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HyperTools for HyperTexts: Supporting Readers of Electronic documents

Kent Norman
Department of Psychology
University of Maryland
College Park, MD 20742, USA
and
Patricia Wright
MRC Applied Psychology Unit
15 Chaucer Road, Cambridge CB2 2EF, England

Running Head: **HyperTools for tasks with texts**

ABSTRACT

The most important factor determining the usability of electronic documents (e.g. hypertexts) is neither the set of links within the material nor the structure of the database but the availability "hypertools" defined as a vast range of electronic tools to support a diversity of reading activities. To illustrate this point, an analysis is undertaken of reading done for the purpose of using the information within a document to assist in tasks involving planning, decision making, and problem solving. Secondly, many readers start with the goals of finding, comparing, and evaluating information. Tools can help them realize these goals by supporting the activities of searching, collecting, and manipulating information. Other tools help people explore task requirements, enable them to preplan details of their interaction with the text, enhance their use of other tools, and optimize their screen-based working environment. It is argued that the support available for people working with electronic texts will not only offer many of of the functions available to readers of printed text, but electronic tools will also offer functionality that has no close counterpart in printed media. Consequently, hypertools will change the way readers do familiar tasks and facilitate tasks which are exceedingly difficult to accomplish when working with information on paper.

1.0 Introduction

The purposes of reading are as diverse as the materials read and the activity of reading often not the end in itself but a means to an end. The present paper focuses on the activities that take place when readers have some goal which the text content is helping them attain. These goals may involve making decisions, diagnosing faults, composing new documents, and solving problems. For convenience, such task-driven reading will be referred to here as *serious reading* to distinguish it from casual browsing or reading for relaxation or entertainment. When people are engaged in serious reading, the actual comprehension of the material is only one of the many activities they undertake. Typically people use a variety of tools so that their reading activities adequately support their reading objectives. This is evident for printed materials where readers may use tools such as highlighting pens, bookmarks, notes they make, dictionaries, and indexes. The equivalents of such tools will be wanted by those working with electronic documents. However, with computer-based tools it is possible to provide much more powerful support for the varied and cognitively complex tasks in which information is both the raw input and the final product. Such tools take advantage of the processability of electronic text.

Electronic documents are not all alike. They include linear texts generated by word processors, databases generated by file management applications, hypertexts generated by architectures that facilitate the creation of links among items of information (cf. Conklin, 1987), and hypermedia where sound and animated graphic displays supplement the written information (cf. Ambron & Hooper, 1988; Laurel et al., 1990). Serious reading may engage any one of these document types, so issues about the development of tools that support reading will apply to a broad range of computer-based documents. Much of the following discussion will be illustrated with reference to hypertexts for two reasons. This is a domain where the need for tools that support readers working with electronic documents can be clearly seen (e.g. McAleese, 1989; McAleese and Green, 1990; Shneiderman & Kearsley, 1989). It is also a domain where there exists research evidence relating to some of the constituent activities of serious reading tasks (e.g. Marchionini, 1988).

A concrete example of the kinds of serious reading task being addressed here will help to make salient the categories of tools that could be useful to readers. Consider people who intend making a day trip to a large city and who have access to a hypermedia database about the city. A visitor to Glasgow, Scotland, for example, may access the hypermedia database Glasgow Online (Baird & Percival, 1989). Such visitors may have agendas that include key places they want to visit (e.g. a museum, an art gallery, a park) and things that they want to do which may not be totally place specific (e.g. see a play, buy a book). There may also be highly underspecified items on the agenda, such as the intention to have lunch but no strong preference about what to eat or where. Converting this outline agenda into a detailed timetable for the day may be hampered from the outset by queries about opening times or how to get from one place to another.

The visitor's main task is to accommodate as many of the key items as possible while satisfying the subordinate goals appropriately. Although relevant hypertexts exist for such tasks (e.g. Baird and Percival, 1989; Hardman, 1989), their use in decision-making and planning tasks has yet to be adequately explored. Readers probably begin by seeking information about these items to which they have assigned high priorities. They may then pause to collate these items into an interim schedule before returning to the document to seek more information, perhaps about less important events or perhaps information related to that already found (e.g. the proximity of a bus stop or car park).

As iterations continue, the compiled schedule for the day may need modification in order to accommodate new information. Processes of comparison and sequencing of the items found become part of the reader's problem solving activity. The behaviour engaged in after relevant information has been collected will here be referred to as *manipulating* the information. From this example it can be seen that when planning a day in town, readers start with the goals of finding, comparing, and evaluating information, which they realize by engaging in activities such as searching, collecting, and manipulating information from one or more documents. Each of these three activities can be cognitively very demanding if attempted without any form of assistance. Even finding relevant information about different destinations means keeping track of one's progress through a mental list of search targets and remembering the outcomes of each search. Fortunately, for electronic documents there are computer-based tools that can be provided to reduce the mental load on memory and decision making processes. Table 1 lists some of the cognitive demands of the three subtasks of serious reading, together with some of the functionality of potential tools that could reduce these demands.

