1989), and Teshiba and Chignell (1988).

In the first experiment of the study by Monk et al. (1988), subjects’ ability to answer comprehension questions about a “literate program” (Knuth, 1984) was compared using (i) a hypertext browser, (ii) a scrolling browser, and (iii) a folding browser. The underlying model for the scrolling and folding browsers was of a single sequential document, while that for the hypertext browser was units of information. Performance in the question-answering task was significantly slower using the hypertext browser than the scrolling one, but there was no significant difference between the three conditions in the accuracy of responses to the questions. In a second experiment, one group of subjects were provided with a non-interactive overview of the document’s structure, in the form of a printed map of the section titles displayed to one side of the screen. To control for the possible influence of the availability of section titles in the map, a second group of subjects was shown a list of these titles.

It was found that, when compared to performance by subjects using the hypertext browser in the first experiment, the provision of a map significantly reduced the time taken to answer questions, but the list of section titles appeared to be of little benefit. Although the difference did not reach significance, fewer sections of text were visited by subjects in the map condition than by those in the list one. The authors concluded that providing readers with a map of a hypertext document was of crucial importance, and that if one was not available, then the cognitive effort required to navigate through the structure may outweigh the benefits provided by a non-linear text structure matching the demands of the task.

The hypertext used in these two experiments contained only 12 sections of text, and the addition of a map to the hypertext browser produced a 25% improvement in performance. Monk et al. proposed that greater improvements may be found with a
hypertext comprising a greater number of nodes, and that an interactive map may further enhance performance.

A study by Edwards and Hardman (1989) compared the effect of three different representations on readers' perceptions of the structure of a hypertext document. The representations were (i) hierarchy (movement through the document was via buttons embedded within the text), (ii) index (movement was through a selectable index), and (iii) mixed (both methods were available).

The following measures were employed (i) the number of screens visited and the time taken to perform a search task, (ii) subjective opinion, (iii) responses to a questionnaire relating to feelings of being lost within the document, and (iv) scores in a map construction task. For the map construction task, miniatures of the screens were printed on cards, with the titles on these cards enlarged in relation to the body of the text, so that the text itself was not legible. Subjects were asked to lay out these miniatures on a board as the screens were thought to be arranged in the document, drawing lines to represent the links between them. It was hypothesized that if subjects were attempting to represent the structure of the document, then this process would be disrupted in the mixed condition.

An analysis of the data obtained for the search task indicated that latency decreased throughout the task in the hierarchy condition, but remained constant in the other two. The lowest number of screens were visited by subjects in the index condition, and the highest number by those in the mixed one, but there was no significant difference between the conditions in the number of questions correctly answered. Scores for the map construction task were highest in the hierarchy condition and lowest in the mixed condition. The type of representation had no significant influence on overall feelings of 'lostness', although the highest score was in the mixed condition. Finally, subjective opinions given by readers suggested that those in the hierarchy condition were most satisfied with the system, and those in the index condition were least satisfied. The latter finding was possibly due to the fact that the hierarchy was still visible in the index condition, but not functional. Significant correlations were found between (i) scores in the map construction task and feelings of being lost, (ii) scores in the map construction task and satisfaction ratings, and (iii) satisfaction ratings and feelings of being lost.

Overall, the results of the study were said to indicate that subjects in the mixed condition had greater difficulty using the hypertext than those in the other two conditions. It was concluded that people do form cognitive representations of documents they read, and that accurate structural knowledge is important if readers are to locate information from a hypertext efficiently. The authors proposed that designers
should provide spatially-based orientating/navigating devices, which present the information in a two or three-dimensional form, rather than just maintaining a record of the units which have been viewed.

An investigation concerning user's models of a hypertext interface is reported by Teshiba and Chignell (1988). The interface to Project Jefferson, which is an online information retrieval hypertext system to help students perform research on issues related to the United States Constitution, was used for the studies. The interface is based on the metaphor of a notebook, and among the facilities it contains is a 'locator' device, which provides links between, and background information on, topics related to that chosen by the user. The thirty topics in the locator are arranged in a three-level hierarchy, and the experiment conducted by Teshiba and Chignell was intended to assess users' models of the structure of the locator in relation to its actual structure. It was hypothesized that (i) users would have prior conceptions concerning the way in which the topics were organized in the locator, (ii) these models would become more similar to the actual structure of the locator during usage, and (iii) the relationship between the user's model of the structure and that of the locator would predict performance in a search task. For the experiment, the titles of the thirty topics in the locator were printed onto index cards, and the subjects' first task was to form these into a hierarchy. They were then required to use the system to search for specific topics and, finally, to perform the card sorting task again. No instructions were given to study the hierarchy during the search task, and subjects were not told that a second card sort would be required.

The results indicated that the accuracy of pre-search hierarchies was positively correlated with performance in the search task. There was also a tendency for the hierarchies produced in the second sorting task to be more similar to the actual structure of the system than those produced in the first sorting task, thus suggesting that some structural learning occurred during the search task.

A number of studies have been conducted in relation to navigation in databases and menu structures, some of which have relevance to the present discussion. For example, Engel et al. (1983) report an investigation examining the retrieval of information from a hierarchically structured database. They describe two basic approaches to the grouping of information in order to provide a retrieval structure (i) indices (e.g., the alphabetic subject index at the end of a book), and (ii) classification (e.g., the table of contents of a book). The authors state that in electronic databases:
"It is our experience that unskilled users easily lose their bearings when searching for certain information, so that they fail to find it. They seem to be uncertain about how they arrived at the current point in the retrieval structure, and about the way to follow in order to find the desired data" (p.146).

Engel et al. note that similar difficulties were observed by van Ness and van der Heijden (1982), in whose study the number of pages accessed by users of a three-level hierarchical menu structure was approximately twice the actual number necessary in order to locate a specified item of information.

The system employed in the study by Engel et al. comprised two types of display: a 'what' screen containing primary information and a 'where' screen containing secondary information. The latter was a map, or overview, of the primary information in the database, with the user's current position marked on it. If the 'where' display was too large to fit onto a single display, then a hierarchical structure of 'where' screens was employed - then the user's problem was in obtaining an internal global representation of the structure. In an attempt to assist in this process, additional navigation information was provided by a list of the numbers of the successively selected pages, thus showing a history of the reader's path through the document. The user was able to move a pointer backwards and forwards in this list, in order to select a destination screen. It was also possible to place flags at various locations, which could be jumped back to at a later stage. The system successively displayed the corresponding 'what' and 'where' screens during pointer movement.

The authors refer to Fitter's (1979) proposition that users of interactive systems need to be provided with information concerning (i) where they have been, (ii) where they are, and (iii) where they can go from their current position. In Engel et al.'s system, it was claimed that the history facility fulfilled the first of these criteria, and that the 'where' screen provided a survey of relevance to the second two criteria. Although extensive testing was not carried out, the authors concluded that the information provided on the 'where' screen did help users to navigate through the database and to retrieve the desired information. In addition, the facility permitting users to place marker flags at points of uncertainty enabled them to return to these quickly if they should become lost.

A study by Isa et al. (1982) compared the utility of two metalanguages, conventional IBM notation ('signs') and Pascal flowcharts ('maps'), for the teaching of programming. Two groups of subjects, programmers and non-programmers, were given different levels of training, after which performance was assessed on twelve test problems. It was found that when non-programmers were trained using a detailed manual, there was no significant difference in performance between the two metalanguages. However, when both programmers and non-programmers were only
given a one-page instruction sheet, overall performance was superior in the maps condition.

Billingsley (1982) hypothesized that subjects would be able to retrieve information from a database most efficiently if they were able to recognize and internalize its hierarchical structure. Performance was compared in three conditions (i) subjects worked through the hierarchical menus on a trial-and-error basis, (ii) they were provided with indexed information which led directly to the target items, and (iii) subjects were provided with a map of the database, showing the links between the objects. A further performance measure was obtained by asking subjects to draw the structure of the database after they had completed the search task.

The results of the study indicated that the search task was completed significantly more quickly in the map condition than in either of the other two, and the fewest number of menu selections were also made by subjects in this condition. In addition, performance in the post-experiment map drawing task was found to be correlated with the total number of choices made in the search task, with more accurate maps being produced by subjects who made the least number of menu selections.

The author concluded that:

"The pattern of results provides support for the hypothesis that exposure to a pictorial representation of the structure of a menu system helps subjects to develop a workable mental model of the way data elements interrelate. The spatial/locational information inherent in a map appears to provide enough additional mnemonic assistance so that subjects are able to remember how to find a target (animal) for a considerable time after the map is no longer available" (p.106).

4.1.6 The present studies

The first aim of the series of studies reported in this and the next chapter was to examine the facilities which may assist readers in navigating through a hypertext document. The second aim was to determine whether people do form mental maps of hypertext documents and, if this is the case, whether the accuracy of such a map influences their ability to navigate through the document. In the absence of any more direct technique, the mental maps of a hypertext that readers may possess were examined by a task requiring them to externalize these maps (see Edwards and Hardman, 1989).

Hypertext documents may be structured in several ways. The three experiments reported in the present chapter were concerned with hierarchically structured
documents. The studies were sequential, those features found to improve performance in one study being retained for all conditions in the next.

4.2 STUDY ONE

4.2.1 Introduction

The first study examined the utility of applying two cues from the paper medium to a hypertext environment. It was proposed that in view of the finding that spatial location acts as a navigation cue in both the paper and electronic media, we should not assume that conventions which have been established for one medium are of no utility in another. Subjects' performance using a hierarchical contents list (which matched the structure of the document) was compared to that using an alphabetical index. Engel et al. (1983) make a distinction between these when they refer to the two basic approaches to the grouping of information as classification and indices. However, their investigation was concerned with the former of these, and did not attempt any comparison between the two approaches.

The hierarchical contents list and alphabetical index employed in the present study were both non-interactive. This decision was made for two reasons. First, in the experiment by Monk et al. (1988) it was concluded that the availability of a non-interactive map depicting the hierarchical structure of the text significantly improved readers' ability to use the hypertext material for problem solving. Second, it was considered that if subjects had to traverse the links within the text, they would gain a greater knowledge of its structure than if they were able to select text cards directly from the contents card.

Contents lists and indexes are both types of 'list structure' (Hartley, 1987), consisting of a number of main elements comprising several sub-elements. In paper documents, these elements and sub-elements are differentiated by a combination of spatial and typographic cues. Consequently, a second variable examined in the present study was the addition of typographic cues to the contents list and index.

In the paper medium, readers frequently place a finger between the pages of a document to mark their current position while consulting the contents list or index. The provision of information concerning the reader's current position may be particularly important in view of Canter's (1984) proposition, that

"Probably the most fundamental starting point for way-finding is the knowledge which the individual has about his present location. Any future navigation is probably built upon knowledge of present location" (p.247).

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The third variable examined in the study reported here was the addition of a footprint to the contents list and index, showing the reader which text card they had just come from, thus helping them to answer the question "Where am I?" in relation to the document as a whole. It was also intended that this would function as an electronic bookmark, making it easier for readers to jump back to their previous position in the text after accessing the contents card.

As Billingsley (1982) says, users tend to assume that a database is structured in accordance with their own mental model, but when there is a mismatch between this and the actual organization of the material, efficient retrieval becomes difficult (Cuff, 1980; Durding, Becker and Gould, 1977). Consequently, an additional measure of interest in the present series of studies was the possible relationship between the accuracy of users' own models of the hypertext's structure and their ability to navigate through it effectively.

The hypotheses examined were that:

1. Readers would have more accurate knowledge of the document's structure, and be able to navigate through it more efficiently, using a hierarchical contents list as compared to an alphabetical index.

2. The provision of a footprint would enhance structural knowledge and navigation efficiency.

3. The addition of typographic cues would enhance structural knowledge and navigation efficiency.

4. There would be a positive correlation between the ability to navigate through the document and the ability to produce an accurate map of its structure.

4.2.2 Method

4.2.2.1 Design

The design was a completely randomized 2 x 2 x 2 ANOVA. The two levels of factor one were hierarchical contents list (see figure 4.1) and alphabetical index (see figure 4.2). The two levels of factor two were footprint (see figure 4.1) and none, and the two levels of factor three were typographical cues (see figure 4.2) and none.
HOUSE PLANT CARE

CONTENTS

HOUSE PLANT BASICS
LOCATION
LIVING ROOM
KITCHEN
BEDROOM
BATHROOM
WATERING
FEEDING

PROPAGATION
DIVISION
CUTTINGS
BABY PLANTS
PESTS
MEALY BUGS
APHIDS
EARWIGS

PLANT PROBLEMS
COLLAPSE
COLD NIGHTS
STRONG SUNLIGHT
DRY SOIL
OVERWATERING

Figure 4.1. Hierarchical contents list with a footprint

HOUSE PLANT CARE

CONTENTS

Aphids
BABY PLANTS
Bathroom
Bedroom
Cold Nights
COLLAPSE
CUTTINGS
DIVISION

Dry Soil
Earwigs
FEEDING
Kichen
Living Room
LOCATION

Mealy Bugs
Overwatering
PESTS
PLANT PROBLEMS
PROPAGATION
STRONG SUNLIGHT
WATERING

Figure 4.2. Alphabetical index with typographical cues

- 160 -
4.2.2.2 Subjects

The 24 subjects comprised members of staff from the HUSAT Research Institute and students from the Department of Human Sciences at Loughborough University. Their ages ranged between approximately 20 - 40 years, and all of the subjects had some experience in using a Macintosh computer. Equal numbers of subjects were randomly allocated to each of the experimental conditions.

4.2.2.3 Materials

The text was a 2,500 word article about houseplants and their care, based on that employed by Tombaugh et al. (1987). It was presented on a Macintosh Plus computer, and constructed in HyperCard, each card measuring 2.4 cm. x 3.4 cm. The article was divided between 24 cards, each of which contained a maximum of 17 lines of 12-point Geneva font text. Movement through the text was by means of ‘buttons’ within cards, these being indicated by words in bold text (see figure 4.3). When subjects clicked on a button, a card bearing the same name as the button was opened. Subjects were able to access the contents card from any text card, but the only route from this was back to the last text card seen. Visual feedback for changes of screen contents was provided by a simulation of page-turning, similar to that employed by Benest and Morgan (1985). In the conditions where a footprint was provided, when subjects moved to the contents card, the text card which they had just seen was indicated by a box drawn round the title of this card on the contents card. For the map construction task, miniatures of the 24 text cards were printed, these being reduced so that only their titles were visible. The miniatures were mounted on cards 3 cm. x 4.5 cm. and randomly arranged on a 1m. x 1m. whiteboard.

The software recorded the cards opened, the order of opening, and the selected sections of text for the question-answering task.

4.2.2.4 Procedure

After a short practice session to familiarize them with the system, subjects were asked to read the article about houseplants. They were told to continue reading until they thought that they had read all of the article. Subjects were then shown the article again and given ten questions, each requiring them to locate specific details from within the text, e.g., “Where does it mention the second most popular room for growing indoor plants?”. The presentation order of the ten questions was randomized between subjects, and each question was printed on a separate piece of card. Questions were answered by highlighting the relevant text with the mouse cursor. Clicking the mouse on the “Next
Question" button returned subjects to the contents card ready to begin searching for the next target. Finally, the display was cleared, and subjects were asked to arrange the miniature cards on the whiteboard to represent the structure of the article, drawing lines with a marker pen to indicate the links between the cards.

Your indoor plant stock can be increased in various ways; by taking cuttings, division, or using the 'babies' that some plants produce. Here are a few basic rules to be followed when propagating.

First, everything connected with the propagating exercise should be meticulously clean, and all procedures should be carried out in good light, but avoiding direct sunlight.

The potting mixture should be of the right texture. Garden soil is much too heavy and is liable to harbour pests and diseases. A proprietary brand is much better.

Try to maintain an even temperature of 65-75 deg. F. (18-24 deg. C.). If cuttings can be placed in a heated propagator, so much the better - they root more readily if their "feet" are warm.

Propagation is one of the most rewarding aspects of houseplant care.

4.2.3 Results

4.2.3.1 Initial reading

The shortest route through the text was determined, and the number of cards that it was necessary to open in order to traverse this route was calculated. The result was then subtracted from the actual number of cards opened, thus producing an additional card score for each subject. A 2 x 2 x 2 ANOVA (hierarchical list/alphabetical index x typographic cues x footprint) was performed on the data (see table 4.1).

<table>
<thead>
<tr>
<th>Hierarchical contents list</th>
<th>Alphabetical index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Footprint</td>
<td>No footprint</td>
</tr>
<tr>
<td>Typo</td>
<td>None</td>
</tr>
<tr>
<td>Mean</td>
<td>0.00</td>
</tr>
<tr>
<td>SD</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Table 4.1. Number of additional cards opened for the initial reading task in each condition

- 162 -
There were main effects of both hierarchical list/alphabetical index ($F_{1,16} = 28.62, p < 0.001$) and footprint ($F_{1,16} = 14.22, p < 0.01$). Subjects using the hierarchical list opened fewer additional cards (mean = 0.50) than those using the alphabetical index (mean = 5.59), and subjects provided with a footprint opened fewer additional cards (mean = 1.25) than those who were not (mean = 4.84). In addition, the interaction between list/index and footprint was significant ($F_{1,16} = 9.42, p < 0.001$). A Tukey test indicated that the differences in the number of additional cards opened were significant for the following pairs of conditions (i) list with footprint vs. index without footprint, and (ii) list without footprint vs. index without footprint ($T_{0.05} = 6.14$).

4.2.3.2 Question-answering

The least number of cards that it was necessary to open in order to locate each target was calculated, and this was subtracted from the actual number of cards opened. A 2 x 2 x 2 ANOVA indicated there to be a main effect of hierarchical list/alphabetical index ($F_{1,16} = 15.12, p < 0.01$). Fewer additional cards were opened by subjects using the list (mean = 4.00) than by those using the index (mean = 14.92) (see table 4.2). All of the subjects located all of the targets.

<table>
<thead>
<tr>
<th>Hierarchical contents list</th>
<th>Alphabetical index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Footprint</td>
<td>No footprint</td>
</tr>
<tr>
<td>Typo</td>
<td>None</td>
</tr>
<tr>
<td>Mean 0.00</td>
<td>1.33</td>
</tr>
<tr>
<td>SD 0.00</td>
<td>2.31</td>
</tr>
</tbody>
</table>

Table 4.2. Number of additional cards opened for the question-answering task in each condition

A 2 x 2 x 2 ANOVA was performed on the data for the number of times that the contents card was accessed by readers during the question-answering task. A main effect of hierarchical list/alphabetical index was again found ($F_{1,16} = 5.78, p < 0.05$), with the contents card being accessed more times by subjects using the hierarchical list (mean = 3.92) than by those using the alphabetical index (mean = 2.50) (see table 4.3).

<table>
<thead>
<tr>
<th>Hierarchical contents list</th>
<th>Alphabetical index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Footprint</td>
<td>No footprint</td>
</tr>
<tr>
<td>Typo</td>
<td>None</td>
</tr>
<tr>
<td>Mean 4.00</td>
<td>3.00</td>
</tr>
<tr>
<td>SD 1.00</td>
<td>2.00</td>
</tr>
</tbody>
</table>

Table 4.3. Number of times the contents card was accessed during the question-answering task in each condition
4.2.3.3 Map construction task

One point was awarded for each card correctly linked to its parent card in the hierarchy (see Edwards and Hardman, 1989). A $2 \times 2 \times 2$ ANOVA indicated there to be a main effect of hierarchical list/alphabetical index ($F_{[1,16]} = 12.79, p < 0.01$), with more accurate maps being produced by subjects provided with a list (mean score = 20.84) than by those provided with an index (mean score = 15.67) (see table 4.4).

<table>
<thead>
<tr>
<th>Hierarchical contents list</th>
<th>Alphabetical index</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Footprint</td>
</tr>
<tr>
<td>Typo</td>
<td>22.00</td>
</tr>
<tr>
<td>None</td>
<td>21.67</td>
</tr>
</tbody>
</table>

Table 4.4. Number of points scored for the post-experiment maps produced in each condition

4.2.3.4 Correlations

A significant positive correlation was found between the number of additional cards opened in the initial reading and question-answering tasks ($r = 0.72, p < 0.001$). Significant negative correlations were found between (i) the number of additional cards opened in the initial reading task and scores for the map construction task ($r = -0.75, p < 0.001$) and (ii) the number of additional cards opened in the question-answering task and scores for the map construction task ($r = -0.92, p < 0.001$).