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Although planning a day in town may seem a special and perhaps rather atypical use of electronic information, its multivariate character gives it many of the features of other serious reading tasks. It has been shown that most of the reading done in the context of work is some form of "reading to do" (Sticht, 1985). Finding, collecting, and manipulating information are normal constituents of this kind of reading (Wright, 1983). The three sets of reading processes highlighted by the example of spending a day in town are a commonplace experience both inside and outside the workplace. These processes are called into play by those making multi-dimensional decisions (e.g. about major purchases such as a car or house), by many who consult reference materials (e.g. to name an unfamiliar bird or flower), by people engaged in planning activities (whether vacations or careers). Finding, collecting and manipulating information from documents are familiar activities to serious readers, even if they are not yet a major feature of the research literature on reading.

The reader's need for supporting tools has been recognized by some software designers. Scrolling, string searching and sorting tools are common place in word processing and database applications. Hypertexts have prompted the development of tools that assist browsing, exploration, and discovery (e.g. Allinson & Hammond, 1989). This paper seeks to show that such tools are likely to be needed in all electronic documents and that the potential of a vast range of other tools remains to be exploited. Consequently *hypertools* refers to the vast network of computer-based support that can be made available to those engaged in serious reading tasks.

2.0 Navigation as a set of tools

The problems of access and traversal through electronic documents are not trivial (cf. Nielsen, 1990; Norman, 1991; Parunak, 1989). Complaints from readers about the difficulties of moving from place to place within computer displayed texts have been frequent. These problems have arisen even in linear documents, particularly if readers want to refer back to information they have previously read (Wright and Lickorish, 1984). Word processors and spreadsheets include GoTo commands which enable readers to go directly to a designated page or cell. Indeed the designation can be made either by document features (e.g. page or cell number) or by the reader's prior assignment of a marker. Nevertheless these kinds of navigation tools are less common in other electronic documents.

In documents having a web structure, such as hypertexts, the difficulties encountered when moving around can be much worse than in linear or matrix structures. Readers may not only be uncertain about where they are but also uncertain where to go next. Readers complain that they get lost (e.g. Edwards and Hardman, 1989; Simpson, 1990). In part readers' difficulties have arisen from the use by document designers of embedded links in the text as a tool for navigation through the material. Hypertext links are both the implicit structural device that transforms the text into a meaningful network and the explicit tool by which readers access the information within that network. In principle these two functions can be separated. The hypertext database would thus contain the text and the links perhaps in the form of a standard generalized markup language (SGML) and a separate navigation tool would make the links explicitly available via a rich diversity of access devices including tables of contents, indexes, glossaries of terms, diagrammatic overviews of the text structure and string searching functions. These navigation tools differ in the functionality they offer. Some tools enable readers to move onward from screen to screen; others help readers retrace their steps to previously displayed information; still others allow readers to jump from overviews or index entries directly to the text.

The range of navigation tools that exists suggests that what superficially appears as the same reading-related activity, namely moving within the text, might be better seen as a cluster of diverse activities which have not yet been clearly articulated in contemporary models of the reading process. The advent of electronic documents makes this aspect of readers' behaviour more salient, and urges its incorporation within theories of reading. Certainly in some serious reading tasks it has been found desirable to provide a diversity of navigation options in order to meet readers' requirements (e.g. Salomon, 1990).

The embedded links within a hypertext can be instantiated in many ways and can have very different display characteristics. Sometimes typographic cues, such as bold and italic type, are stripped of their conventional meanings and reassigned to navigation functions. For example, a phrase in bold face may signal to readers that additional information can be seen by clicking on this phrase (e.g. Shneiderman, 1989). On the other hand, designers could take advantage of the conventional meanings of typographic cues by associating their connotation with the type of link provided. For example, parenthetic citations could be used to go to that reference. Moreover designers are inventing new typographic cues with new meanings such as boxes, pointers, and animated words. Embedded links may only become apparent when requested by readers (e.g. GUIDE™). Readers might wish to create their own personal routes through the text, routes which they could re-navigate whenever they wanted (Chin, 1989). This might be done on either a temporary (e.g. task specific) or a permanent basis. Such functionality requires new tools and perhaps also new skills being made available to readers.

There are important issues about the integration of navigation control with the display(s) of the text content. For example, navigation options can be either embedded in the text itself or integrated with the syntax of the screen display surrounding the text but separate from the actual content matter, or allocated to a completely independent window. Design differences such as these will have psychological implications. Wright and Lickorish (1990) showed that there were circumstances where restricting navigation to a table of contents was not only acceptable to readers but they preferred it to using links that were integrated with the screen display surrounding the text. However, even for these readers, changing the content and structure of the information changed their preference. At present these issues can be raised but we lack the deep understanding of serious reading that would allow us to resolve them.