4.2.4 Discussion

4.2.4.1 Hierarchical contents list vs. alphabetical index

The first hypothesis, that structural knowledge would be more accurate, and navigation more efficient, using a hierarchical contents list as compared to an alphabetical index was supported. Subjects using a list produced more accurate maps of the text’s structure and opened fewer additional cards during both the initial reading and question-answering tasks than did subjects using an index. Furthermore, in the list/index by footprint interaction found for the initial reading task, the three pairs of conditions whose scores differed significantly contrasted a list and an index condition. It should be pointed out that subjects using the hierarchical list were not merely able to reproduce the contents card in the map construction task, because they were required to represent the structure graphically.
It was observed that, in all conditions, the highest number of additional cards were opened during the first half of the initial reading session. In the majority of cases these cards were only opened for a few seconds, just long enough for their contents to be scanned. It was possible to distinguish two patterns of interaction during this period, (i) opening the same two or three cards repeatedly and (ii) methodically opening all of the cards at successive levels of the hierarchy. The first pattern of interaction may indicate disorientation or being lost, and was more commonly exhibited by subjects in the index conditions. The second pattern of interaction may be described as exploratory, and occurred more frequently in the list conditions.

It is also noteworthy that during the question-answering task, subjects provided with a hierarchical list accessed the contents card more often than those using an alphabetical index. One possible explanation for this is that the list was found to be of greater utility than the index, and it was therefore consulted more frequently.

As the hypertext used in the study was hierarchically structured, an alphabetical index would clearly not map onto the document's structure in the same way as would a hierarchical contents list. Hence, the finding that performance by subjects using a list was superior to that by subjects using an index suggests that textual representations of a hypertext's structure convey information that readers are able to use in constructing a map of, and navigating through, the document. Monk et al. (1988) concluded that a non-interactive map of a document's section titles was of more benefit to readers than a list of the titles. The results of the present study indicate that a non-interactive textual, as opposed to graphical, representation of the document's structure is also of benefit to readers.

4.2.4.2 Footprint

It was predicted that the addition of a footprint to the hierarchical list or alphabetical index would enhance structural knowledge and navigation efficiency. In the initial reading of the text, subjects who were provided with a footprint did navigate through the document more efficiently than those who were not. Although the provision of a footprint had no influence on navigation efficiency in the question-answering task or performance in the map construction task, subjects who were provided with a footprint opened fewer cards per find than did those who were not (means = 7.83 and 11.08), and the former group of subjects also scored higher in the map construction task than the latter (means = 19.00 and 17.50). It would therefore appear that the provision of a footprint may be of greater benefit for some types of tasks than others.
4.2.4.3 Typographical cues

The third hypothesis was that the addition of typographic cues to the hierarchical list or alphabetical index would enhance readers' navigation efficiency and their knowledge of the article's structure. However, although an established convention in the paper medium, typographical cues were not found to be of utility in a hypertext environment. One possible explanation for this may be that in paper documents the typographical cues are mirrored in the text itself (e.g., headings and subheadings), but there were no equivalent cues in the HyperCard titles, all of these being shown in the same text font and style. However, Hartley (1987) concluded that of the two types of cue used in a contents list, typographical and spatial, the latter were more important. Consequently, an alternative explanation for the present finding is that readers relied upon the spatial cues provided in the contents list. The finding that performance by subjects using the index was inferior to that by those using the contents list may be evidence in support of this hypothesis – although typographical cues were available in both conditions, spatial cues were only available in the index condition.

4.2.4.4 Correlations

Finally, it was hypothesized that navigation efficiency and performance in the map construction task would be correlated. This hypothesis was supported – subjects who produced more accurate maps opened fewer additional cards in both the initial reading and question-answering tasks. The correlation between performance in the question-answering and map construction tasks is in agreement with the results of Billingsley's (1982) study using a hierarchical menu system. If it is accepted that the externalization of a mental map provides an accurate representation (see section 4.1.6), then the present findings provide support for the theory that readers form mental maps of documents they read (e.g., Waller, 1985), and the proposition that a mental map of the text's structure is essential for navigation (e.g., Mahony, 1988; Edwards and Hardman, 1989).

4.2.5 Conclusion

The study reported here examined the use of three types of cues on readers' ability to navigate through, and construct a map of, a hierarchical hypertext document. It was found that (i) readers using a hierarchical contents list navigated through the text more efficiently, and produced more accurate maps of its structure, than readers using an alphabetical index, (ii) the provision of a footprint was beneficial for the initial reading task, but not for the question-answering or map construction tasks, (iii) the addition of typographic cues to the contents card did not significantly improve performance for any
of the tasks, and (iv) performance in the question-answering task was positively correlated with that in map construction task.

4.3 STUDY TWO

4.3.1 Introduction

The results of the study reported in section 4.2 indicated that readers were able to navigate through a hierarchical hypertext document more efficiently, and form a more accurate map of its structure, when using a hierarchical contents list as compared to a straightforward alphabetical listing of the card titles. However, there are several reasons why a graphical representation of the structure could be of even greater benefit than a textual one (Billingsley, 1982). First, there is evidence from the verbal learning literature that people take advantage of the spatial structure of hierarchically organized information when it is made available, and that they recreate the structure on paper when asked to recall all the items in a given hierarchy (Bower et al., 1969; Broadbent et al., 1978). Second, the ease with which data items in a hierarchical structure are comprehended and remembered is due to the inherent structure of the hierarchy itself (Brosey and Shneiderman, 1978). Third, both the semantic and locational attributes of data are encoded in memory regardless of whether subjects are asked to attend to the spatial information (e.g., Zechmeister et al., 1975).

A further reason why a graphical representation, or map, of a hypertext’s structure may be of more benefit than a textual one is that the titles in the map may be compared to the window titles in the reverting stack and tiled conditions in the study reported in section 3.3, in that they are both labels representing units of text and have a permanent, spatially defined, location. In the earlier investigation, it was found that readers used the spatial cues provided by the windowing techniques to help relocate information from within a document; furthermore, they were able to associate the content of a window with its title.

McGee (1976) introduced the concept of ‘picturability’, suggesting that the display of databases in a pictorial form would help users to learn their structure. Such representations may not only assist in the initial comprehension of the structure, but might also provide a reference point to which users could return; in other words, acting as a landmark. Such a proposition is supported by Canter (1984), who considers that an important aspect of the way in which places are organized is an understanding of where further information about the organization of the place can be found.
According to Mahony (1988),

"A well-defined graphic solution is more likely to be intuitively understandable; graphic representations are better at providing constant orientation 'at a glance' for the inexperienced user. In the context of hypertext, then, a diagram may well be worth more than the thousand characters of complex pathnames for simple navigation" (p.7).

There are two questions involved in this proposition – is a graphical representation of greater benefit to readers, and what constitutes a "well-designed" graphical representation?

The first aim of the present study was therefore to compare the influence of graphical and textual representations of a hierarchical contents list on readers' ability to relocate information from, and form mental maps of, a hierarchical hypertext document. The textual representation was a hierarchical list of card titles, with very limited spatial cues. The graphical representation had much clearer spatial cues, and the links between the levels of the hierarchy were also indicated.

The contents list and index used in the previous investigation were both non-interactive, i.e., subjects could not go directly to a text card by selecting it from the list or index, but were only able to move through the document via the links between the cards. However, Monk et al. (1988) concluded that while a non-interactive map depicting the structure of the document was of benefit to readers, an interactive one may be of greater assistance. Consequently, the second factor examined in the present study was the influence of interactive and non-interactive representations of the document’s structure on readers’ performance in a relocation and a map construction task. It was proposed that information relocation would be more efficient if the representation was interactive, but that readers’ knowledge of the document’s structure may be less accurate, because they did not have to travel between the cards via the links.

The results the study reported in section 4.2 suggested that the addition of a footprint to a textual representation of a hypertext document’s contents was of significant benefit for an initial reading task, but not for a location one. However, it is very possible that the utility of such a facility may be influenced by (i) the type of location task employed, (ii) whether the representation is interactive or non-interactive, and (iii) whether it is textual or graphical. In view of these factors, plus the finding that, although not significantly so, navigation in the question-answering task was more efficient when a footprint was provided, it was decided to retain the footprint variable for further evaluation in the present study.
The hypotheses examined were that:

1. Navigation through the document would be more efficient, and the increase in the accuracy between pre- and post-experiment maps of its structure would be greater, when using a graphical, as compared to a textual, representation of the structure.

2. The increase in accuracy between pre- and post-experiment maps of the document's structure would be less when subjects were provided with an interactive representation than when they were provided with a non-interactive one.

3. The provision of a footprint would enhance structural knowledge and navigation efficiency.

4. There would be a positive correlation between the ability to produce an accurate map of a document's structure and the ability to navigate through the document.

4.3.2 Method

4.3.2.1 Design

The design was a completely randomized 2 x 2 x 2 ANOVA. The two levels of factor one were a graphical representation of the document's structure (see figure 4.4) and a textual representation (see figure 4.5). The two levels of factor two were an interactive and a non-interactive representation, and the two levels of factor three were footprint and none (see figure 4.5).

4.3.2.2 Subjects

The 24 subjects comprised different members of the same population sample as that employed in the study reported in section 4.2. Equal numbers of subjects were randomly allocated to each of the experimental conditions.
Figure 4.4. Graphical representation

Figure 4.5. Textual representation with a footprint
4.3.2.3 Materials

The text was again a 2,500 word article about houseplants, but the content differed from that of the text employed in the study reported in section 4.2. It was presented on a Macintosh Plus computer, and constructed in HyperCard. The article was divided between 26 cards, each of which contained a maximum of 17 lines of 12-point Geneva font text. Movement through the text was by means of 'buttons' within cards, these being indicated by bold text (see figure 4.3). When subjects clicked on a button, a card bearing the same name as the button was opened. Subjects were able to access the contents card from any text card. In the non-interactive conditions, the only route from this was back to the last text card seen. In the interactive conditions, subjects were able to select a text card directly from the contents card. The footprint was shown as described in section 4.2.2.3. The materials for the map construction task were produced in the same way as for the earlier study (see section 4.2.2.3).

4.3.2.4 Procedure

Subjects were first asked to arrange the miniatures of the cards on the whiteboard to represent a possible structure for the document, drawing lines with a marker pen to indicate the links between the cards. The difference between these pre-experiment maps and those produced after reading the article was considered to provide a more useful measure than the accuracy of post-experiment maps per se; as the latter may have been differentially influenced by preconceived notions of the document's structure. Following the initial map construction task, subjects were given six minutes in which to familiarize themselves with the structure and contents of the article. This time limit was taken from a mean reading time determined from pilot studies. Subjects were then shown the article again, and required to locate from within it as many references as they could find to each of three types of plant. Each plant name was mentioned six times within the document, but subjects were merely told that each was mentioned more than once. The presentation order of the plant names was randomized between subjects, and the three plant names were printed on separate pieces of paper. Subjects recorded references to the items by highlighting the relevant sections of text. Clicking the mouse on the "Next Question" button returned them to the contents card ready to begin the next question in the series. Finally, the screen was cleared, and subjects were asked to construct a map of the actual structure of the document, using the same technique as for the pre-experiment map construction task.

The software recorded the cards opened, the order of opening, the time spent on each card, and the selected text for the question-answering task.
4.3.3 Results

4.3.3.1 Number of finds

A 2 x 2 x 2 ANOVA (graphical/textual x interactive/non x footprint/none) indicated there to be main effects of both representation type ($F_{[1,16]} = 5.25, p < 0.05$) and interactive vs. non-interactive representation ($F_{[1,16]} = 8.57, p < 0.01$) on the number of finds (see table 4.5). Subjects provided with a graphical representation of the document's structure found more references to the target items than those provided with a textual one (means = 13.42 and 10.41), and subjects using an interactive representation found more references than those using a non-interactive one (means = 13.83 and 10.00).

<table>
<thead>
<tr>
<th>Graphical representation</th>
<th>Textual representation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interactive F NF F NF F NF F NF F NF</td>
<td>Interactive F NF F NF F NF F NF</td>
</tr>
<tr>
<td>SD 0.67 1.16 2.01 0.58 1.63 0.78 1.62 0.87</td>
<td>SD 0.67 1.16 2.01 0.58 1.63 0.78 1.62 0.87</td>
</tr>
</tbody>
</table>

Table 4.5. Mean number of finds in each condition (max = 18)

4.3.3.2 Cards per find

The mean number of cards opened per find was calculated for each subject, and separate 2 x 2 ANOVAs (graphical/textual x footprint/none) were performed for the interactive and non-interactive conditions (see table 4.6). Separate analyses were performed because it was necessary to open more cards in order to travel through the document when using a non-interactive representation than when using an interactive one.

In the non-interactive conditions, main effects of both representation type ($F_{[1,8]} = 23.65, p < 0.001$) and footprint ($F_{[1,8]} = 6.4, p < 0.05$) were found. Readers using a graphical representation opened fewer cards for each reference found than those using a textual one (means = 12.81 and 17.98), and subjects provided with a footprint opened fewer cards for each reference than those who were not (means = 14.05 and 16.74). Neither representation type or the provision of a footprint had any significant effect on the number of cards opened per find in the interactive conditions.
<table>
<thead>
<tr>
<th></th>
<th>Graphical representation</th>
<th></th>
<th>Textual representation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Interactive</td>
<td>Non</td>
<td>Interactive</td>
</tr>
<tr>
<td>Mean</td>
<td>8.72</td>
<td>11.48</td>
<td>12.37</td>
</tr>
<tr>
<td>SD</td>
<td>1.63</td>
<td>2.23</td>
<td>0.69</td>
</tr>
</tbody>
</table>

Table 4.6. Mean number of cards opened per find in each condition

4.3.3.3 Time per find

Separate 2 x 2 ANOVAs were again calculated for the interactive and non-interactive conditions. The analyses indicated there to be a main effect of representation type \( F_{[1,8]} = 30.15, p < 0.001 \) and footprint \( F_{[1,8]} = 7.93, p < 0.05 \) in the non-interactive conditions (see table 4.7). References were located more quickly in the graphical conditions than in the textual ones (means = 110.47 and 437.51 seconds), and subjects provided with a footprint located references faster than those who were not (means = 87.58 and 460.41 seconds). Again, neither representation type or the provision of a footprint had any significant effect on performance in the interactive condition.

<table>
<thead>
<tr>
<th></th>
<th>Graphical representation</th>
<th></th>
<th>Textual representation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Interactive</td>
<td>Non</td>
<td>Interactive</td>
</tr>
<tr>
<td>Mean</td>
<td>40.51</td>
<td>47.21</td>
<td>77.54</td>
</tr>
<tr>
<td>SD</td>
<td>2.94</td>
<td>2.03</td>
<td>1.97</td>
</tr>
</tbody>
</table>

Table 4.7. Mean time per find in each condition (in seconds)

4.3.3.4 Map construction task

The same scoring technique was employed as in the study reported in section 4.2. A 2 x 2 x 2 ANOVA was then performed on the difference between the scores obtained for the pre- and post-experiment maps produced by subjects (see table 4.8). Main effects of representation type and interactive vs. non-interactive representation were found. The increase in scores by subjects in the graphical conditions was greater than that by subjects in the textual conditions \( F_{[1,16]} = 26.92, p < 0.001 \) (means = 14.59 and 11.09), and the increase by subjects using an interactive representation was greater than that by those using a non-interactive one \( F_{[1,16]} = 8.79, p < 0.01 \) (means = 11.83 and 13.84).
4.3.3.5 Correlations

A significant positive correlation was found between the increase in accuracy of pre- and post-experiment maps and the number of finds \( r = 0.70, p < 0.01 \), and a significant negative correlation between the increase in accuracy of pre- and post-experiment maps and the number of cards opened per find \( r = -0.75, p < 0.001 \).

4.3.4 Discussion

4.3.4.1 Representation type

The first hypothesis was that navigation through the document would be more efficient, and the increase in accuracy between pre- and post-experiment maps of its structure greater, when subjects were provided with a graphical, as compared to a textual, representation of the structure. The second part of this hypothesis was clearly supported, with a significantly greater increase in accuracy between pre- and post-experiment maps being found in the graphical conditions than in the textual ones.

Three measures of navigation efficiency were employed (i) the number of references to each target item found, (ii) the number of cards opened in order to locate each reference, and (iii) the time taken to locate each reference. Significantly more references to the targets were found by subjects using a graphical representation than by those using a textual one, but the data obtained for the other two measures of navigation efficiency do not present such a clear picture.

In the non-interactive conditions, subjects using a graphical representation of the document’s structure opened fewer cards in order to locate each reference and located them more quickly than subjects provided with a textual representation, but representation type had no significant influence on either of these measures in the interactive conditions. However, subjects using an interactive textual representation opened more cards per find than those using an interactive graphical one (means = 17.14 and 10.10), and finds were made more slowly by subjects in the former condition (mean search time = 62.87 seconds) than by those in the latter one (mean

<table>
<thead>
<tr>
<th></th>
<th>Graphical representation</th>
<th></th>
<th>Textual representation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Interactive</td>
<td>Non</td>
<td>Interactive</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>NF</td>
<td>F</td>
</tr>
<tr>
<td>Mean</td>
<td>14.67</td>
<td>13.67</td>
<td>16.00</td>
</tr>
<tr>
<td>SD</td>
<td>0.93</td>
<td>1.68</td>
<td>1.53</td>
</tr>
<tr>
<td></td>
<td>8.33</td>
<td>10.67</td>
<td>12.67</td>
</tr>
<tr>
<td></td>
<td>0.91</td>
<td>1.29</td>
<td>0.56</td>
</tr>
</tbody>
</table>

Table 4.8. Mean increase in scores between pre- and post-experiment maps in each condition
search time = 43.86 seconds). Subjects using an interactive representation were able to select a text card directly from the contents list, but the only way in which a text card could be accessed in the non-interactive conditions was by traversing the links within the document. Consequently, knowledge of the document's structure therefore had more influence on navigation performance in the non-interactive conditions than in the interactive ones. If a graphical representation provided readers with better structural cues than a textual one, then a more marked performance difference between the two types of representation would therefore be expected in the non-interactive conditions, as was found to be the case.

In section 4.3.1, it was suggested that a map would facilitate the retrieval of information from a hypertext document in a similar way as the reverting stack and tiled windowing techniques were of benefit to subjects in the study reported in section 3.3, and the results of the present investigation support this hypothesis. In Tombaugh et al.'s (1987) investigation, it was assumed that sections of text should be read in different locations if incidental location cues were to be encoded, but the authors did acknowledge that an adequate retrieval tag may be established if the reader merely knows which location the text came from. The fact that readers were able to use the spatial cues provided by a graphical representation of a hypertext's structure in order to relocate information from within the document suggests that this may be so — the titles of the nodes had unique locations on the map, but when subjects read the document, all of the cards appeared in the same place on the screen. The finding that subjects using a graphical representation of the document's structure were able to navigate through it more efficiently also supports the proposition made by a number of writers (e.g., Waller, 1985; Hammond and Allinson, 1987), that people construct mental maps of documents that they read. Subjects shown a graphical representation were able to navigate through the text better because presumably this type of representation more closely matched their own internal model of the document's structure.

It could be argued that the increase in accuracy between pre- and post-experiment maps of the document's structure would be greater for subjects using a graphical representation than for those using a textual one because subjects in the former condition would be able to reproduce the map they were shown. However, a number of other findings point to the superiority of a graphical representation and, furthermore, performance in the map construction task was correlated with that in the location task. The data obtained from the present study would therefore appear to support Mahony's (1988) proposition, that:
"A well-designed graphic solution is more likely to be intuitively understandable; graphic representations are better at providing constant orientation, 'at a glance' for the inexperienced user. In the context of hypertext, then, a diagram may well be worth more than the thousand characters of complex pathnames for simple navigation" (p.7).

4.3.4.2 Interactive vs. non-interactive

The second hypothesis was that the increase in accuracy between pre- and post-experiment maps of the document's structure would be greater for subjects using a non-interactive representation than for those using an interactive representation. An analysis of the maps produced by subjects did not support this hypothesis – there was a greater increase between the scores obtained for pre- and post-experiment maps in the interactive conditions than in the non-interactive ones.

It was proposed that in the interactive conditions, subjects would not gain as much knowledge of the structure of the article as in the non-interactive conditions, because they would not have to navigate through the text via the links, but this did not appear to be the case. However, readers provided with an interactive representation did access it more frequently than those using a non-interactive one (travel through the document being more frequently by this method than via the links between the cards in the interactive conditions), and it may be that the increased frequency of access enhanced performance in the map construction task in the interactive conditions. An alternative explanation is that subjects using an interactive representation found it easier to move through the text, and that this ease of movement facilitated the formation of a mental map of the document's structure. The finding that significantly more references were located in the interactive conditions than the non-interactive ones supports the latter suggestion – subjects were able to locate more targets because they were able to navigate through the text more easily. It may also be that, because the system was found easier to use, subjects provided with an interactive representation continued searching until they had found more target references.

Monk et al. (1988) concluded that a non-interactive map of a hierarchical hypertext was of significant benefit to readers, while Yankelovich et al. (1983) consider that interactive maps are the optimum method of travelling through an information structure. The results of the study reported here provide evidence in support the latter proposition and, furthermore, the use of an interactive representation of the document's structure exploits facilities which are available in the electronic medium, but not in the paper one.
4.3.4.3 Footprint

It was proposed that the provision of a footprint would be of benefit to readers of hypertext documents because it showed their current position within the text, therefore answering the question “Where am I?” in relation to the document as a whole. However, the data obtained from the study reported in section 4.2 would suggest that such a cue may only be of significant utility during an initial familiarization period. In the present investigation, the provision of footprint was of significant benefit for readers using a non-interactive representation of the document’s structure, but not for those using an interactive one. In the interactive conditions, fewer cards were opened per find when a footprint was provided (mean = 10.03) than when it was not (mean = 12.22), and the mean time taken to locate each target was shorter when a footprint was provided (mean = 48.46 seconds) than when it was not (mean = 58.28 seconds), but the performance differences were not significant. Perhaps the most likely explanation for these findings is that it was more important for readers using a non-interactive representation to know which text card they had just come from, because the only route from the contents card was back to this text card, and the only way in which they could move through the document was by following the links on this card, which were shown on the contents card. In the interactive conditions, knowledge of the last text card seen was not so crucial, as readers were able to travel through the document by selecting a card directly from the contents card.

It is suggested that when there are a greater number of nodes of information, such a marker will be of significant benefit to readers using an interactive map, as well as to those using a non-interactive one. Support for this proposition is provided by the observation by Engel et al. (1983), that the provision of a footprint on the ‘where’ screen in their study did assist readers in retrieving information from an electronic document.

4.3.4.4 Correlations

The fourth hypothesis was that navigation efficiency would be positively correlated with the ability to produce an accurate map of the document’s structure. This hypothesis was supported, with the increase in accuracy between pre- and post-experiment maps being positively correlated with the number of finds made, and negatively correlated with the number of cards opened per find. Thus the results of both this investigation and that reported in section 4.2, are in agreement with the proposition that people construct mental maps of documents they read, and that the accuracy of these is an important determinant of navigation efficiency. Teshiba and Chignell (1988) found that post-experiment maps constructed by subjects were more similar to the
actual structure of the document than pre-experiment ones, and it was therefore proposed that structural learning took place during readers’ interactions with the document. The findings of the present investigation indicate that the degree of learning may be significantly influenced by the structural cues provided by the system.

4.3.5 Conclusion

The study reported here examined the influence of three variables on readers’ ability to relocate information from within a hierarchical hypertext and to construct a map of its structure. It was found that (i) performance in both a relocation and map construction task was superior when subjects were provided with a graphical representation of the document’s structure, as compared to a textual one, (ii) information was located more efficiently, and the increase in accuracy between pre- and post-experiment maps was greater, when the representation was interactive, (iii) the provision of a footprint was of benefit for subjects using a non-interactive representation and (iv) performance in the location task was positively correlated with the increase in accuracy between pre- and post-experiment maps produced by subjects.

4.4 STUDY THREE

4.4.1 Introduction

Readers of hypertexts are often unsure which parts of the document they have seen, and this obviously makes it more difficult for them to relocate information from within the text. One solution may be to provide a record of the cards which have been accessed during a reading session, and the possible utility of such a navigation aid was the focus of the third study reported in this chapter. The provision of information concerning the units of text which have been accessed may be particularly important in view of Canter’s (1984) proposition, that

“In considering the processes involved in knowing where you are, it is worth emphasizing that this knowledge would appear to be built upon knowledge of where you have been” (p.248).

It was considered that showing readers a record of the cards they had accessed would improve performance in the relocation task because it reduced the number of potential target cards, and also help them to answer questions such as “Where was I when I saw...?” and “Have I seen everything?”. In addition, it was hypothesized that the reduction in the number of cards unintentionally revisited would enable readers to form a more accurate map of the hypertext’s structure.
The hypotheses examined were that:

1. Navigation through the document would be more efficient, and the increase in accuracy between pre- and post-experiment maps of its structure would be greater, if readers were provided with a record of the cards which they had accessed.

2. There would be a significant positive correlation between performance in the relocation and map construction tasks.

4.4.2 Method

4.4.2.1 Design

There were two independent groups of subjects, one in each of the two experimental conditions. The two conditions were (i) providing subjects with a record of the cards accessed during the interaction and (ii) no record.

4.4.2.2 Subjects

The 12 subjects comprised members of the same population sample as that employed in the study described in section 4.2, but none of them had participated in either of the other two studies reported in this chapter. Equal numbers of subjects were randomly allocated to each of the experimental groups.

4.4.2.3 Materials

The text was an 8,300 word article about growing herbs. It was presented on a Macintosh II computer, and constructed in HyperCard. The article was divided between 48 cards, each of which contained a maximum of 17 lines of 12-point Geneva font text. As for the studies reported in sections 4.2 and 4.3, movement through the text was by means of 'buttons' within cards. The contents card was interactive, so that subjects were able to select a text card directly from it, and showed a graphical representation of the document's structure. A footprint took the form of a small marker cross by the last text card seen, and for the record of cards accessed, the titles of those card which had been opened were shown in reverse video (see figure 4.6). The materials for the map construction task were produced as described in section 4.2.2.3.
4.4.2.4. Procedure

Subjects were first asked to perform a pre-experiment map construction task, as described in section 4.3.2.4. They were then given eight minutes in which to familiarize themselves with the structure and contents of the article (this time limit was taken from a mean reading time determined from pilot studies), and the record of cards accessed was then cleared. Following this, subjects were shown the article again, and asked to locate from within it as many references as they could find to each of four herbs. Each herb name occurred five times within the document, but subjects were merely told that each was mentioned more than once. The presentation order of the questions was randomized between subjects, and the four herb names were printed on separate pieces of paper. Subjects recorded references to the items by highlighting the relevant sections of text. When they had finished answering a question, subjects were required to click on the "Next Question" button. This took them back to the contents card ready to begin answering the next question in the series, but it is important to note that the record of cards accessed was not cleared between questions. The remainder of the experimental procedure was as described in section 4.3.2.4.
4.4.3 Results

4.4.3.1 Number of finds

Providing subjects with a record of the cards accessed during the question-answering task had no significant influence on the number of target items located ($t_{10df} = -1.39, p > 0.05$) (see table 4.9).

<table>
<thead>
<tr>
<th>Record</th>
<th>No record</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>13.00</td>
</tr>
<tr>
<td>SD</td>
<td>3.03</td>
</tr>
</tbody>
</table>

Table 4.9. Mean number of finds made in each condition (max = 18)

However, when the scores for the first question per subject were analysed, it was found that the provision of such a record did have a significant effect on the number of finds made ($t_{10df} = -7.89, p < 0.001$) (see table 4.10).

<table>
<thead>
<tr>
<th>Record</th>
<th>No record</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>4.67</td>
</tr>
<tr>
<td>SD</td>
<td>0.82</td>
</tr>
</tbody>
</table>

Table 4.10. Mean number of finds for the first question per subject

4.4.3.2 Cards per find

Providing readers with a record of the cards accessed had no significant influence on the number of cards opened per find ($t_{10df} = 2.03, p > 0.05$) (see table 4.11), but again there was a significant difference in performance between the conditions when the data for the first question per subject was analysed ($t_{10df} = 5.81, p < 0.001$) (see table 4.12).

<table>
<thead>
<tr>
<th>Record</th>
<th>No record</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>13.18</td>
</tr>
<tr>
<td>SD</td>
<td>3.42</td>
</tr>
</tbody>
</table>

Table 4.11. Mean number of cards opened per find in each condition

<table>
<thead>
<tr>
<th>Record</th>
<th>No record</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>9.79</td>
</tr>
<tr>
<td>SD</td>
<td>2.21</td>
</tr>
</tbody>
</table>

Table 4.12. Mean number of cards per find for the first question per subject
4.4.3.3 Time per find

Target items were located significantly more quickly when subjects were shown a record of the cards which they had accessed than when they were not (t \[10df\] = 2.83, p < 0.05) (see table 4.13).

<table>
<thead>
<tr>
<th>Record</th>
<th>No record</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>13.92</td>
</tr>
<tr>
<td>SD</td>
<td>11.69</td>
</tr>
</tbody>
</table>

Table 4.13. Mean time per find (in seconds)

4.4.3.4 Map construction task

The gain in accuracy between pre- and post-experiment maps of the document’s structure produced by subjects was significantly greater when they were provided with a record of the cards which they had accessed than when they were not (t \[10df\] = 4.84, p < 0.01) (see table 4.14).

<table>
<thead>
<tr>
<th>Record</th>
<th>No record</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>14.00</td>
</tr>
<tr>
<td>SD</td>
<td>2.10</td>
</tr>
</tbody>
</table>

Table 4.14. Mean gain in scores between pre- and post-experiment maps

4.4.3.5 Correlations

Significant negative correlations were found between (i) the number of finds and cards opened per find (r = -0.84, p < 0.01), and (ii) cards per find and the gain in map scores (r = -0.88, p < 0.001). Significant positive correlations were found between (i) time per find and cards opened per find (r = 0.66, p < 0.05), and (ii) map score gains and number of finds (r = 0.65, p < 0.05).

4.4.4 Discussion

As noted in section 4.4.2.4, the record of cards accessed was not cleared between questions, because it had been assumed that subjects may have noticed references to later target items while searching for the current one. In this case, a record of the cards accessed for previous questions would have been of utility for later ones. The data indicated that providing subjects with a record of the cards which they had accessed did not have a significant influence on the total number of finds made during the question-answering task, although more finds were made in the record condition (mean = 13.00) than in the non-record one (mean = 10.83). However, when the scores for the first
question per subject were analysed, significantly more finds were made by readers who were shown a record of the cards accessed for that particular question.

Similarly, there was no significant difference between the two conditions in the number of cards opened per find, although performance was again superior in the record condition (mean = 13.18), than in the non-record one (mean = 17.10). But for the first question per subject, significantly fewer cards were opened per find in the record condition than in the non-record one, with a large differences between the means being found (9.79 and 20.75). These findings, together with comments made by subjects, suggest that readers would have found the record of cards accessed of greater benefit if it had been cleared between questions, so that only those cards visited for the current question were flagged. The construction of the document employed in the study was such that it was quite possible that target items for different questions could have been located on the same cards, but for different types of text, and indeed tasks, the same recommendation may not apply.

Subjects who were provided with a record of the cards accessed located target items significantly more quickly than those who were not. In view of the fact that there was a positive correlation between the time per find and the number of the cards accessed per find, it would appear that all subjects spent a similar amount of time searching for target information on a card once it had been opened.

The finding that the gain between pre- and post-experiment map scores was higher for subjects shown a record of the cards accessed than for those who were not supports the proposition that a reduction in the number of cards unintentionally revisited enabled readers to form a more accurate mental map of a document’s structure.

Finally, the positive correlation between the number of finds and map score gains and the negative correlation between cards per find and map score gains again indicates that the accuracy of a reader’s mental map of a document’s structure has an important influence on navigation efficiency.

4.4.5 Conclusion

The results of the study reported in this section indicated that showing readers which sections of a document they had accessed was of benefit for an information relocation task and it also helped them to form an accurate map of a hypertext’s structure.
4.5 GENERAL DISCUSSION

There are a several more general points which should be mentioned in relation to the studies reported in this chapter. First, it is recognized that some of the search tasks could perhaps have been better performed using a keyword search facility. Subjects were not permitted to use this because the experiments were intended to examine their ability to navigate through the document. Furthermore, it has been shown that readers often have difficulty in using search facilities, even when these are provided (see Richardson et al., 1988). Second, in measuring efficiency of information location, these studies have adopted Elm and Woods' (1985) definition of being lost as

"a decrease in the ability to extract the information needed to successfully perform domain tasks, rather than by subjective feelings of being lost" (p.927).

However, it is not clear that performance and subjective measures may be considered in isolation. In an experimental situation, subjects use a system to perform certain tasks because they are asked to do so, but outside of such a setting circumstances are very different. If readers are frequently lost, then they will become frustrated and cease to use the system, in which case "information needed to successfully perform domain tasks" will not be found. Consequently, subjective feelings of being lost cannot be totally disregarded — they may have an important influence on the reader's interaction with the system.

Finally, the studies examined readers' navigation through, and ability to construct maps of, hierarchical hypertexts. This may not be the most appropriate structure for all types of documents, and different methods of assisting readers to navigate through non-hierarchical hypertexts may be required.

4.6 GENERAL CONCLUSION

The findings of the three studies reported in this chapter suggested that a number of features may assist readers in both navigating through, and forming a mental map of, a hierarchically structured hypertext. The studies were sequential, in that those features found to be beneficial in one study were retained for all conditions in the next. The contents card found to be of greatest benefit in the third study was as follows:

The representation of the document's structure was graphical and interactive. It contained a footprint, showing the reader which text card he had just seen, and a record of the cards accessed was also provided.
As stated above, a hierarchy is only one possible structure for a hypertext document, and the main focus of chapter five is on navigation in web structured hypertexts.
CHAPTER FIVE

NAVIGATION IN NON-HIERARCHICAL HYPERTEXTS AND THE UTILITY OF TEMPORAL SEQUENCE INFORMATION

5.1 INTRODUCTION

The studies reported in the previous chapter were all concerned with readers’ navigation through, and ability to construct maps of, hierarchical hypertexts, but this may not be the most appropriate structure for all types of documents or databases. It was therefore decided to examine the utility of those facilities which were found to be of benefit for readers of hierarchically structured hypertext documents when applied to hypertext documents of a non-hierarchical structure. However, although the actual structure of a paper document may be more complex (through the use of cross-references, etc.), its explicit structure is frequently hierarchical – shown by chapters, headings and subheadings. Consequently, as a result of their experiences in the paper medium, readers are more familiar with hierarchical documents, and may possibly have difficulty in forming a mental map of a non-hierarchical one.

In the first two studies reported in the present chapter, with the exception of the hierarchical contents list vs. alphabetical index and typographical cues (which could not be applied to a non-hierarchical document), the influence of the same variables on users’ performance were investigated as in the previous chapter. The contents cards for these two studies using non-hierarchical documents were interactive, on the grounds that (i) this takes advantage of the facilities offered by the electronic medium, and (ii) even when told that this was not possible, those subjects who had used the non-interactive contents card in the experiment reported in section 4.3 had frequently attempted to select text cards directly from the contents card, becoming frustrated when they were unable to do so. As in chapter four, the studies were sequential, in that those features found to be of significant benefit in the first study were retained for all conditions in the second study.

5.2 STUDY ONE

5.2.1 Introduction

In the first experiment, the possible utility of a graphical, as compared to a textual, representation of the document’s structure was examined. In chapter four, it had been
found that showing readers a graphical representation of a hierarchical hypertext’s structure significantly improved performance in both a relocation and map construction task, and it was predicted that the same pattern of results would be obtained using a non-hierarchical document. The second variable explored in the first study in the present chapter was the addition of a footprint to the contents card. Although the data from the studies in chapter four had not presented a clear picture, it was concluded that the provision of a footprint did help readers to navigate through, and construct a map of, a hierarchical hypertext. It was also suggested that such a facility may be of greater benefit for a non-hierarchical document. The second aim of the study reported in this section, therefore, was to determine whether a footprint was of significant benefit to readers of non-hierarchical hypertexts.

The hypotheses examined were that:

1. Navigation through the document would be more efficient, and the increase in the accuracy between pre- and post-experiment maps of its structure would be greater, when using a graphical, as compared to a textual, representation of the structure.

2. The provision of a footprint would enhance structural knowledge and navigation efficiency.

3. There would be a positive correlation between the ability to produce an accurate map of a document’s structure and the ability to navigate through the document.

5.2.2 Method

5.2.2.1 Design

The design was a completely randomized 2 x 2 ANOVA. The two levels of factor one were a textual representation of the document’s structure (see figure 5.1) and a graphical representation (see figure 5.2), and the two levels of factor two were footprint (see figure 5.2) and none.

5.2.2.2 Subjects

The 12 subjects comprised students from the Department of Human Sciences at Loughborough University, none of whom had participated in any of the previous studies. Their ages ranged between approximately 19-25 years, and all of the subjects had some experience in using a Macintosh computer. Equal numbers of subjects were randomly allocated to each of the experimental conditions.
Figure 5.1. Textual representation

Figure 5.2. Graphical representation with a footprint
5.2.2.3 Materials

The text was an 4,900 word article containing various facts about coffee (growing, processing, production, etc.). The presentation method was as described in section 4.4.2.3, except that there were 53 text cards in the experiment reported here. Subjects were able to move through the text either by clicking on 'buttons' within cards (see section 4.2.2.3), or by selecting a card title from the contents card. In the conditions in which a footprint was provided, the title of the text card the reader had just come from was shown in reverse video on the contents card. The materials for the map construction task were produced as described in section 4.2.2.3.

5.2.2.4 Procedure

Subjects were first asked to perform a pre-experiment map construction task (see section 4.3.2.4), being told that the document was not hierarchically structured. They were then allowed eight minutes in which to familiarize themselves with the structure and contents of the article (this time limit was taken from a mean reading time determined from pilot studies). Following this, subjects were shown the article again, and given eight questions, each requiring them to locate specific details from within the text (e.g., "Where does it mention replacing rubber seals?"). The presentation order of the questions was randomized between subjects, and each question was printed on a separate piece of card. Questions were answered by highlighting the relevant text with the mouse cursor. When they had finished answering a question, subjects were required to click on the "Next Question" button. This took them back to the contents card ready to begin answering the next question in the series. The remainder of the experimental procedure was as described in section 4.3.2.4.

5.2.3 Results

5.2.3.1 Number of questions correctly answered

A 2 x 2 ANOVA (graphical/textual x footprint/none) indicated there to be main effects of both of these variables on the number of targets located in the question-answering task (see table 5.1). Significantly more targets were located by subjects shown a graphical representation of the document's structure (mean = 7.84) than by those shown a textual one (mean = 6.00) ($F_{1,8} = 40.36, p < 0.001$), and more questions were correctly answered by readers who were provided with a footprint (mean = 7.34) than by those who were not (mean = 6.50) ($F_{1,8} = 8.36, p < 0.05$).
Table 5.1. Mean number of targets located in each condition (max = 8)

<table>
<thead>
<tr>
<th></th>
<th>Graphical representation</th>
<th>Textual representation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Footprint</td>
<td>No footprint</td>
</tr>
<tr>
<td>Mean</td>
<td>8.00</td>
<td>7.67</td>
</tr>
<tr>
<td>SD</td>
<td>0.00</td>
<td>0.47</td>
</tr>
</tbody>
</table>

5.2.3.2 Cards accessed per correctly answered question

The number of cards accessed per correctly answered question was calculated, and a 2 x 2 ANOVA was performed on the resulting scores. A main effect of representation type was found on this measure ($F_{[1,8]} = 6.31, p < 0.05$) (see table 5.2), with significantly fewer cards being accessed by subjects using a graphical representation than by those using a textual one (means = 11.53 and 15.32).

Table 5.2. Mean number of cards accessed per correctly answered question in each condition

<table>
<thead>
<tr>
<th></th>
<th>Graphical representation</th>
<th>Textual representation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Footprint</td>
<td>No footprint</td>
</tr>
<tr>
<td>Mean</td>
<td>10.51</td>
<td>12.54</td>
</tr>
<tr>
<td>SD</td>
<td>2.61</td>
<td>2.46</td>
</tr>
</tbody>
</table>

5.2.3.3 Time per correctly answered question

A 2 x 2 ANOVA indicated there to be a main effect of the footprint variable on the time taken to locate targets for correctly answered questions ($F_{[1,8]} = 6.28, p < 0.05$) (see table 5.3). Targets were found more quickly when a footprint was provided (mean time per question = 95.70 seconds) than when it was not (mean time per question = 139.82 seconds).

Table 5.3. Mean latency for correctly answered questions in each condition (in seconds)

<table>
<thead>
<tr>
<th></th>
<th>Graphical representation</th>
<th>Textual representation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Footprint</td>
<td>No footprint</td>
</tr>
<tr>
<td>Mean</td>
<td>95.24</td>
<td>120.52</td>
</tr>
<tr>
<td>SD</td>
<td>35.66</td>
<td>23.85</td>
</tr>
</tbody>
</table>

5.2.3.4 Map construction task

A 2 x 2 ANOVA showed there to be main effects of both representation type and the availability of a footprint on the increase in accuracy between pre- and post-experiment scores for the map construction task (see table 5.4). The gain in scores was higher when subjects were shown a graphical representation of the document's structure (mean = 7.50) than when they were shown a textual one (mean = 2.00) ($F_{[1,8]}$
= 98.64, p < 0.001), and higher when a footprint was provided (mean = 6.67) than when it was not (mean = 2.84) (F[1,8] = 47.91, p < 0.001).

### 5.2.3.5 Correlations

A significant positive correlation was found between the gain in map scores and the number of questions correctly answered (r = 0.87, p < 0.001), and significant negative correlations between (i) the gain in map scores and the mean number of cards accessed per correctly answered question (r = -0.60, p < 0.05), and (ii) the number of questions correctly answered and the mean number of cards accessed per correctly answered question (r = -0.65, p < 0.05).

<table>
<thead>
<tr>
<th>Graphical representation</th>
<th>Textual representation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Footprint</td>
<td>No footprint</td>
</tr>
<tr>
<td>Mean</td>
<td>10.00</td>
</tr>
<tr>
<td>SD</td>
<td>0.82</td>
</tr>
</tbody>
</table>

Table 5.4. Mean increase in scores between pre- and post-experiment maps in each condition

### 5.2.4 Discussion

#### 5.2.4.1 Representation type

The first hypothesis, that showing readers a graphical representation of a non-hierarchical hypertext document's structure would significantly improve performance in both a relocation and map construction task was supported. Significantly more questions were answered correctly and fewer cards were accessed for each correctly answered question by subjects using a graphical representation, as compared to a textual one. In addition, although the difference was not significant, subjects in the former condition located targets for correctly answered questions faster (mean time = 95.47 seconds) than those in the latter condition (mean = 139.82 seconds). Finally, the increase in accuracy between pre- and post-experiment maps of the document's structure was significantly higher when readers were shown a graphical representation of the document's structure than when they were shown a textual one.

It would therefore appear that, in the same way as they do for hierarchically structured hypertext documents, readers form mental maps of non-hierarchically structured ones. The graphical representation more closely matched their own internal model of the document's structure, and so was of greater benefit than a textual one. Charmey (1987) suggests that a graphical display of an information structure may provide an explicit guideline for an internal representation of the structure if it is strictly hierarchical, but
the results of the investigation reported here indicate that this is also the case for a non-
hierarchical structure.

5.2.4.2 Footprint

The second hypothesis was that the addition of a footprint to the contents card would
assist readers in a relocation and a map construction task. It was found that the
provision of a footprint both increased the number of questions correctly answered and
reduced the time taken to locate targets for correctly answered questions. Although not
reaching significance, fewer cards were accessed per correctly answered question when
a footprint was shown (mean = 12.82), than when it was not (mean = 14.03). In
addition, the gain in map scores was significantly higher when subjects were provided
with a footprint. The results of the investigation described in section 4.3 indicated that
the provision of a footprint was only of significant benefit to readers using a non-
interactive contents card. However, the data obtained from the study reported here
would suggest that a footprint is of significant utility for readers of non-hierarchically
structured hypertext documents which have an interactive contents card. One possible
explanation for this finding may be that readers are more familiar with using
hierarchical documents, from their knowledge of the paper medium, but they are not
experienced in interacting with non-hierarchical ones. Consequently, additional
navigation support is of greater benefit for the latter type of document structure.

5.2.4.3 Correlations

The findings that there were a significant positive correlation between the gain in map
scores and the number of questions correctly answered, and a significant negative
correlation between the gain in map scores and the mean number of cards accessed per
correctly answered question indicates that, as for hierarchically structured hypertexts,
the accuracy of the reader's mental model (as indicated by their externalization) of a
non-hierarchical hypertext's structure is an important determinant of navigation
efficiency.

5.2.5 Conclusion

The study reported in this section examined the influence of two variables on readers' ability to relocate information from within, and construct an accurate map of, a non-
hierarchical hypertext document. It was found that (i) performance in both a relocation
and map construction task was superior when subjects were provided with a graphical
representation of the document's structure, (ii) the addition of a footprint to the contents
card was of significant benefit for both tasks, and (iii) performance in the relocation
task was positively correlated with the increase in accuracy between pre- and post-experiment maps of the document's structure produced by subjects.

5.3 STUDY TWO

5.3.1 Introduction

The first variable examined in the second study reported in this chapter was the provision of a record of the cards which subjects had accessed during a reading session. In chapter four, it was found that when such a record was only derived from their response to the current relocation question, it did help readers to relocate information from within, and construct an accurate map of, a hierarchical hypertext document. The first aim of the present study was to determine whether a record of cards accessed was of significant benefit to readers of a non-hierarchical hypertext document.

In the hierarchically structured documents employed in chapter four, all of the links between the cards were bidirectional (i.e., from parent to child and vice versa). However, for the non-hierarchical documents used in the present chapter, some of the links were unidirectional. According to Canter (1984), a person's understanding of how he travelled between his present and previous locations is particularly important for navigation purposes. Consequently, the second variable examined in the study reported in this section was indicating the direction of the links between the text cards. It was proposed that this information, especially when combined with a record of the cards accessed, would enhance the readers' knowledge of how they travelled between the cards.

The hypotheses examined were that:

1. Navigation through the document would be more efficient, and the increase in accuracy between pre- and post-experiment maps of its structure would be greater, if readers were provided with a record of the cards which they had accessed.

2. Navigation through the document would be more efficient, and the gain in map scores would be greater, if the direction of the links between the cards was indicated on the map.

3. There would be a significant positive correlation between performance in the relocation and map construction tasks.
5.3.2 Method

5.3.2.1 Design

The design was a completely randomized 2 x 2 ANOVA. The two levels of factor one were providing a record of the cards accessed during the interaction (see figure 5.3) and no record, and the two levels of factor two were indicating the direction of the links between the cards (see figure 5.4) and not.

5.3.2.2 Subjects

The 12 subjects were from the same population sample as that employed in the previous study, but none of them had participated in any of the other experiments reported in this thesis. Equal numbers of subjects were randomly allocated to each of the experimental conditions.

5.3.2.3 Materials

The text was an 3,250 word article about tea (types, growing, preparation, etc.). The presentation method was as described in section 4.4.2.3, except that there were 31 text cards. Subjects were able to move through the text either by clicking on 'buttons' within cards (see section 4.2.2.3), or by selecting a card title from the contents card,
which showed a graphical representation of the document’s structure. The footprint was a small marker cross by the title of the last text card seen, the titles of the text cards which had been accessed were shown in reverse video on the contents card, and the direction of the links between the cards was indicated by arrows. The materials for the map construction task were produced as described in section 4.2.2.3.

![Diagram of link direction, record of cards accessed and footprint](image-url)

Figure 5.4. Link direction, record of cards accessed and footprint

### 5.3.2.4 Procedure

Subjects were first asked to perform a pre-experiment map construction task (see section 4.3.2.4). They were then given five minutes in which to familiarize themselves with the structure and contents of the article (this time limit was taken from a mean reading time determined from pilot studies) and the record of cards accessed was cleared. Following this, subjects were shown the article again, and given eight questions, each requiring them to locate specific details from within the text (e.g., “Where does it talk about aluminium foil?”). The presentation order of the questions was randomized between subjects, and each question was printed on a separate piece of card. The remainder of the experimental procedure was as for the study reported in section 5.2, except that in the present experiment (unlike that described in section 4.4), the record of the cards accessed was cleared between questions.
5.3.3 Results

5.3.3.1 Number of questions correctly answered

A 2 x 2 ANOVA (record vs. none x direction indicators vs. none) showed there to be main effects of both of these variables on the number of questions correctly answered. (Record: $F_{[1,8]} = 32.00, p < 0.001$; Direction: $F_{[1,8]} = 72.00, p < 0.001$). However, the interaction between the two factors was also significant ($F_{[1,8]} = 18.00, p < 0.01$) (see table 5.5). Further analysis revealed that the significant differences were between the following pairs of conditions (i) no record without direction indicator vs. record without direction indicator, (ii) no record without direction indicator vs. no record with direction indicator, and (iii) no record without direction indicator vs. record with direction indicator ($T_{0.05} = 1.53$).

<table>
<thead>
<tr>
<th>Record of cards accessed</th>
<th>No record</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direction</td>
<td>None</td>
</tr>
<tr>
<td>Mean</td>
<td>8.00</td>
</tr>
<tr>
<td>SD</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Table 5.5. Mean number of targets located in each condition (max = 8)

5.3.3.2 Cards accessed per correctly answered question

A 2 x 2 ANOVA indicated there to be main effects of both providing a record of the cards opened ($F_{[1,8]} = 29.52, p < 0.001$) and showing the direction of the links between cards ($F_{[1,8]} = 36.37, p < 0.001$) on the mean number of cards accessed per correctly answered question. However, the interaction between the two factors was also significant ($F_{[1,8]} = 9.60, p < 0.05$) (see table 5.6), with the significant differences again being between the no record with no direction indicator condition and each of the other three conditions ($T_{0.05} = 6.98$).

<table>
<thead>
<tr>
<th>Record of cards accessed</th>
<th>No record</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direction</td>
<td>None</td>
</tr>
<tr>
<td>Mean</td>
<td>3.71</td>
</tr>
<tr>
<td>SD</td>
<td>0.78</td>
</tr>
</tbody>
</table>

Table 5.6. Mean number of cards accessed per correctly answered question in each condition

5.3.3.3 Time per correctly answered question

A 2 x 2 ANOVA showed there to be main effects of both variables on the time taken to locate targets for correctly answered questions (see table 5.7). Targets were located significantly more quickly when subjects were provided with a record (mean time per
question = 67.70 seconds) than when they were not (mean time per question = 86.94 seconds) \( (F_{1,8} = 6.20, p < 0.05) \), and more quickly when the direction of the links was indicated (mean time per question = 58.51 seconds) than when it was not (mean time per question = 96.12 seconds) \( (F_{1,8} = 23.68, p < 0.01) \).

![Table 5.7](image)

<table>
<thead>
<tr>
<th>Record of cards accessed</th>
<th>No record</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direction</td>
<td>None</td>
</tr>
<tr>
<td>Mean</td>
<td>47.72</td>
</tr>
<tr>
<td>SD</td>
<td>1.19</td>
</tr>
</tbody>
</table>

Table 5.7. Mean location time per question for correctly answered questions in each condition (in seconds)

### 5.3.3.4 Map construction task

An analysis of the difference between pre- and post-experiment map scores showed there to be a main effect of the record variable \( (F_{1,8} = 8.64, p < 0.05) \) and the direction indicator variable \( (F_{1,8} = 13.07, p < 0.01) \) on this measure (see table 5.8). The gain in map scores was greater when a record of the cards accessed was provided (mean = 11.39) than when it was not (mean = 5.33), and greater when the direction of the links between the cards was shown (mean = 9.50) than when it was not (mean = 7.15).

![Table 5.8](image)

<table>
<thead>
<tr>
<th>Record of cards accessed</th>
<th>No record</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direction</td>
<td>None</td>
</tr>
<tr>
<td>Mean</td>
<td>12.67</td>
</tr>
<tr>
<td>SD</td>
<td>0.47</td>
</tr>
</tbody>
</table>

Table 5.8. Mean increase in scores between pre- and post-experiment maps in each condition

### 5.3.3.5 Correlations

A significant positive correlation was found between the gain in map scores and the number of questions correctly answered \( (r = 0.67, p < 0.05) \). There were significant negative correlations between (i) the number of questions correctly answered and the time per correctly answered question \( (r = -0.77, p < 0.01) \), (ii) the number of questions correctly answered and the number of cards accessed per correctly answered question \( (r = -0.71, p < 0.01) \), (iii) the gain in map scores and the time per correctly answered question \( (r = -0.70, p < 0.05) \), and (iv) the gain in map scores and the number of cards accessed per correctly answered question \( (r = -0.77, p < 0.01) \).
5.3.4 Discussion

5.3.4.1 Record of cards accessed

It was hypothesized that showing readers of a non-hierarchical hypertext which cards they had accessed while answering a relocation question would be of significant benefit, and the data obtained from the study reported here supported this hypothesis. Significantly more questions were answered correctly, fewer cards were accessed per correctly answered question, and targets for correctly answered questions were located significantly more quickly when a record of cards accessed was shown. In addition, the gain in scores between pre- and post-experiment maps of the document’s structure was greater when such a record was provided. It would therefore appear that this facility is as valuable for readers of non-hierarchically structured hypertexts as the results of the study reported in section 4.4 indicated it to be for readers of hierarchical hypertext documents.

5.3.4.2 Direction of links

The second hypothesis was that showing the direction of the links between cards would be of significant benefit to readers, because it enhanced their understanding of how they travelled between the text nodes. This hypothesis was supported, with significantly superior performance being found in both the relocation and map construction tasks. In addition, the record by direction indicator interactions obtained for (i) the number of questions correctly answered and (ii) the number of cards accessed per correctly answered question measures indicated that performance was significantly inferior when neither a record of cards accessed or the direction of the links between cards was shown. Furthermore, although the difference was not significant, it should be noted that performance in the relocation task and the gain in map scores was superior when readers were provided with both a record and direction indicators. The data obtained from the present investigation therefore indicate that when readers have information concerning where they have been within a document, and how they travelled between the different locations, navigation and map formation are both enhanced.

5.3.4.3 Correlations

The results of the present experiment again indicated that the accuracy of a reader’s mental map of a hypertext’s structure has a significant influence on his ability to navigate through the document efficiently. The increase in accuracy between pre- and post-experiment maps produced by subjects was negatively correlated with both the
time taken to locate targets for correctly answered questions and the number of cards accessed per correctly answered question.

5.3.5 Conclusion

The study reported in this section examined the influence of two variables on readers' ability to relocate information from within, and construct an accurate map of, a non-hierarchically structured hypertext document. The data obtained indicated that (i) providing readers with a record of the cards accessed significantly enhanced performance on both tasks, (ii) showing the direction of the links between cards significantly improved performance on both tasks, and (iii) the ability to relocate information was positively correlated with the gain in accuracy between pre- and post-experiment maps of the document's structure produced by subjects.

5.4 TEMPORAL SEQUENCE AND DOCUMENT NAVIGATION

5.4.1 Introduction

There is evidence to suggest that temporal information is, like spatial information, incidentally encoded (e.g., Hintzman and Block, 1973; Proctor and Ambler, 1975). A number of writers have proposed that memory for textual material comprises a constellation of attributes (e.g., Underwood, 1969), and it may be that, in the same way as spatial information has been shown to facilitate content recall and vice versa (e.g., Rothkopf, 1971), so the provision of temporal sequence information may facilitate the recall of spatial location.

Showing readers the order in which text cards have been accessed may also be of benefit in that it further enhances their understanding of how they travelled between locations within the document (see section 5.1). An additional benefit of such a feature is that it indicates which cards have been visited more than once during an interaction, whereas the record of cards accessed depicted on the map (as described the previous study) does not provide this information. Showing readers in which order they accessed nodes of text helps to answer the question “Where was I when I saw...?”

Rothkopf concluded that text-sequence location is incidentally encoded, and may act as a retrieval cue in a linearly structured text. In a later study, Christie and Just (1976) found that readers of a disordered text were able to use the order in which the information appeared as a relocation cue. However, the texts were accessed
sequentially, and it is not clear whether it is the order in which the information is presented, or in which it is or accessed, that is the important factor.

As described in section 4.1.5, the second type of display in the study by Engel et al. (1983) was a map, or overview, of the primary information in the database, with the user's current position marked on it. Additional navigation information was provided by a list of the numbers of the successively selected pages, showing the reader a history of his path through the document. This list was interactive, so that the user was able to move a pointer backwards and forwards in it to select a destination screen. The authors proposed that the information shown on the 'where' screen did help users to navigate through the database and to retrieve the desired information. However, little formal evaluation of the system was conducted. The main aim of the study reported in this section was to determine whether providing subjects with an ordered list of cards accessed would significantly enhance navigation efficiency, for both hierarchical and non-hierarchical hypertext documents.

As discussed in section 5.1, readers are more familiar with documents which have an explicitly hierarchical, as opposed to a non-hierarchical, structure, and the second aim of the study reported here was to compare readers' ability to relocate information from within documents of both structures.

The hypotheses examined were that:

1. Performance in a relocation task would be superior if subjects were provided with temporal sequence information.

2. Performance in a relocation task would be superior using a hierarchically structured document as compared to a non-hierarchically structured one.

5.4.2 Method

5.4.2.1 Design

The design was a completely randomized 2 x 2 ANOVA. The two levels of factor one were the provision of temporal sequence information and none, and the two levels of factor two were a hierarchically structured and a non-hierarchically structured document (see figures 5.5 and 5.6).
Figure 5.5. Temporal sequence information in a hierarchical structure

Figure 5.6. Temporal sequence information in a non-hierarchical structure
5.4.2.2 Subjects

The 40 subjects were members of the same population sample as that employed in the previous experiment, but none of them had participated in any of the earlier studies. Equal numbers of subjects were randomly allocated to each of the experimental conditions.

5.4.2.3 Materials

The texts were 4,500 word articles about herbs (adapted from the document employed in the study described in section 4.4). The card titles were the same for both document structures, but the content of the cards was altered very slightly between the two conditions in order for the appropriate links to be made. There were the same number of links (21) for both document structures. The presentation method was as described in section 4.4.2.3, except that there were 31 cards. Subjects were able to move through the text either by clicking on 'buttons' within cards (see section 4.2.2.3), or by selecting a card title from the contents card. The footprint, record of cards accessed and direction indicators were as reported in section 5.3.5.3. For the temporal sequence information, a non-interactive scrolling field was displayed down the right-hand side of the contents card. Each time a subject accessed a card, its title was added to the bottom of the field. The materials for the map construction task were produced as described in section 4.2.2.3.

5.4.2.4 Procedure

The procedure was as reported in section 5.3.2.4, with 10 location questions, such as “Where does it talk about swollen, twisted shoots?”.

5.4.3 Results

5.4.3.1 Number of questions correctly answered

A 2 x 2 ANOVA (temporal sequence vs. none x document structure) indicated there to be main effects of both variables on the number of questions correctly answered (see table 5.9). Significantly more targets were located when subjects were provided with temporal sequence information (mean = 8.65) than when they were not (mean = 6.25) (F[1,36] = 48.81, p < 0.001), and more targets were located by subjects using the hierarchical document (mean = 7.90) than by those using the non-hierarchical one (mean = 7.00) (F[1,36] = 6.86, p < 0.05).
5.4.3.2 Cards accessed per correctly answered question

A 2 x 2 ANOVA showed there to be main effects of both variables on the number of cards accessed per correctly answered question (see table 5.10). Significantly fewer cards were accessed per correctly answered question by subjects provided with temporal sequence information (mean = 3.93) than by those who were not (mean = 6.53) (F[1,36] = 18.69, p < 0.001), and by those using the hierarchical document (mean = 4.45) as compared to the non-hierarchical one (mean = 5.60) (F[1,36] = 5.49, p < 0.05).

<table>
<thead>
<tr>
<th>Hierarchical</th>
<th>Non-hierarchical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sequence</td>
<td>None</td>
</tr>
<tr>
<td>Mean</td>
<td>3.48</td>
</tr>
<tr>
<td>SD</td>
<td>1.48</td>
</tr>
</tbody>
</table>

Table 5.10. Mean number of cards accessed per correctly answered question in each condition

5.4.3.3 Time per correctly answered question

There was also a main effect of temporal sequence information on the time taken to locate targets for correctly answered questions (F[1,36] = 30.67, p < 0.001) (see table 5.11). Targets were located significantly more quickly when such information was provided than when it was not (mean times = 140.70 and 152.10 seconds).

<table>
<thead>
<tr>
<th>Hierarchical</th>
<th>Non-hierarchical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sequence</td>
<td>None</td>
</tr>
<tr>
<td>Mean</td>
<td>103.50</td>
</tr>
<tr>
<td>SD</td>
<td>12.44</td>
</tr>
</tbody>
</table>

Table 5.11. Mean location time per question for correctly answered questions in each condition (in seconds)

5.4.3.4 Correlations

A significant positive correlation was found between the time taken to locate targets and the number of cards accessed per question for correctly answered questions (r = 0.78, p < 0.01). Significant negative correlations were found between (i) the number of correctly answered questions and the number of cards accessed per correctly answered question.
question \( r = -0.72, p < 0.05 \), and (ii) the number of correctly answered questions and the time taken to locate the targets for correctly answered questions \( r = -0.71, p < 0.05 \).

5.4.4 Discussion

5.4.4.1 Temporal sequence information

The first hypothesis was that the provision of temporal sequence information would enhance performance in an information relocation task. This hypothesis was supported, with significantly more questions being correctly answered, more quickly, and with fewer cards opened per question, by subjects who were shown an ordered list of cards accessed. It would therefore appear that supplementing the past route information provided by the reverse video on the map of the document's structure with temporal sequence information was of significant benefit to readers. While the former facility gave subjects cues which enabled them to exploit incidental memory for spatial location, the ordered list provided cues which exploited another incidentally encoded attribute of memory for text. In Engel et al.'s (1983) study, there was no past route information on the map, it only had a footprint marked on it. However, it is suggested that, for the reason mentioned above, a record showing the text nodes visited should be provided on the map itself, in addition to the ordered list, so that readers may utilize both spatial and temporal components of incidental memory for text.

5.4.4.2 Document structure

The second hypothesis was that performance in a relocation task would be superior for a hierarchically structured document, as compared to a non-hierarchical one. The data obtained also support this hypothesis. Significantly more questions were answered correctly, and fewer cards were accessed per correctly answered question, by subjects using a hierarchical document. Although the difference did not reach significance, targets for correctly answered questions were also located more quickly in the hierarchical document (mean time = 140.20 seconds) than in the non-hierarchical one (mean time = 152.10 seconds).

In view of the fact that there were the same number of cards and links for both documents, and the texts were almost identical, these findings would suggest that readers are able to navigate through a hierarchical hypertext more efficiently than through a non-hierarchical one. However, as discussed in section 5.1, an explicitly hierarchical document structure is familiar to readers from its use in the paper medium, but paper documents do not often have a structure which is explicitly non-hierarchical.
(although it is frequently implicitly so). It may therefore be that readers' performance was influenced by prior expectations and experiences, and not that a hierarchical structure is 'better' in any way. Further support for this proposition is that, even when they were told that it was not hierarchical, a number of subjects’ pre-experiment maps of the document's structure produced in the study reported in sections 5.2 and 5.3 were hierarchical.

Brown (1987) advocates that hypertext documents should have a strong hierarchical backbone, one of the reasons being that readers are less likely to get lost. However, the present author considers there to be evidence that readers are able to navigate through, and construct maps of, non-hierarchical documents. Although performance using hierarchically structured documents may appear to be superior, this is largely a result of previous experiences in the paper medium. Many types of documents are not hierarchically structured, and to attempt to impose such a structure on them loses one of the major benefits of hypertext – the ability to make the implicit structure of a document explicit. Furthermore, hypertext systems can obviously be used at the database level, as well as that of the individual document, and it may be inappropriate to place the content of the database into a hierarchical framework. The navigation issues at the database level are very similar to those encountered at the document level, and so it is important for designers to be aware of those facilities which may assist users in navigating through non-hierarchical hypertexts.

5.4.5 Conclusion

The study reported in this section examined the effect of providing readers with temporal sequence information on their ability to relocate information from within both hierarchically and non-hierarchically structured documents. It was found that (i) the addition of an ordered list of cards accessed was of significant benefit for a relocation task, and (ii) performance was superior using a hierarchically structured document. It was suggested that the latter finding may have been influenced by prior experiences in the paper medium.

5.5 GENERAL CONCLUSION

The first two studies reported in this chapter examined the influence of four variables on readers' ability to relocate information from within, and construct an accurate map of, a non-hierarchical hypertext document. It was found that performance in both a relocation and map construction task was superior when (i) subjects were provided with a graphical representation of the document's structure, (ii) a footprint was added to
the contents cards, (iii) a record of the cards accessed was provided, and (iv) the direction of the links between cards was shown. Performance in the relocation task was positively correlated with the increase in accuracy between pre- and post-experiment maps of the document's structure produced by subjects.

In the third study, it was found that (i) the addition of an ordered list of cards accessed significantly improved performance in a relocation task, using both hierarchical and non-hierarchical documents, and (ii) performance was superior using a hierarchically structured document. It was suggested that the latter finding may have been influenced by prior experiences in the paper medium.

The results of the studies reported in this chapter and the previous one are summarized in chapter six, and the findings are applied to the design of a hypertext journal article.
CHAPTER SIX

NAVIGATION IN A HYPERTEXT JOURNAL ARTICLE

6.1 INTRODUCTION

The studies reported in the previous two chapters have examined a number of facilities which may assist readers in navigating through, and forming a mental map of, both hierarchically and non-hierarchically structured hypertext documents. The documents employed in these investigations were of an encyclopaedic style, comprising fairly discrete units of information. In the present chapter, the findings of these earlier studies are summarized, and then those features which were found to be of assistance to readers are applied to a hypertext journal article.

6.2 NAVIGATION CUES IN HYPERTEXT DOCUMENTS

6.2.1 Hierarchical contents list vs. alphabetical index

The first variable investigated (for hierarchically structured documents only) was providing readers with a hierarchical contents list or an alphabetical index. As the hypertexts were hierarchically structured, an alphabetical index would clearly not map onto the actual structure of the document in the same way as would a hierarchical contents list. It was found that readers using a hierarchical contents list navigated through the text more efficiently, and produced more accurate maps of its structure, than readers using an alphabetical index. This would suggest that readers are able to use cues from a textual representation of a document’s structure to help them relocate information from within, and construct an accurate map of, the document.

6.2.2 Typographical cues

The second variable studied, again only for hierarchically structured documents, was the addition of typographical cues to a contents list or index. However, although an established convention in the paper medium, such a cue did not significantly improve performance for either the relocation or map construction task. One possible explanation for this may be that in paper documents the typographical cues are mirrored in the text itself (e.g., headings and subheadings), but there were no equivalent cues in the HyperCard titles, all of these being shown in the same text font and style. However, Hartley (1987) concluded that of the two types of cue used in a contents list,
typographical and spatial, the latter are more important. An alternative explanation for the present finding is, therefore, that readers relied upon the spatial cues provided in the contents list. Support for this hypothesis may be that performance by subjects using an index was inferior to that by those using a contents list. Although typographical cues were available in both conditions, spatial cues were only available in the list condition.

6.2.3 Footprint

In the first of the three studies examining the utility of providing a footprint on the contents card showing readers which text card they had just come from, such a facility was found to be beneficial for an initial reading task, but not for a question-answering or map construction task. In the second study, the provision of a footprint was of benefit for subjects using a non-interactive representation of the hypertext's structure. The documents employed in these two investigations were hierarchically structured, while the third study examined the utility of a footprint for non-hierarchically structured hypertexts. In this case, it was found that the provision of a footprint was of significant benefit to readers, for both a relocation and a map construction task.

Perhaps the most likely explanation for the finding of the second of these studies, that the provision of footprint was of significant benefit for readers using a non-interactive representation of the document's structure, but not for those using an interactive one, is as follows. It was more important for readers using a non-interactive representation to know which text card they had just come from, because the only route from the contents card was back to this text card, and the only way in which they could move through the document was by following the links on this card, which were shown on the contents card. In the interactive conditions, knowledge of the last text card seen was not so crucial, as readers were able to travel through the document by selecting a card directly from the contents card. It may be that the footprint was of benefit to readers of a non-hierarchically structured interactive document because such a structure is less familiar than a hierarchical one, the latter being more common in the paper medium.

6.2.4 Graphical vs. textual representation

In both a relocation and map construction task, performance by subjects provided with a graphical representation of the document's structure was superior to that by those using a textual one. This was found to be the case for hierarchical and non-hierarchical documents.

In the studies by Tombaugh et al. (1987), and that reported in section 3.5, when information was presented using a multi-window display, readers were able to
remember in which window the information was located, and to use this cue for its later retrieval. It did not appear to be necessary for the text within the window to always be visible, but it was sufficient that the title was visible, and that the window had a permanent location on the screen. It may be that the node titles in a graphical representation of a document's structure act in the same way as the window titles in these earlier studies — they are both labels representing blocks of text, and have a unique, spatially defined, location. Consequently, a graphical representation, with its use of spatial location, provides a more effective relocation cue than a textual representation.

The finding that subjects using a graphical representation of the document's structure were able to navigate through it more efficiently also supports the proposition made by a number of writers (e.g., Waller, 1985; Hammond and Allinson, 1987), that people construct mental maps of documents that they read. Subjects shown a graphical representation were able to navigate through the text better because this type of representation more closely matched the document's structure.

6.2.5 Interactive vs. non-interactive representation

In a hierarchical hypertext, information was located more efficiently, and the increase in accuracy between pre- and post-experiment maps was greater, when the representation was interactive.

As the subjects using an interactive representation were able to select a text card directly from the contents card, the superiority of this condition for the location task was not particularly surprising. However, the finding that an interactive representation of the document's structure helped readers to form a more accurate mental map than did a non-interactive representation was not as predicted. One possible explanation for this may be that subjects who were able to navigate through the document more efficiently (i.e., those using an interactive representation) were less confused about the structure of the document, opened fewer additional cards, and therefore formed a more accurate mental map of its structure.

For the reasons described in section 5.1, it was decided to make the contents cards interactive for both of the studies using non-hierarchical hypertext documents.

6.2.6 Record of cards accessed

It was found that, for both hierarchical and non-hierarchical hypertexts, showing readers which sections of a document they had accessed was of benefit for an
information relocation task and it also helped them to form an accurate map of a hypertext’s structure.

In much the same way that providing readers with cues to their present location is important for future navigation, so giving them cues concerning their past route through a document may be an important determinant of knowledge of present location:

“In considering the processes involved in knowing where you are, it is worth emphasizing that this knowledge would appear to be built upon knowledge of where you have been” (Canter, 1984, p.248).

Information was relocated more efficiently because the number of potential target cards was reduced, therefore helping readers to answer the question “Where have I been?”. In addition, readers of hypertexts are often unsure whether they have seen all of the document, and showing them a record of the cards that have been opened would clearly be of assistance in answering the question “Have I seen everything?”.

6.2.7 Direction of links

In the hierarchically structured documents employed in the studies reported in chapter four, the links between the text nodes were all bi-directional, but in the non-hierarchical documents, some of them were uni-directional. It was found that showing the direction of the links on the contents card significantly improved performance in both a relocation and a map construction task.

6.2.8 Temporal sequence information

Providing readers with temporal sequence information resulted in a significant improvement in their ability to relocate information from within hierarchically and non-hierarchically structured documents.

Rothkopf (1971) concluded that text-sequence location may act as a retrieval cue in a linearly structured text. In a later study, Christie and Just (1976) found that readers were able to use the order in which the information appeared as a relocation cue in a disordered passage. The results of the present studies suggest it is the order in which information is accessed, rather than any sequence suggested by the document, which is the important cue.

The finding that the addition of an ordered list of the cards which readers had accessed was of significant benefit also supports Canter’s (1984) hypothesis, that a person’s knowledge of their earlier location is linked to their knowledge of their present location
by an understanding of how they travelled between the locations. It would therefore appear that temporal sequence information enhanced the reader's understanding of how he travelled between the nodes of text in a hypertext document.

6.2.9 Design recommendations

The findings described in the previous sections would suggest that the representation of a hypertext document's contents should provide readers with the following facilities:

1. It should be interactive.
2. The representation should be graphical.
3. There should be a footprint on it, showing the reader which text node they have just come from.
4. A record of the text nodes which have been accessed should be provided.
5. The direction of the links between the nodes should be shown.
6. Readers should be provided with temporal sequence information.

6.3 A HYPERTEXT JOURNAL ARTICLE

6.3.1 Introduction

A paper academic journal article is frequently hierarchical in structure, especially if it is arranged in the 'conventional' sections of abstract, introduction, method, results, etc., these sections often being divided into subsections. There are a number of reasons for preserving the structure of the paper journal article in the electronic medium.

First, the structure of the academic journal article mirrors that of the research process itself:

"....in the case of the scientific journal article reporting the results of some experiment, the linear structure of the components of the article can be seen to map onto the structure of science itself. The typical empirical article will contain an introduction in which the relevant literature is reviewed, a statement of the aims of the experiment, a description of the method and results, a discussion of the results and a conclusion. This mirrors the process of scientific endeavour whereby the experimenter, on the basis of previous work, formulates a question or hypothesis, designs and conducts an experiment in order to test the hypothesis, and finally attempts to relate the results to the existing corpus of knowledge" (McKnight, 1990, p.289).

Although it is important to note that, as the author says, this does not necessarily reflect the way in which the article is accessed by the reader.
Second, McKnight et al. (1990b) discuss two studies by Dillon (1989), in which subjects were found to have an accurate model of the structure of a typical journal article, which permits them to judge whereabouts particular information may be located. Marchionini (1989b) defines a mental model in the following way:

"In general, a mental model is a cognitive representation of a problem situation or system which is active in the sense that it can take inputs from the external world and return predictions of the effects for those inputs. It can be 'run' to allow predictions which then determine what actions should be taken. Mental models serve the dual purpose of representing entities and relationships which are refreshed and extended by experience, and simulating the possible effects of acting on these entities and relationships" (p.56).

Third, it has been shown that people rarely read journal articles in a sequential manner (e.g., Dillon et al. 1988), but adopt different strategies according to their reason for accessing the article. An academic journal article is used for a variety of purposes, for example, skimming though an abstract to decide if the article is relevant, reading the method section in order to replicate the study, or looking at the results and discussion for use in a paper being written. Consequently, a structure capable of supporting a wide variety of tasks is required.

The present author is in agreement with McKnight et al. (1988) who consider that:

"In view of the number of different purposes, a general structure is required if all purposes are to be supported" (p.340).

Although it is proposed that the constituent sections of the existing paper journal article should be preserved, there are several reasons why we should not merely attempt to imitate the paper medium. One of these is that people often dislike reading from screen, and so if the electronic version of a journal article just imitates the paper one, they will prefer the former. However, if electronic documents permit the reader to do things they would find useful, but which are difficult or impossible when using paper documents (e.g., keyword searching), the electronic version may be considered preferable.

In addition, some of the facilities offered by the paper medium (e.g., rapid page flicking) are difficult to imitate in the electronic one. A related point is that merely imitating the paper journal article does not permit those facilities which are available in the electronic medium to be fully exploited.

It is therefore proposed that the existing components of the journal article should be preserved in a hypertext environment, but that the linear form of presentation used in the paper medium may not be the optimum, and a system which permits rapid and easy scanning and browsing is necessary.
McAleese (1989) proposes there to be a distinction, not always made, between the terms browsing and navigation in a hypertext environment:

"There are two states: browsing is where an idea is followed using the linking mechanism of the hypertext elements (e.g., cards, windows, nodes); navigation involves the use of a graphic aid such as a browser or map to show an overview representation of the nodes and links" (p.6).

The present author considers there to be two distinctions between browsing and navigation. First, in terms of the degree of certainty that the desired information may be there — when browsing through an information structure, the reader does not know that any information relevant to a particular task will be present, but ‘navigation’ implies movement through the information structure towards something which is known to be present. Second, in terms of the specificity of the target or goal — it is proposed that when browsing, the target or goal is less specific than when navigating.

The tasks employed in the studies reported in this and the following chapter were intended to assess navigation performance, rather than browsing, in a hypertext journal article.

6.3.2 Method

6.3.2.1 Design

There were two independent groups of subjects, one in each of the two experimental conditions. These conditions were (i) an interface to the journal article taken from the paper medium (List), and (ii) an interface incorporating those facilities which had been shown to assist readers in the studies reported in chapters four and five (Map).

6.3.2.2 Subjects

The 16 subjects comprised members of staff from the HUSAT Research Institute and students from the Department of Human Sciences at Loughborough University of Technology. Their ages ranged between approximately 20-40 years, and all had some experience in using a mouse-driven computer system. Equal number of subjects were allocated to each of the experimental groups, with equal numbers of both staff and students in each group.
6.3.2.3 Materials

The text was a 4,700 word article by R.T. Wilkinson and H.M. Robinshaw, entitled *Proof-reading, VDU and paper text compared for speed, accuracy and fatigue*, taken from the journal *Behaviour and Information Technology*. The article comprised the following sections: authors’ names and addresses, abstract, introduction, method (subjects, materials, test and procedure, design), results, discussion and references. It was presented on a Macintosh II computer, and constructed in a version of HyperCard 1.2 modified by Dartmouth College to allow different card sizes. For the study described here, each card measured 21 cm. by 15.5 cm. The article was divided between 24 cards, containing a maximum of 25 lines of 12-point Geneva font text. In cases where a section contained too much text to fit onto a single card, continuation arrows were shown and the card gave the information “Page 2 of 4”, etc. (see figure 6.1). Clicking on a reference (shown in bold text) took readers to the full details of that article in the references section of the current article, and clicking on the title of a figure or table took them to a card containing the relevant graphic.

Figure 6.1. Example of a text card

The contents cards were interactive in both conditions. For the first condition, subjects were shown a list of the sections within the article (as in the contents list for a book) (see figure 6.2). For the second condition, the contents card contained all of the
facilities described in section 6.2.9, with the sections of the article arranged in a hierarchy (see figure 6.3). When a text card had been accessed, its title was shown in reverse video on the map. The footprint was a small marker cross by the title of the last text card seen, and the temporal sequence information was shown in a scrolling field (see section 5.4.2).

There were eight questions, each requiring subjects to locate where in the document a particular topic was mentioned (e.g., "Where does it talk about lack of clarity or flicker?"). Two questions were taken from each of the following sections of the article: introduction, method, results, discussion. The questions were divided into two blocks, A and B, and each presentation order (AB and BA) was used four times in each condition.
6.3.2.4 Procedure

Subjects were first given a practice text with which to familiarize themselves with the method for manipulating the document. They were then asked to answer the eight location questions, each question being printed on a separate piece of card and handed to subjects one at a time. Subjects were required to highlight the relevant portion of the text with the mouse, then to click on the 'Next Question' button. This took them back to the contents card ready to begin answering the next question.

The system recorded the titles of the cards accessed, the order in which they were accessed, the time spent on each card, and the sections of text highlighted during the question-answering task.

6.3.3 Results

6.3.3.1 Number of questions correctly answered

An analysis of the number of questions correctly answered in each condition indicated that significantly more answers were located by subjects using the map than by those using the list ($t_{(14df)} = 3.05, p < 0.01$) (see table 6.1).
6.3.3.2 Cards accessed per correctly answered question

The number of cards accessed per correctly answered question was calculated, and the analysis of the resulting data showed that significantly fewer cards were accessed by subjects in the map condition than by those in the list condition ($t_{14df} = 3.90, p < 0.01$) (see table 6.2).

<table>
<thead>
<tr>
<th></th>
<th>Map</th>
<th>List</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>7.50</td>
<td>6.25</td>
</tr>
<tr>
<td>SD</td>
<td>1.03</td>
<td>0.52</td>
</tr>
</tbody>
</table>

Table 6.2. Mean number of cards accessed per correctly answered question in each condition

6.3.3.3 Time per correctly answered question

An analysis of the time taken to locate targets for correctly answered questions revealed that interface type again had a significant influence on performance, with questions being answered faster in the map condition than in the list condition ($t_{14df} = -4.17, p < 0.001$) (see table 6.3).

<table>
<thead>
<tr>
<th></th>
<th>Map</th>
<th>List</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>112.40</td>
<td>196.92</td>
</tr>
<tr>
<td>SD</td>
<td>19.92</td>
<td>24.98</td>
</tr>
</tbody>
</table>

Table 6.3. Mean location time per question for correctly answered questions in each condition (in seconds)

6.3.3.4 Correlations

There was a significant positive correlation between the number of cards accessed per correctly answered question and the time taken to locate targets per correctly answered question ($r = 0.96, p < 0.001$). Significant negative correlations were found between (i) the number of questions correctly answered and the time taken to locate targets for correctly answered questions ($r = -0.71, p < 0.01$), and (ii) the number of questions correctly answered and the number of cards accessed per correctly answered question ($r = -0.65, p < 0.01$).
6.3.4 Discussion

The results of this study therefore indicate that those features found to assist readers in navigating through the encyclopaedic style documents employed in the studies reported in chapters four and five are also of benefit to readers of academic journal articles presented in a hypertext environment. Performance on all of the navigation measures was superior using the Map interface to the article as compared to the List interface: more questions were answered correctly, more quickly and by opening fewer cards.

The negative correlations between (i) the number of questions correctly answered and the time taken to locate targets and (ii) the number of questions correctly answered and the number of cards accessed per correctly answered question, point to a general measure of navigation efficiency, which was influenced by interface type.

In view of that the journal article employed in the study was in a 'conventional' structure, it may be argued that readers were able to use their knowledge of where certain information was likely to be located in order to answer the questions (see McKnight et al., 1990b). However, the navigation facilities which the interface producing superior performance in the present investigation contained had been shown to be of benefit to readers of other types of texts in the studies reported in chapters four and five. It is therefore proposed that the difference in performance by subjects using the two interfaces to the journal article may be attributed to the influence of interface type. It is recognized that other structures than that employed in the article selected for the present study may be used by authors, and in the database of journal articles described in the next chapter, the articles were of a variety of structures.

6.3.5 Conclusion

The results of the study reported in this chapter indicated that the features found to assist readers in navigating through the encyclopaedic style documents employed in chapters four and five were also of benefit for a hypertext academic journal article. Navigation was significantly more efficient using an interface to the article which contained these features than one resembling a contents list from the paper medium.

In the final study, reported in the next chapter, subjects’ ability to use a database of such hypertext journal articles is examined.
7.1 INTRODUCTION

7.1.1 The academic journal

As discussed in section 1.2.1, there are a number of reasons why the future of the academic refereed papers journal would now seem to be in question. One of these relates to difficulties in keeping pace with the ever-increasing amount of information available. The format of the academic journal has been mainly dictated by developments in the paper-making and print industries, and it imposes restrictions on the number and length of the articles within a volume. These limitations, combined with delays in the publication process, are serious impediments to scholarly communication.

A second reason why the future of the existing journal system may be in question is that for a long time paper has been the only viable presentation medium for academic journals, but recent advances in computer-based technology now make it possible to present journals electronically, and the considerable advantages of the electronic storage and retrieval of information have also been demonstrated. The findings of several investigations (e.g., Martyn, 1987; Pullinger, 1983) have indicated that the speed at which information becomes available is considered to be important. However, studies involving the ADONIS system (see Dillon et al., 1988) have demonstrated that rapid access to material is not sufficient, but it is necessary to show that the electronic medium has additional benefits for the reader. The journal database described in the present chapter was intended to provide such benefits.

7.1.2 The journal database

The individual articles in the journal database were constructed in the same way as that found to produce superior navigation performance in the study reported in the previous chapter. Due to limitations of screen size, it was not possible to display the entire structure of some of the articles on a single card. Engel et al. (1983) suggest there to be three possible solutions to situations in which the structure of an information system is too large and/or complex to fit onto one screen: (i) 'zooming in', (ii) panning across the structure, or (iii) a hierarchical series of screens. The third of these approaches was employed in the present investigation, for two reasons. First, the hierarchical series of
screens reflected the hierarchical structure of the articles, and second, this solution was the easiest to implement using HyperCard.

Two different interfaces to the database were constructed. The first (map) interface contained the same features which had been found to help readers navigate through a single hypertext journal article (see chapter six), and was therefore similar to that used for the individual articles in the present study. The graphical representation of the database was formed by depicting the titles of the articles as nodes, with the cross-references being shown by lines linking the nodes—thus forming a non-hierarchical structure. The second (list) interface was a straightforward chronological list of the articles contained within the database. The study therefore compared performance using an interface taken from the paper medium with one taking advantage of the facilities offered by the electronic medium.

Smith et al. (1987) consider that rather than “a flat hyperspace of spaghetti”, there should be “peaks of understanding” which, although linked, each have “a single integral hierarchical structure”. It is suggested that this description could be applied to the present electronic journal database: the individual articles are linked, but they each have a hierarchical structure.

The results of the studies reported in chapter five had indicated that those features which were of benefit to readers of hierarchical hypertext documents were also of benefit to readers of non-hierarchical ones. A document and a database have some similarity in that they both provide information and cues for the selection of further information (Marchionini and Shneiderman, 1988). It was therefore proposed that those features which had been found to assist readers in navigating through non-hierarchically structured articles would also help them to navigate through a non-hierarchically structured database.

One criticism sometimes made of hypertext studies is that the tasks employed are not representative of those normally undertaken by subjects in their everyday life. The study reported in this chapter attempted to demonstrate that meaningful tasks may be adequately performed using a hypertext journal database. In view of the fact that the subjects were students, the task selected involved the location of information relevant to answering two questions of the type commonly set for class or examination essays (e.g., “What are the advantages and disadvantages of menu selection systems? What have studies shown us about their suitability for naive/novice computer users?”). The students were drawn from a population familiar with the area covered by the journal from which the articles in the database were taken. Nickerson (1984) refers to several clusters of issues in relation to a reading task, one of which is the filtering and
evaluation of the potentially useful information available to the reader. The essay type questions employed in the present investigation would appear to involve this particular kind of task.

It was hypothesized that readers would be able to locate relevant information from the database more efficiently using the map type interface, as compared to the list type interface. The main measures of efficiency of information location were the number of relevant points found by readers, the number of relevant and irrelevant articles visited, the number of different articles visited and the total number of articles visited.

7.2 METHOD

7.2.1 Design

The design was a 2 x 2 mixed ANOVA. Factor one (Interface type) was between subjects and factor two (Question type) was a within subjects variable. The presentation order of the two questions was counterbalanced between subjects.

7.2.2 Subjects

The 32 subjects used in the study were final year and postgraduate students from the Department of Human Sciences at Loughborough University. They were each paid £5 for participating in the experiment. All had some experience in using a Macintosh computer.

7.2.3 Materials

The database was presented on a Macintosh II computer, and constructed using a version of HyperCard 1.2 modified by Dartmouth College to allow the card sizes to be altered. For the study described here, each card measured 21 cm. by 15.5 cm. The database contained 18 articles taken from the human factors journal Behaviour and Information Technology. All of the articles referred to at least one other article in the database, and some of them to several other articles. The individual articles were the same for both interface types, and constructed as follows.

On selecting an article from the database, subjects were shown a ‘title page’, containing the author(s)’ names(s) and address(es) and the title of the article. This card also showed a list of the other articles in the database either referred to by the selected
article, or referring to it (see figure 7.1). The articles in this list were selectable, so that readers could go directly to them without having to go back to the database level.

The structure of an article was shown by a series of tree diagrams, each of which displayed one level of the hierarchy, with arrows indicating the links to other levels (see figures 7.2 and 7.3). Readers were able to move up and down the hierarchy, and the sections of text were selectable. Additional cues to the position of particular sections of text within the hierarchy were provided by typographical cues, which were mirrored in the titles of the text cards themselves. Reverse video was used to show readers which sections of the text they had visited, and the ‘footprint’ was a small marker cross by the title of a section.

<table>
<thead>
<tr>
<th>MORRISON &amp; NOBLE (1984)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Contents</strong></td>
</tr>
<tr>
<td><strong>TOLENT SOFTWARE FOR THE RECOGNITION OF USER-DEFINED COMMANDS IN A DATA-BASE ENVIRONMENT</strong></td>
</tr>
</tbody>
</table>

PERRY R. MORRISON and GRANT NOBLE
Department of Psychology, University of New England, Armidale, NSW 2351, Australia

REFER TO:
MAGUIRE (1982) Computer Recognition of Textual Keyboard Inputs From Naive Users

REFERRED TO BY:

Figure 7.1. ‘Title page’ for an article

It was possible to access both the contents card for the database and the hierarchical representation of the structure of the current article from all of the text cards, and a list of the sections of an article which had already been visited was also available (see figure 7.4). The titles of the cards indicated their position in the hierarchical structure of the document, using the same typographical cues as in the tree diagrams (see figure 7.5). If a reference to another article in the database was made by an author, then a small arrow was placed in the text after the reference, and clicking the mouse on this arrow took readers to the ‘title page’ of that article. Thus there were three possible
Figure 7.3. Article structure - lower level
methods of moving between articles: at the database level, from the 'refers to/referred to by' on the title page of an article, and via the arrows embedded in the text.

The two interfaces to the database were as follows. For the map type interface, the articles in the database were displayed graphically, with directional lines indicating the cross-references, thus producing a network type of display (see figure 7.6). Articles were selected by clicking the mouse in the appropriate box. When an article had been accessed, its author and title were displayed in reverse video, thus providing readers with a record of the articles that they had visited. An ordered list of the articles seen was obtainable by clicking on a button at the top of the screen (see figure 7.7), and a small marker cross, or 'footprint' showed readers which article they had just come from. For the list type interface, subjects were shown a chronological list of the 18 articles (see figure 7.8). Articles were selected by clicking the mouse on the author's name.

Information relevant to each of the two questions employed in the study was contained in a different set of seven articles. The questions differed in the number of these articles which referenced one or more of the other seven, i.e., which were linked within the database. For question one (linked), all of the articles were linked to at least one other article, but for question two (unlinked), none of the articles referenced any other article in the database.
IMPLIES THAT EVEN COMMAND POOLS CREATED FROM THEIR RESPONSES COULD BE USEFUL FOR EMPIRICAL METHODS OF NOMOTHETIC COMMAND SET CONSTRUCTION.

AS A FIRST STEP TOWARD THIS GOAL, IT WAS NECESSARY TO DEMONSTRATE THAT INDIVIDUALS CAN MATCH ALIASES AND THEIR PARENT COMMANDS AND FUNCTIONS. SUCH A DEMONSTRATION WOULD INDICATE THAT, DESPITE SURFACE HETEROGENEITY, ALIASES MAY CONTAIN A CORE OF MEANING AND STRUCTURE WHICH CAN BE IDENTIFIED IN THEIR PARENT COMMAND AND DEFINITION. THIS WOULD FURTHER IMPLY THAT INDIVIDUALS CAN CREATE ALIASES WHICH ARE MEANINGFUL IN TERMS OF THEIR PARENT COMMANDS/FUNCTIONS AND THAT POOLS OF ALIASES COULD BE ESTABLISHED FROM WHICH THE MOST COMPREHENSIBLE COULD BE IDENTIFIED FOR USE ACROSS INDIVIDUALS.

SOME EFFORTS IN THIS DIRECTION HAVE ALREADY BEEN MADE. JONES AND LANDAUER (1985) FOUND THAT WHEN INDEPENDENT SUBJECTS RECEIVED EITHER 'NOVICE GENERATED' OR 'EXPERT GENERATED' MAPPINGS (I.E. WHERE NAMES WERE SELECTED BEFORE OR AFTER PREVIEWING THE ENTIRE SET OF COMMAND DESCRIPTIONS), RECALL WAS BETTER FOR THE EXPERT GENERATED MAPPINGS, AND THAT THIS WAS POSSIBLY DUE TO THE FACT THAT THESE STIMULI WERE FOUND TO BE MORE STRUCTURED. THE STRUCTURING STRATEGIES MENTIONED BY JONES AND LANDAUER SEEM PRINCIPALLY TO INVOLVE SEQUENCES OF THE SCALE OF OPERATIONS, SUCH AS COMMAND (A) TO MOVE TO THE NEXT LETTER, (B) TO MOVE TO THE NEXT WORD AND (C) TO MOVE TO THE NEXT SENTENCE. HOWEVER, THIS RESEARCH HAS SEVERAL LIMITATIONS WHICH THE PRESENT EXPERIMENTS WERE PARTLY INTENDED TO OVERCOME. GENERALIZATION FROM JONES AND LANDAUER'S SINGLE LETTER COMMANDS TO THE STRINGS NORMALLY USED FOR OPERATING SYSTEM COMMANDS REMAINS PROBLEMATIC, AND THE MEANINGFULNESS OF THESE COMMANDS IN THE ABSENCE OF SUCH STRUCTURING IS DIFFICULT TO GAUGE. ALSO, ALTHOUGH THESE AUTHORS HAVE PROVIDED A PLAUSIBLE EXPLANATION FOR THE SUPERIORITY OF EXPERT GENERATED ALIASES IN TERMS OF THE ABOVE OBSERVATIONS OF STRUCTURE, THIS INTERPRETATION IS NECESSARILY POST HOC. IN ADDITION, THERE ARE A NUMBER OF OTHER POSSIBLE PROCESSES THAT ARE EQUALLY LIKELY CANDIDATES IN THE MEDIATION OF THIS EFFECT AND THIS AVENUE NEEDS TO BE EXPLORED. FINALLY, WHILE RECALL OF COMMAND NAMES IS UNDOUBTEDLY AN IMPORTANT ASPECT OF REAL SYSTEM USE, SOME UNDERSTANDING OF THE MEANINGFULNESS OF COMMANDS IS UNDOUBTEDLY AN IMPORTANT ASPECT OF THEIR MEMORABILITY AND THIS FACET OF COMPUTER COMMAND ALIASES WAS NOT TESTABLE GIVEN THE ONE-LETTER COMMANDS USED BY JONES AND LANDAUER.

IN CONTRAST, ONE OF THE AIMS OF THE FIRST EXPERIMENT OF THE PRESENT STUDY WAS TO MEASURE THE EXTENT TO WHICH INDEPENDENT NOVICES COULD ENCODE SUFFICIENT SEMANTIC CONTENT INTO FULL-STRING COMMAND ALIASES TO ALLOW OTHERS TO IDENTIFY THEIR PARENT COMMAND/FUNCTIONS. SUCH A DEMONSTRATION WOULD BE A STRINGENT TEST OF THE NOTION THAT ALIASES ENCODE GENERALLY ACCESSIBLE
A questionnaire given to subjects after they had completed the question-answering task required them to indicate their computer experience and prior knowledge of the topics addressed by each of the questions, using five-point rating scales.

<table>
<thead>
<tr>
<th>THE DATABASE</th>
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<tbody>
<tr>
<td>ARTICLES SEEN</td>
</tr>
</tbody>
</table>

MORRISON & NOBLE (1984)
MORRISON & NOBLE (1984)
JONES & LANDAUER (1983)
MAGUIRE (1982)
MORRISON & NOBLE (1984)
MAGUIRE (1982)
MORRISON & NOBLE (1987)
MORRISON (1988)

Figure 7.7. 'Articles Seen' list

7.2.4 Procedure

After a short practice session in which to familiarize them with the system, subjects were given a printed instruction sheet. These instructions stated that information relevant to each question would be found in more than one article, and subjects were asked to write down each piece of information located, together with the author of the article from which it came. It was emphasized that only information obtained from the database was to be used, not any that subjects may have already obtained from other sources.
<table>
<thead>
<tr>
<th>Year</th>
<th>Author(s)</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>1982</td>
<td>Carroll</td>
<td>Learning, Using and Designing Filenames and Command Paradigms</td>
</tr>
<tr>
<td>1982</td>
<td>Maguire</td>
<td>Computer Recognition of Textual Keyboard Inputs from Naive Users</td>
</tr>
<tr>
<td>1982</td>
<td>Rosenberg</td>
<td>Evaluating the Suggestiveness of Command Names</td>
</tr>
<tr>
<td>1982</td>
<td>Scapin</td>
<td>Generation Effect, Structuring and Computer Commands</td>
</tr>
<tr>
<td>1982</td>
<td>Zoltan &amp; Chapinis</td>
<td>What do Professional Persons Think About Computers?</td>
</tr>
<tr>
<td>1984</td>
<td>Gilligan &amp; Long</td>
<td>Videotext Technology: An Overview</td>
</tr>
<tr>
<td>1984</td>
<td>Morrison &amp; Noble</td>
<td>Software for the Recognition of User-defined Commands</td>
</tr>
<tr>
<td>1985</td>
<td>Canter et al</td>
<td>Navigation Through Data Structures</td>
</tr>
<tr>
<td>1985</td>
<td>Greenberg &amp; Witton</td>
<td>Adaptive Personalized Interfaces: A Question of Viability</td>
</tr>
<tr>
<td>1985</td>
<td>Jones &amp; Landauer</td>
<td>Context and Self-selection Effects in Name Learning</td>
</tr>
<tr>
<td>1985</td>
<td>Parton et al</td>
<td>Learning a Menu Selection Tree</td>
</tr>
<tr>
<td>1985</td>
<td>Robertson</td>
<td>Human Information Processing</td>
</tr>
<tr>
<td>1985</td>
<td>Weerdmeester et al</td>
<td>Keywords for Retrieval on Videotext</td>
</tr>
<tr>
<td>1987</td>
<td>Morrison &amp; Noble</td>
<td>Individual Differences and Ergonomic Factors in Performance on a Videotex Type Task</td>
</tr>
<tr>
<td>1988</td>
<td>Morrison</td>
<td>Evaluating Expert Created, Ideographic Command Sets</td>
</tr>
<tr>
<td>1989</td>
<td>Safayeni et al</td>
<td>Social Meaning of Personal Computers</td>
</tr>
<tr>
<td>1989</td>
<td>Gardner et al</td>
<td>Evolution of Attitudes Toward Computers</td>
</tr>
<tr>
<td>1989</td>
<td>Joseph et al</td>
<td>User Perceptions of an Information Retrieval System</td>
</tr>
</tbody>
</table>

End
When subjects had read the instructions they were given a piece of paper containing their first question. They were told that there was no time limit for the task, and asked to indicate to the experimenter when they were ready for the second question. After the second question had been completed, the questionnaire was administered. Finally, subjects were shown a paper reproduction of the alternative version of the interface to that they had used, and asked to state their preference. General comments on the database were also noted.

The software recorded the articles and cards visited by readers during the question-answering task.

7.3 RESULTS

7.3.1 Question scores

The questions were scored as follows. The points pertaining to each question were extracted from the relevant articles, there being 21 points for the linked question and 17 for the unlinked question. The number of points recorded by each subject for each question was calculated as a percentage of the maximum possible number of points for that question. A 2 x 2 ANOVA (Interface type x Question type) on the resulting data indicated there to be a main effect of interface type ($F_{(1,30)} = 43.90$, $p < 0.0001$) and a significant interaction between the interface and question variables ($F_{(1,30)} = 12.25$, $p < 0.01$) (see table 7.1). Further analysis ($T_{0.01} = 9.86$) indicated that the difference between four of the five significantly different pairs of means could be accounted for by the effect of interface type.

<table>
<thead>
<tr>
<th></th>
<th>Map</th>
<th>List</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linked</td>
<td>45.24</td>
<td>15.78</td>
<td>30.51</td>
</tr>
<tr>
<td>Unlinked</td>
<td>36.76</td>
<td>21.69</td>
<td>29.23</td>
</tr>
<tr>
<td>Total</td>
<td>41.00</td>
<td>18.74</td>
<td></td>
</tr>
</tbody>
</table>

Table 7.1. Mean percentages of points recorded by subjects in each condition

7.3.2 Number of moves between articles

The number of moves between articles made by subjects while locating information was calculated (see table 7.2). A 2 x 2 ANOVA revealed a main effect of interface type on this measure ($F_{(1,30)} = 4.85$, $p < 0.05$), with significantly fewer moves being made by readers using the map than by those using the list.
7.3.3 Number of different articles visited

A 2 x 2 ANOVA indicated that neither interface type or question type, nor the interaction between these two variables, had a significant influence on the number of different articles visited during the question-answering task ($F_{1,30} = 6.65, p > 0.05$) (see table 7.3).

![Table 7.3. Mean number of different articles visited in each condition (max = 18)]

<table>
<thead>
<tr>
<th></th>
<th>Map</th>
<th>List</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linked</td>
<td>7.94</td>
<td>8.94</td>
<td>8.44</td>
</tr>
<tr>
<td>Unlinked</td>
<td>7.81</td>
<td>11.25</td>
<td>11.25</td>
</tr>
<tr>
<td>Total</td>
<td>7.88</td>
<td>10.00</td>
<td>10.00</td>
</tr>
</tbody>
</table>

7.3.4 Number of different relevant articles visited

A 2 x 2 ANOVA showed there to be a main effect of interface type ($F_{1,30} = 4.29, p < 0.05$) and a significant interaction between this and the question variable ($F_{1,30} = 4.31, p < 0.05$) on the number of different relevant articles visited during the question-answering task (see table 7.4). Further analysis ($T_{0.01} = 1.52$) indicated that for the linked question, significantly more relevant articles were visited by subjects using the map than by those using the list, and for the map interface, significantly more relevant articles were visited for the linked question than for the unlinked question. In addition, significantly more different relevant articles were visited by subjects in the map/unlinked condition than by those in the list/linked one.

![Table 7.4. Mean number of different relevant articles visited in each condition (max = 7)]

<table>
<thead>
<tr>
<th></th>
<th>Map</th>
<th>List</th>
<th>Total</th>
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<tbody>
<tr>
<td>Linked</td>
<td>5.50</td>
<td>3.94</td>
<td>4.72</td>
</tr>
<tr>
<td>Unlinked</td>
<td>4.25</td>
<td>4.00</td>
<td>4.13</td>
</tr>
<tr>
<td>Total</td>
<td>4.88</td>
<td>3.97</td>
<td>4.13</td>
</tr>
</tbody>
</table>

7.3.5 Number of different irrelevant articles visited

A 2 x 2 ANOVA indicated there to be a main effect of interface type on this measure ($F_{1,30} = 6.57, p < 0.05$), with fewer irrelevant articles being visited by subjects using the map type interface than by those using the list (see table 7.5).
7.3.6 Movement through the database

As mentioned in section 7.2.3, there were three methods of moving between articles available to subjects: at the database level, from the 'refers to/referred to by' on the 'title page' of an article, and via the arrows embedded in the text. The percentages of the total number of moves between articles were calculated for each type of inter-article movement, and a series of 2 x 2 ANOVAs was performed on the resulting data.

7.3.6.1 Database level

For the first method of movement, there were main effects of both interface and question type, and also a significant interaction between these two variables ($F_{1,30} = 10.11, p < 0.01$) (see table 7.6). Further analysis ($T_{0.05} = 18.18$) indicated that the significant differences were between the following pairs of means:

Map/linked - map/unlinked; Map/linked - list/unlinked; Map/linked - list/linked.

<table>
<thead>
<tr>
<th></th>
<th>Map</th>
<th>List</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linked</td>
<td>50.02</td>
<td>90.68</td>
<td>70.35</td>
</tr>
<tr>
<td>Unlinked</td>
<td>83.30</td>
<td>94.05</td>
<td>88.63</td>
</tr>
<tr>
<td>Total</td>
<td>66.61</td>
<td>92.37</td>
<td></td>
</tr>
</tbody>
</table>

Table 7.6 Mean percentage of moves at the database level in each condition

7.3.6.2 Via the 'title page'

There were again main effects of both variables and a significant interaction between the two ($F_{1,30} = 5.14, p < 0.05$) (see table 7.7). Further analysis ($T_{0.05} = 11.98$) indicated that the significant differences were between the same pairs of means as for navigation between articles at the database level.

<table>
<thead>
<tr>
<th></th>
<th>Map</th>
<th>List</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linked</td>
<td>28.30</td>
<td>7.39</td>
<td>17.85</td>
</tr>
<tr>
<td>Unlinked</td>
<td>9.48</td>
<td>2.78</td>
<td>8.63</td>
</tr>
<tr>
<td>Total</td>
<td>18.89</td>
<td>5.09</td>
<td></td>
</tr>
</tbody>
</table>

Table 7.7. Mean percentage of moves via the 'title page' in each condition
7.3.6.3 Via the embedded arrows

A 2 x 2 ANOVA showed there to be a main effect of interface type and a significant interaction between this and the question variable ($F_{[1,30]} = 13.26, p < 0.01$) (see table 7.8). Further analysis ($T_{0.05} = 10.26$) indicated that the significant differences were between the same three pairs of means as for the other methods of inter-article navigation.

<table>
<thead>
<tr>
<th></th>
<th>Map</th>
<th>List</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linked</td>
<td>21.68</td>
<td>1.93</td>
<td>11.81</td>
</tr>
<tr>
<td>Unlinked</td>
<td>7.32</td>
<td>3.17</td>
<td>5.25</td>
</tr>
<tr>
<td>Total</td>
<td>14.50</td>
<td>2.55</td>
<td></td>
</tr>
</tbody>
</table>

Table 7.8. Mean percentage of moves via the embedded arrows in each condition

7.3.7 Reading strategies

The strategies used by readers when accessing an article was examined, and it was found that all article accesses could be accounted for by the following five strategies:

1. Title – main map – abstract – (map – text) may be repeated one or more times (used for 40.74% of article visits).
2. Title – main map – abstract – new article (used for 24.07% of article visits).
3. Title – main map – (map – text) may be repeated one or more times (used for 14.20% of article visits).
4. Title only (used for 11.73% of article visits).
5. Title – main map – new article (used for 9.26% of article visits).

It is of interest to note that strategies one and two (in which the abstract was consulted) together account for 64.81% of all article visits.

7.3.8 Correlations

The number of relevant articles visited by subjects was positively correlated with the scores obtained for the question-answering task ($r = 0.60, p < 0.01$), and the number of times the "sections seen" list was accessed was positively correlated with scores for the question-answering task ($r = 0.78, p < 0.001$).

For the map interface, there was a positive correlation between the number of times the ordered list of articles seen was accessed and the number of relevant articles visited ($r = 0.69, p < 0.01$), and a negative correlation between the former measure and the number of irrelevant articles visited ($r = -0.68, p < 0.01$). Question scores were also
positively correlated with the number of times that the ordered list of articles visited was accessed ($r = 0.66$, $p < 0.01$).

### 7.3.9 Questionnaires

There was no significant difference in the level of computer usage reported by subjects using the map or list type interface ($p > 0.05$) (means = 4.50 and 4.00 for each interface type respectively). In addition, a $2 \times 2$ ANOVA did not show there to be any significant differences in the degree of prior knowledge of the question topics for the four conditions ($p > 0.05$) (see table 7.9).

<table>
<thead>
<tr>
<th></th>
<th>Map</th>
<th>List</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linked</td>
<td>2.25</td>
<td>1.94</td>
<td>2.10</td>
</tr>
<tr>
<td>Unlinked</td>
<td>2.38</td>
<td>2.12</td>
<td>2.25</td>
</tr>
<tr>
<td>Total</td>
<td>2.32</td>
<td>2.03</td>
<td></td>
</tr>
</tbody>
</table>

Table 7.9. Mean prior knowledge ratings in each condition

When subjects were shown a paper reproduction of the alternative interface to the database to that which they had used, 87.00% of those in the map condition and 81.25% of those in the list condition said they preferred the map type of interface, discussing the benefits of the various features and facilities which it provided.

### 7.3.10 Comments from subjects

Typical comments from subjects concerning various aspects of the database were as follows.

**Database map**

“With a map you could see the cross-references and so know which other articles might be relevant without having to go to the title page of one.”

**Record of articles seen**

“Knowing which papers I had seen was good — I often went back to look at the map.”

“A list would not have been as good — I liked being able to see what I had looked at, I went back several times to check.”

**Footprint at the database level**

“It (the footprint) was also good on the sort of map when I'd gone round a few different papers.”

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Article maps

"It's funny, but journal articles always look very complicated, but when you can see the way the sections are all joined like this, you realise they aren't really at all. I know the importance of the headings is supposed to be shown by underlining and things, but I never seem to take much notice of that. Diagrams are far better -- I always seem to think of things in pictures."

"I thought I found the information quicker than if I'd had paper journals. Being able to go and look at the main section titles all together on a page was good. With paper you have to go right through to find them."

"I found the hierarchies very easy to go up and down through -- I could see which sections were likely to be relevant to the questions."

"I like the trees for the articles, especially being able to go right to the abstract."

Footprint at the article level

"When I'd looked at a lot of cards the mark on the map was helpful too."

Ordered list of sections seen

"I also found it useful sometimes to see which order I'd looked at them -- I knew I had seen something only a few sections ago."

Reading from screen

"I don't usually like reading from computers, but this seemed OK."

"If you are going to use a computer then you should use what it's capable of. Just giving people a list, like on paper, doesn't do this."

Larger database

"I can see problems when there are lots more articles. You could use one of those 'You are here' sort of maps, with 'here' in the middle, if you see what I mean."

"I can see problems when there are more articles -- you could try sort of panning across the map."

Keyword search

"Keyword search would have been useful. We have a new system in the library, but it does have problems. It's very inflexible for one thing. If you type in a word that means something very similar it won't recognize it. Also spelling mistakes are a nuisance."
“Interesting! It’s an improvement on wading through the library shelves I must say. It’s about time someone did something like this. Those new search systems we’ve got aren’t really much good. I always seem to keep putting in the wrong words when I try them.”

**General**

“Could I come back and have another longer look sometime?”.

“I've never seen anything like this before. If this is what an ‘Electronic Journal’ looks like, then I’m all in favour! It would be a huge job, but it would be fantastic if everything was on a system like this. So many people have computers nowadays – it would be well worth it.”

“It was quicker than using paper journals when I was doing the questions. It would have taken me ages, and I probably wouldn’t have done as well, been as thorough.”

“I enjoyed it – more fun than reading from paper articles. Also more efficient, less time-consuming. That’s important when searching for relevant information. There are so many papers and journals and you need to get through them fast.”

### 7.4 DISCUSSION

#### 7.4.1 Question answering

The study reported here examined the hypothesis that the interface to a hypertext database would have a significant influence on readers’ ability to locate information relevant to two essay-type questions. It was proposed that performance would be superior using an interface whose features were found to be of benefit to readers of individual hypertext articles. This hypothesis was supported, with significantly higher scores being obtained by subjects using such an interface than by subjects using a straightforward list of the articles in the database. The effect of interface type on the number of relevant points located was particularly strong (p < 0.0001), with the mean percentages of the total number of points available being 41% in the map condition and 18.70% in the list condition. Furthermore, the significant interaction between interface type and question type could be mainly accounted for by the effect of the former variable.

The scores obtained by subjects in the question-answering task were not significantly correlated with their prior knowledge of the two question topics. This finding would
suggest that differences in the amount of relevant information located from within the database may be attributed mainly to the characteristics of the interface per se.

7.4.2 Articles visited

Although subjects using the map type interface made significantly fewer moves between articles (mean = 7.88) than those using the list type interface (mean = 10.00), this variable had no significant influence on the number of different articles visited during the question-answering task. Taken together, these findings indicate that subjects in the list condition revisited more articles than those in the map condition. The most obvious explanation for this is that both a record and an ordered list of articles visited were available to subjects using the map type interface, but neither were available to those using the list.

The analysis of the number of different relevant articles visited indicated that, while answering the linked question, subjects using the map type interface visited significantly more relevant articles (mean = 5.50) than those using the list type interface (mean = 3.94). In addition, for subjects using the map interface, more relevant articles were visited for the linked question (mean = 5.50) than for the unlinked question (mean = 4.29). It be therefore be concluded that subjects using the graphical interface found the illustration of the way in which the articles referred to each other to be of benefit. This proposition is supported by the comments made by subjects, a number remarking that once they had found one relevant article, they used the map to see which other articles were linked on the display, and therefore likely to be relevant. Although, for both interface types, similar information was available on the 'title page' of each article, it was not found to be as easy to assimilate – hence the performance difference for the two interface types.

The results of the study also indicated that significantly fewer different irrelevant articles were visited by subjects using the map type interface (mean = 1.94) than by those using the list type one (mean = 3.04). In addition, although the difference did not reach significance, for the unlinked question, subjects using the map type interface visited more different relevant articles than those using the list type interface. It is therefore suggested that the data for the number of different relevant articles visited points to the superiority of the map type of interface. However, these findings do not show whether, when there are no links between relevant articles, it is the use of a graphical representation or the record of articles which have been visited which is the important factor.
7.4.3 Movement through the database

There was a significantly lower percentage of movement between articles at the database level in the map/linked condition than in any of the other three conditions. Conversely, the percentages of inter-article movement by each of the other methods (via the ‘title page’ or by the embedded arrows) were higher in the map/linked condition than in any of the other conditions. It may therefore be suggested that subjects using the map type interface for the linked question had a more accurate mental map of the way in which the articles were linked, and so felt sufficiently confident to navigate between articles by other methods than at the database level.

The findings that (i) a significantly lower percentage of inter-article navigation was at the database level, and (ii) a significantly higher percentage of navigation was via the ‘title page’ and embedded menus, for the map type interface, points to the superiority of the graphical representation for helping readers to form a mental model of the database. The finding that more navigation was at the database level than by the other methods for the unlinked questions is not particularly surprising, in view of the fact that there were no links between relevant articles, and it was not therefore possible to access one relevant article from another via the ‘title page’ or the embedded arrows.

7.4.4 Correlations

The results of the study reported in section 5.4 indicated that temporal sequence was an important navigation cue at the article level, and the findings of the present investigation would suggest that this was also the case at the database level. Subjects who accessed the ordered list of ‘articles seen’ the greatest number of times scored higher in the question-answering task, visited more relevant articles and fewer irrelevant ones. Comments by subjects support this proposition. The questions comprised several distinct parts, and a number of subjects made remarks such as “I remembered that I had seen something relevant to the second part when I started the question, and I could see from the list which article I had looked at first”.

The number of relevant articles visited was positively correlated with the scores obtained for the question-answering task, and the number of times the ‘sections seen’ list was accessed was also positively correlated with question scores. These findings may be taken to indicate that once subjects had decided that an article was relevant, they were able both to decide which sections were likely to contain relevant information and to locate this information. This supports the proposition that readers have a mental model of the structure of an article, which is used to judge where particular information may be (see McKnight et al., 1990b).
7.4.5 Reading strategies

As mentioned in section 7.3.7, for 64.81% of all article visits, subjects accessed the abstract of the article. In addition, for those occasions when subjects went further than merely looking at the 'title page' of an article, 73.43% of article visits followed the initial sequence of 'title-main map-abstract'. Furthermore, for those occasions on which subjects went on to read the main text of an article, the abstract was consulted on 74.16% of visits. The most obvious explanation for these findings is that readers accessed the abstract of an article prior to the main body of the text because this is the presentation order for paper journal articles, with which they are more familiar. An alternative interpretation of the data is that readers accessed the abstract because of its perceived utility in providing further information than the title and author about an article, thus suggesting that a method of accessing the abstract of an article quickly and easily is an important consideration for the design of an electronic journal.

7.4.6 Subjects' comments

Comments made by subjects suggested that they did find the additional facilities offered by the electronic medium to be of benefit for the question-answering task. The graphical representations, at both the database and article level, were considered to be useful, especially the ability to access the constituent sections of an article directly. Several readers said that it was particularly helpful to be able to go straight to the abstract of an article, thus agreeing with the conclusions derived from the analysis of the reading strategy data — that the abstract provides important information for the reader. Comments such as "I could see which sections were likely to be relevant to the questions" again support the suggestion that people have mental models of the structure of journal articles which permit them to judge where information may be located. The fact that a number of readers referred to "the sort of map" and "a 'you are here' marker" even though neither maps or navigation were mentioned by the experimenter may indicate that they were using their existing world knowledge in a new domain (Carroll and Carrithers, 1984).

It is of interest to note that several readers recognized that there would be problems in relation to displaying the structure of larger databases, mentioning several possible solutions. However, it should be said that the subjects employed in the study were students in the human factors field, and so it is likely that they were especially aware of such issues.

Finally, although the majority of subjects used a computer several times a week, this was mainly for statistics and word-processing, rather than reading lengthy texts from
screen. Nonetheless, none of them mentioned any difficulty in reading the journal articles in the electronic medium, and comments such as “Could I finish reading that article before I go?” were not uncommon.

7.5 CONCLUSION

In conclusion, the results of the present investigation indicate that those features which readers found to be of benefit for navigating through a hypertext journal article are also useful for navigating through a database of such articles. Although the aim of the study was not to compare the paper medium with the electronic one, the majority of subjects said that an electronic journal of this kind was far preferable to the existing paper journal system.

According to Elm and Woods (1985):

“Getting lost in a display network means that the user not have a clear conception of the relationships within the system, does not know his present location in the system relative to the display structure, and finds it difficult to decide where to look next within the system” (p.927).

There is evidence that the users of the database described in the present study did not ‘get lost’, but were able to use the database in order to perform a realistic task. It is therefore proposed that the electronic journal found to produce superior performance in this study should be used as the starting point for the design of future electronic journals.
CHAPTER EIGHT

CONCLUSIONS AND SUGGESTIONS FOR FUTURE ELECTRONIC JOURNALS

In this chapter, the main findings of the studies reported in the thesis are summarized, and the proposed electronic journal database is discussed in a broader context. Suggestions are made for the design of future electronic journals, and issues to be explored in future research are also discussed.

8.1 THE STUDIES

The findings of the studies conducted by the author were briefly as follows.

8.1.1 Readers' use of the paper journal system

The second chapter of the thesis described a series of interviews concerning readers' use of the present paper-based journal system. It was intended that the findings would provide information which might assist in the design of an electronic journal system. In both this study and the earlier ones reported in the chapter, two of the factors most frequently mentioned by subjects were shortage of time and the importance of obtaining material quickly. Readers claimed that their coverage of relevant material was limited by the time available, and the various skimming and scanning strategies employed represent attempts to assess the relevance of an article, and extract information from it, as rapidly as possible. A number of subjects suggested that interlibrary loans were too slow, and delays in the publication process were considered to be unsatisfactory.

A third factor frequently mentioned was the value of serendipity, with browsing through current publications being the most common method of discovering relevant material by chance. The value of serendipity was also acknowledged by those interviewees who said that its loss was one of the reasons why they did not delegate searching for information.

It was suggested that the main benefit of an electronic journal may lie in the provision of facilities which permit readers to access articles in a more flexible manner than in the paper medium, thus facilitating the selection of relevant information at both the journal and article level.
8.1.2 Readers’ memory for the location of text

The two studies reported in the third chapter focussed on the role of location as a navigation cue, for both sequentially and non-sequentially presented documents. The main aim of the first of the studies was to determine whether the findings of previous investigations, that incidental memory for the location of text was more accurate than by chance, were replicated in the electronic medium. The data obtained indicated that there was no significant difference in the levels of within-page, text-sequence, or left/right-hand page location recall when a document was presented on paper or screen. As in the earlier studies, accuracy of substantive content recall was related to that of incidental memory for the location of the text within a document, and the loss of within-page location cues resulted in inferior performance in the content recall task. In both the paper and electronic media, incidental memory for the location of text was significantly more accurate than by chance, and it was proposed that these findings were consistent with the hypothesis that spatial location is one of the fundamental attributes comprising the constellation involved in an episodic memory.

In the second study, performance in information relocation and content recall tasks was compared using three different windowing techniques: a reverting stack, a non-reverting stack and tiled windows. The results indicated that performance in both tasks was inferior when the text was presented in a non-reverting stack of windows. However, the enhanced spatial cues provided by the tiled display did not significantly improve performance as compared to the reverting stack of windows. The finding that accuracy of content recall was correlated with efficiency of information relocation again supports the hypothesis that memory for textual material comprises a constellation of attributes, in which recall of one attribute may facilitate recall of another.

8.1.3 Navigation in hierarchical hypertexts

The fourth chapter described a series of three studies examining the effect of a number of features in helping readers to navigate through, and form a map of, hierarchically structured hypertexts. The studies were sequential, in that those features found to be beneficial in one study were retained for all conditions in the next. It was found that:

1. Readers using a hierarchical contents list navigated through the text more efficiently, and produced more accurate maps of its structure, than readers using an alphabetical index.

2. Performance was superior when subjects were provided with a graphical representation of the document’s structure, as compared to a textual one.
3. The addition of typographic cues to the contents card did not significantly improve performance for either of the tasks.

4. Information was located more efficiently, and the increase in accuracy between pre- and post-experiment maps of the document's structure was greater, when the representation was interactive.

5. In the first study, the provision of a footprint showing readers which text card they had just come from was beneficial for an initial reading task, but not for the navigation or map construction tasks. However, in the second study, a footprint was of benefit to subjects using a non-interactive representation of the document's structure.

6. Showing readers which sections of a document they had accessed was of benefit for both tasks.

7. Navigation efficiency was positively correlated with performance in the map construction task.

8.1.4 Navigation in non-hierarchical hypertexts and the role of temporal sequence information

The first two studies reported in chapter five examined the possible utility of those features which had been found to assist readers in navigating through hierarchically structured hypertext documents when applied to non-hierarchically structured ones. The contents cards for both studies were interactive (see section 5.1) and the features found to be of significant benefit in the first study were retained for both conditions in the second. The data obtained indicated that the features which were found to be of benefit to readers of hierarchical hypertexts were also of benefit to readers of non-hierarchical hypertexts:

1. Performance in both a relocation and map construction task was superior when subjects were provided with a graphical representation of the document's structure.

2. The addition of a footprint to the contents card was of significant benefit for both tasks.

3. Providing readers with a record of the cards which they had accessed significantly enhanced performance.
4. Showing the direction of the links between cards significantly improved performance on both tasks.

5. The ability to relocate information was positively correlated with the gain in accuracy between pre- and post-experiment maps of the document's structure produced by subjects.

The third experiment described in this chapter investigated the effect of providing temporal sequence information on readers' ability to relocate information from within both hierarchically and non-hierarchically structured documents. It was found that (i) the addition of an ordered list of cards accessed was of significant benefit for a relocation task, and (ii) performance was superior using a hierarchically structured document. It was suggested that the latter finding may have been influenced by prior experiences in the paper medium.

8.1.5 Navigation in a hierarchical journal article

Chapter six described a study in which readers' ability to navigate through a hierarchically structured academic journal article was compared using two different interfaces to the article. The first interface was a straightforward list of the sections of text within the article, and the second contained those features found to be of benefit to readers in the experiments reported in the previous two chapters. The results of the study indicated that those features which were of assistance to readers of the encyclopaedic style documents employed in chapters four and five were also of benefit to readers of a hypertext journal article.

8.1.6 An electronic journal

In the final study of the thesis, reported in chapter seven, readers' ability to navigate through, and retrieve information from within, a database of hypertext journal articles was examined. The interfaces to the individual articles resembled the interface which had been found to be most helpful to subjects in the experiment described in chapter six. Performance was compared using two interfaces to the database itself: one contained the same features as those for the individual articles, and the other was a chronological list of the articles in the database. Subjects were required to locate information relevant to answering two essay-type questions. For the first question, the articles containing relevant information were linked within the database, while for the second question, the relevant articles were not linked.
The results indicated that those features which readers found to be of benefit for navigating through a hypertext journal article were useful for navigating through a database of such articles: performance by subjects using the interface containing these features was superior to that by subjects using the list type interface. Although the aim of the study was not to compare the paper and the electronic media, it was noted that the majority of subjects considered that an electronic journal of this kind was far superior to the existing paper journal system. The results of the study provide evidence that users of the proposed journal database did not 'get lost', but were able to use the database in order to perform a realistic task.

8.2 GENERAL DISCUSSION

A number of more general points relating to the proposed electronic journal are discussed in this section.

8.2.1 Electronic journals

There are perhaps two main approaches to the storage and distribution of an electronic journal. The first approach is that used for *Computer Human Factors*, where the material was stored centrally and accessed via a network. The second approach is that envisaged for the present electronic journal, where the journal would be available to the reader from their own microcomputer, and stored on CD-ROM, which is a publishing media rather than a shared resource such as a file server. The proposed electronic journal would therefore be similar to the reader having a personal subscription to a journal in the existing paper system. This approach eliminates the problems associated with the transmission of material over a network, such as bandwidth restrictions.

According to Gurnsey (1985):

"An electronic journal is where the writing, editing, refereeing and distribution of an item are carried out without any paper intermediaries" (p.131).

The aim of *Computer Human Factors* was to provide online support for the whole of the publication process and, as the necessary technology is now available, it would seem likely that this will occur in the near future. Indeed the majority of writers now use a wordprocessor, and some journals require authors to submit articles in an electronic format.

Gumsey also considers that:
"What essentially distinguishes the electronic journal from full text online retrieval is its degree of interaction" (p.134).

The use of hypertext for the presentation of the electronic journal described in chapter seven permits readers to interact with the information to a far greater degree than if it was merely an electronic replication of the paper medium. It is therefore suggested that the proposed electronic journal fulfills the second of Gumsey’s criterion.

8.2.2 Comparison with Computer Human Factors on the BLEND system

The difficulties encountered by readers of Computer Human Factors were mainly due to technological problems – a lack of graphics, poor display quality, slow response time and insufficient support for both browsing and information retrieval.

The lack of graphics was found to have an adverse influence on both authors’ ability to display material and readers’ ability to interpret information. However, as noted in section 6.3.2.3, all of the graphics from the original paper versions of the articles were available in the electronic versions employed in the studies reported in this thesis.

Hardware difficulties were also responsible for some readers’ dissatisfaction with the quality of the display in Computer Human Factors, and it was not acceptable to all users. Although the aim of the present studies was not to compare the two media, none of the users of the electronic journal database described in this thesis mentioned having any problems in reading from the screen – even if they had been led to believe that they would, e.g., “People have said that it’s hard to read things from a computer screen, but after seeing this, I don’t think it’s a problem at all”.

The response time was considered to be acceptable by all the users of the proposed electronic journal, and it is of interest to note that this was thought to be an important factor, several subjects saying that a slow response time would have made their opinions of the journal less favourable.

Perhaps the major conclusion to be drawn from the findings of the BLEND project was that readers required a system which would enable them to browse through, search, and retrieve, information more easily from an electronic journal. The provision of facilities permitting readers to do this was the main consideration in the design of the electronic journal database described in chapter seven, and it is suggested that this aim was accomplished.
8.2.3 Benefits of the proposed electronic journal

In section 1.2.1, a number of the difficulties found by users of the paper-based journal system were discussed, and it was proposed that an electronic journal could help to alleviate many of them. Some of these problems concern access to journals: rising costs and lack of storage space have resulted in libraries being able to hold fewer journals, and physical access to libraries (e.g., limited opening hours) constitutes a further difficulty for readers. In addition, even if a library holds a volume, it may not actually be available to the reader — for example, it could already be out on loan. However, the proposed electronic journal, using CD-ROM as the storage medium, would provide access to a full range of journals from the reader’s own microcomputer, which would therefore be available whenever they desired.

A second shortcoming of the paper-based journal system is that there are restrictions on the number and length of articles which can be published in an issue, but there would be no such restrictions in the proposed electronic journal. Indeed, as will be discussed in section 8.3.2, it would not be necessary for articles to be published in issues at all.

Perhaps the major criticism of the paper journal system is that it does not support rapid access to relevant information, as one of the proposed electronic journal users remarked “It was quicker than using paper journals when I was doing the questions. It would have taken me ages, and I probably wouldn’t have done as well, been as thorough”. Readers need to be able to assess the relevance of an article quickly (e.g., Kilgour, 1987) and, as it would appear that only a small portion of an article is actually used (e.g., Sabine and Sabine, 1987), access that material rapidly from within the article. The present author considers that the proposed electronic journal facilitates both of these processes, permitting readers to both assess the relevance of an article and extract the required information more efficiently than in the paper journal system. This suggestion would seem to be supported by users of the electronic journal, e.g., “I thought I found the information quicker than if I’d had paper journals. Being able to go and look at the main section titles all together on a page was good. With paper you have to go right through to find them” and “I enjoyed it – it’s more fun than reading from paper articles. Also more efficient, less time-consuming. That’s important when searching for relevant information. There are so many papers and journals and you need to get through them fast”. Over half of those readers interviewed by Dillon et al. (1988) felt that they missed relevant material from paper journals, and it is suggested that an electronic journal could improve this situation considerably.
8.2.4 Does the electronic journal support the ways in which the paper journal system is used?

In addition to alleviating some of the problems associated with the paper-based journal system, an electronic journal must permit readers to perform those tasks for which paper journals are used.

In the paper journal system, the commonest method of making accidental discoveries is by scanning current articles, browsing through primary publications is the main method of maintaining current awareness (Royal Society, 1981), and the value of serendipity is recognized by readers (e.g., Line, 1971). Support for browsing must therefore be a major consideration in the design of an electronic journal. It is suggested that the interactive maps at the database and article levels, and permitting readers to jump to cross-referenced articles from the "title page" of the article and citations in the text, all support and encourage browsing.

As discussed in section 1.2.2.3, users of the paper journal system frequently take photocopies of articles. Reasons given by those readers interviewed by Dillon et al. (1988) included (i) they did not want to remove the journal in case another person needed it, (ii) a photocopy could be read in detail at their own convenience, (iii) it could be annotated and highlighted, and (iv) it could be stored for easy retrieval at a later date. The first two of these would not be an issue with the proposed electronic journal, as each reader would have unrestricted access to the entire journal. The third is already possible with existing technology and is an area to be examined with regard to future electronic journals, and the fourth reason is discussed in section 8.3.5.

The findings of the studies reported in chapter two of this thesis indicated that a large proportion of an academic's reading is carried out either whilst travelling or at home. Consequently, it is recognized that although many advances have recently been made in the development of lap-top computers, and an ever-increasing number of people have access to a computer at home, there will still be a requirement for readers to be able to obtain a hard-copy of journal articles for some time to come.

8.2.5 What facilities have other writers proposed that designers of hypertext should provide, and has the electronic journal done so?

Several writers have pointed to specific facilities which they consider that a hypertext system should provide. According to Shneiderman (1988), readers of a hypertext should be provided with information as to whether they have read everything, and information that enables them to form a concept of the total structure of the hypertext. A
similar view is expressed by Wright (1989), who considers that hypertext systems should (i) permit readers to return to some part of the text they have seen earlier, (ii) give them some assistance in planning their way forward – where they can go to from their current position, and (iii) provide them with information concerning which parts of the hypertext they have not already seen. Oren (1988) suggests that a hypertext system should include facilities that can (i) tell the reader when they have seen everything and how much they have not seen, (ii) show them something new, (iii) show them the path to something they have seen before, and (iv) review the particular paths they have taken to a certain location. Mahony (1988) proposes that the basic requirements of a good hypertext interface include:

1. Facilities for browsing.
2. Good searching and navigation techniques.
3. Clear and consistent information about link types and link labels.
4. Clear and consistent information concerning the type, content, author, size and name of objects.

The electronic journal described in chapter seven of this thesis provides readers with the majority of these facilities. For example, Shneiderman, Wright and Oren all consider that a hypertext system should show readers which parts of the information structure they have/have not seen – the record of cards opened on the article maps, and of the articles visited on the database map, fulfill such a function. Additional information is available in the ‘sections seen’ and ‘articles seen’ lists. The map at the database level provides readers with information enabling them to form a concept of the overall structure of the database (Shneiderman, 1988). The ordered lists of sections and articles seen and the reverse video on the maps show readers the path to something they have seen before (Oren, 1988), and depicting the links on the maps (at both the article and journal level) shows readers where they can go from their current position (Wright, 1989).

8.3 FUTURE ELECTRONIC JOURNALS

Following the sequence of development from EIES, through BLEND, to the present electronic journal, each has provided valuable information to assist in the design of the next. In a similar manner, readers’ responses to the present electronic journal provide lessons for the design of future ones. As Brown (1988b) says:

"Few, if any, of the areas lend themselves to dramatic ‘solutions’. Instead we must hope for steady progress, each step extending the viability of hypertext by a small amount” (p.190).
Suggestions for the design of future electronic journals and issues to be explored are discussed in the following section.

8.3.1 Hypertext systems

One question to be addressed concerns the relative merits of different hypertext systems for the presentation of an electronic journal. Some systems (e.g., HyperCard) are based on the concept of index cards, thus displaying the text in 'pages', whereas others (e.g., Guide) are based on the notion of an unfolding scroll. The provision of alternative navigation cues may be more important in the latter type of systems, because some of the location cues known to assist readers (e.g., Rothkopf, 1971; Lovelace and Southall, 1983) are lost. For example, the position of a particular item of text on the screen is dependent upon which sections of the article are 'unfolded', and so there are no within-page location cues. However, there may be an advantage in employing a system based on an 'unfolding' metaphor, in that it reflects the hierarchical structure of an academic journal article more easily than a card-based system, and it is also argued (see Brown, 1987) that providing a strong hierarchical structure may help readers to navigate through a hypertext.

How a map of a database's structure may be implemented in a scrolling type of hypertext system is yet another question – indeed it may be that different types of systems are required at different levels of an electronic journal database (see, for example, McKnight, 1990).

In some hypertext systems (e.g., Intermedia) it is possible for more than one window to be open at a time. This permits alternative designs for an electronic journal to be explored, such as displaying the database map in one window, and the article text in another, or allowing readers to have several articles (or several pages from the same one) visible simultaneously. In view of the fact that for many tasks, readers of paper journals frequently have more than one article open on their desks at a time, it is likely that an equivalent facility in the electronic medium would be of benefit. However, the additional navigation issues involved in a multi-window environment would require some investigation, e.g., how many windows are readers able to open simultaneously, and what navigation facilities should designers provide?

8.3.2 Journal structure

One criticism of the electronic journal described in chapter seven of this thesis is that, due to limited copyright permission, the articles all came from a single paper journal title.
Pullinger (1983) suggests that a structure comprising journals, volumes and issues, as in the paper medium, is the optimum format for an electronic journal, for the following reasons:

1. In the early days of EIES, it was found that issues, rather than accumulation, was the preferred format — readers liked to know that a new issue would be available when they logged in.

2. An electronic journal would be "easier and 'more obvious' to use" if it was structured in a familiar way.

3. The danger of information overload (Hiltz and Turoff, 1985) may be alleviated.

4. A journal broadly corresponds to a reader's interests, i.e., he selects a particular journal title because he knows that it contains articles in his own field.

5. Citations would be difficult unless the articles form part of a 'package' similar to existing journals (Line, 1984).

Nonetheless, it is proposed that articles could be published individually in the electronic medium. Pullinger's first consideration would not apply in the type of electronic journal envisaged by the present author, because readers would not log-on to a system, but would receive articles on CD-ROM as they were produced, and the second point has yet to be empirically validated. The same amount of information would be available regardless of whether articles were published singly or grouped together under journal titles, and it would be possible to set up filters, such as in Newspeek (see Yankelovich et al., 1985), whereby readers could enter a user profile and articles could be selected according to their own needs and interests. Citations would still be possible if articles were published individually, as they could be identified by a title, author, year of publication, and reference number.

8.3.3 Journal size

A second shortcoming of the electronic journal constructed for the present research is that it only contained a small number of articles. When there are more articles in the database, it will obviously not be possible to show the entire contents on a single screen, and finding a suitable solution to this problem is one of the issues to be addressed in future research. As noted in sections 7.3.10 and 7.4.6, some suggestions were made by users of the electronic journal, and other possible solutions have been proposed by various writers. For example, Engel et al. (1983) suggest three
approaches to the problem: (i) 'zooming in', (ii) panning across the structure, and (iii) a hierarchical series of screens. The third of these (as used at the article level of the electronic journal) is clearly not appropriate for the electronic journal described in chapter seven of this thesis, because the database is not hierarchically structured.

Two alternative solutions are discussed by Oren (1987) – filtering and distorted views. Filtering is the removal of documents from view based on some simple criterion (Kay, 1983), with the user being required to manipulate the filtering criteria, rather than the system doing this automatically. Distorted views use more complex criteria for the rejection or inclusion of nodes in the display. The 'fisheye view' (Furnas, 1986) is one example of a distorted view, where information is shown according to the distance from the viewing point, with more detail omitted farther away from it. Clusters are another kind of distorted view. Here each document is assigned to one or more clusters, and the neighbourhood view from a node shows the adjoining clusters, rather than single documents.

Spence and Apperley (1982) describe a 'bifocal display', in which the screen is divided into three vertical sections. The information of main interest is displayed in the centre of the screen at a high level of detail, and the outer two regions display information in just enough detail to give an overall impression of its content. The authors claim that such a technique has the advantage of providing the user with a detailed view of a particular item, whilst also placing it in context.

There are potential problems associated with all of these proposed solutions. For example, filtering removes serendipity (Oren, 1987), there are difficulties in determining the appropriate amount of detail for each level of the display in a fisheye view (Valdez et al., 1988) and in deciding which attributes it is necessary to show in order for users to be able to identify items in the outer regions of a bifocal display.

8.3.4 Search facilities

As discussed in section 1.11, a search facility was not provided in the studies reported in this thesis because one of the main aims of the research was to examine readers' ability to navigate through the information structure. The possible benefits of search facilities were noted by users of the electronic journal, but they also spoke of the difficulties experienced when attempting to use existing search mechanisms. Problems with search facilities in the electronic medium have also been noted by Marchionini (1988a), who found that subjects did not take advantage of the full-text search facilities offered by the system, and Richardson et al. (1988), in whose study a string search facility was used both inappropriately and unsuccessfully by readers.
Lack of familiarity with both the existence and use of a string search facility would clearly have some influence on these findings, and it is possible that user training has an important role to play in the future. Nonetheless, there would appear to be some problems associated with existing facilities, and, given there are many types of task for which they may be of benefit to readers, it would seem that (i) a string search facility is desirable for an electronic journal, and (ii) that work is required in order to make existing facilities more 'user friendly'.

8.3.5 Links

There are a number of questions to be addressed concerning the use of links within a hypertext journal database. In the electronic journal described in chapter seven, the links between articles take the reader to the 'title page' of a referenced article. However, in some situations, he may prefer to jump to another part of the article (e.g., to see a quote in context), and the desirability and implementation of links to specific points within articles is another issue to be examined in future research.

"The links in a body of literature can be viewed as connecting two classes of associations: objective and subjective. Objective associations are those which derive from the structure of the texts themselves, the text as data. Subjective associations are those which derive from an interpretative understanding of the document" (Kahn, 1989, p.112).

The links provided in the present database were explicitly indicated in the text, but there are also other kinds of links – those which are implicitly suggested by the document. Explicit/objective links could be generated automatically, but the selection of implicit/subjective links is a more complex issue. If the article was originally constructed in hypertext, then the author would put in their own links, but if it was a conversion of a document from the paper medium, then there would be questions concerning the interpretation of another person's work. One possible solution to this problem is that, because it is impossible to anticipate all of the possible reasons why a reader may choose to access an article or a journal, it may be useful to let them create their own links. According to Yankelovich et al. (1985):

"Ideally, authors and readers should have the same set of integrated tools that allow them to browse through material during the document preparation process and to add annotations and original links as they progress through the information web. In effect, the boundary between author and reader should largely disappear" (p.21),

and such a suggestion would perhaps be nearer to the "true spirit" of hypertext. If readers were able to put in their own links between articles, then they could construct personalized databases comprising a subset of the original database. This would offer a
similar facility to taking photocopies in the paper medium, but also allow readers to link the selected articles. Furthermore, it would be possible for readers to annotate articles, perhaps indicating the reason for their selection, and why particular links were made.

8.3.6 Additional features

There are a number of features that could be added to the proposed electronic journal database which may be of benefit to readers. First, the electronic journal does not provide any indication of the length of an article – such information may be particularly important in view of Dillon et al.'s (1988) finding that this factor has an influence on decisions about whether or not to read an article. If a card-based hypertext system was used, the simplest solution would be to add the number of cards that an article contained to its ‘title page’. Other facilities that readers may find useful include: the option of returning to the card they were last on when going back to a particular article (either within or between sessions), the option of retaining the records of article sections and/or articles visited between sessions, and a record of whether they had ever looked at a particular article. All of these are issues should be examined in future research.

8.3.7 Authoring

In section 8.3.5, hypertexts converted from paper documents were contrasted with those constructed in a hypertext environment. The articles employed in the present electronic journal were converted from existing articles in the paper medium. However, for Computer Human Factors in the BLEND system, the articles were especially written for the electronic medium. It would seem likely that future hypertext electronic journals will be concerned both with the conversion of existing articles into a hypertext format and the construction of articles specifically for such journals. There are obviously many design issues involved with the latter, but, as Lacy, Chignell and Kinnell (1988) state:

"Hypertext authoring is a new and poorly understood process" (p.314).

and work is clearly required in this area. It is of interest to note that a special issue of the journal Hypermedia will be produced next year, only available as a hypertext, and containing articles written specifically for the hypertext environment, rather than converted from paper versions.
In section 4.1.3, it was proposed that if people are to prefer the electronic medium, then they must be provided with facilities which enable them not only to do things which they are able to in the paper medium, but also those that they would find useful, but which are not possible using the paper medium. The intention of the research reported in this thesis was to identify those facilities which readers of academic journals would find of benefit, and to determine how these could be provided in an electronic journal. It was suggested that the major difficulty encountered by users of the paper-based journal system is in accessing relevant information both quickly and easily, and it was concluded that the use of hypertext as a presentation vehicle could assist readers in this process. However, the flexible access that hypertext systems permit may cause readers to become 'lost in hyperspace', and a series of studies was conducted in order to identify those facilities which could help to prevent this. The features found to assist readers in navigating through, and retrieving information from within, hypertext documents were applied to a database of academic journal articles. The objective and subjective data obtained from users of the proposed electronic journal suggested that if additional functionality is provided, an electronic journal may be considered preferable to the paper version.

The present author is in no doubt that, as has been shown in the research reported in this thesis, hypertext systems can provide many benefits for readers, but it is vital that navigation support is considered from the very first stages of the design process. As Shneiderman (1989) says:

"Hypertext can be helpful, but there is a real danger that it can also lead to hyperchaos" (p.116).

Finally, and most importantly, any future development of the electronic journal must be user, and not technology, driven – in the words of Shneiderman (1989):

"But we hope that the trail-blazers will think about where they are going in addition to how to get there. And those that follow them will do so for purpose as well as for possibilities" (p.130).
REFERENCES