Something of the flavor of the psychological importance of different navigation styles can be seen with reference to the earlier example of a visitor seeking to spend a day in town. The reader who is moving from a text location, such as the description of a special exhibition within a museum, to check on the opening time of that museum, may feel quite a different transition from that made when checking what is happening at another museum. Furthermore, both these moves may feel different to the reader from going to an electronic map to check where the nearest bus stop is. These feelings may derive from the orientation imposed by the task rather than being a property inherent in the text structure. However, it is not necessarily a low level description of the task activities that will capture this adequately. In procedural terms these different kinds of information may all be the same number of clicks/choices away from the reader's starting point, but the psychological distances can differ greatly. Varying psychological distance may influence readers' willingness to make the transition. Creating adequate interfaces for hypertexts may require a detailed understanding of readers' information seeking behaviour. A promising start in this direction has already been made by Guthrie (1990) who presents a model of how users search electronic documents.

DeRose (1989) has shown how varied the semantic links can be within a document, and so has emphasized that not all links are equal. Readers may find it helpful if the display of these navigation options reflects something of the psychological closeness of the destination. This could be done either by providing similar tools (e.g. buttons at the side of the screen) in visually different forms, or by providing completely different tools for the different kinds of movement (e.g. embedded links to pop-up displays for psychologically close destinations (Stark, 1990); margin buttons for movements up and down the hierarchy; and either maps or cross-reference cues as ways of reaching destinations further afield). In time, conventions for navigating in electronic documents may become established. At present readers are usually faced with learning the ad hoc conventions of the document they are trying to use. Working simultaneously with more than one document, created by different hypertext designers, can therefore be a taxing adventure.

The functionality of navigation tools is likely to be reflected in the professional affiliation of those who provide them. The author of a text may be responsible for creating the embedded links within that text and perhaps also providing some form of overview or table of content. In contrast, third party vendors could provide software for generating indexes and might supply some of the non-embedded navigation aids. SuperBook™ offers one example of just such a division of labor between author and the provider of additional navigation assistance (Remde et al. 1987). Tools from third parties are particularly valuable as a resource for dealing with materials which have already been written, or which are being written primarily for printed distribution but are available electronically.

The main purpose of navigation tools is to allow readers to move within the document looking at information in various locations. As such, navigation resources are one means of finding information. However, the complexity of many search tasks means that a range of other tools are also needed to assist readers locate the material they seek (see below). Moreover, as we have already noted, in serious reading searching for information is but one of several activities that readers engage in. They may also wish to move through the information they have collected, and go back and forth among different organizations of this information. So navigation support is also likely to be found within or associated with other tools as suggested in Figure 1. Therefore the emerging picture of the support that hypertext users need is of sets of tools, each set clustering around the reading activities it assists. Some of the ways in which a variety of reading aids may be linked to each other will be considered later in the discussion of tools that can help readers plan and co- ordinate their reading activities. Before this, it is appropriate to examine the kinds of tools that are needed to support readers' activities of searching, collecting and manipulating information.

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3.0 Searching for relevant material

A great deal is known about the difficulties of formulating queries so that the information wanted is the information found by a particular search (Dumais, 1988). Some on-line systems respond to this problem by having a human intermediary help people hone their queries and maximize their chances of success. Without such help it is easy for searchers to either define the search target so narrowly that many relevant items are missed, or define the target so broadly that the information being sought is swamped by a mountain of irrelevant material (cf. Lesk, 1989).

The kinds of search tools required will depend on the specificity of the target. At one end of the specificity continuum, it may be possible to use a string search to find the few instances of an easily specifiable target (e.g. the whereabouts of Picasso exhibits). However, not all targets that can be well specified are amenable to string search (e.g. the time of the last train home). Here readers may be able to rely on navigation tools that allow them to go from either a table of contents or some other map of the document structure to those parts of the text most likely to contain the information wanted. It becomes a natural extension of this kind of search support to enable movement to be made directly, perhaps by selecting text locations from a range of clickable indexes or glossaries without having to remember and interpret intermediate text locations. Wright (1990) provides a more detailed outline of the functionality that could be provided within a range of search tools for use in locating different kinds of targets.

At the other end of the continuum of target specificity readers may have little knowledge about what they are looking for (e.g., *something to do before the play starts*). When the search target is ill-defined, tools which support free browsing and which offer overviews or content maps or even guided tours may be very helpful. Husic (1989) has coined the phrase *goal directed browsing* to describe this kind of reading activity. The network of links within hypertexts may be a particularly useful way of instantiating tools to support such searching. Laurel et al. (1990) have shown how the help of a guide which selectively highlights just some of the embedded links can improve the quality of readers' browsing. Other kinds of tools may help readers formulate their query more precisely. Norman and Chin (1989) introduced the metaphor of a *server* as an intelligent mediator to guide menu selection processes much as a helpful waiter may in a restaurant. This advice might be given indirectly (e.g., by providing information about the document content) or more directly by engaging readers in a preliminary dialogue about their main task and reading objectives. Both forms of advice giving point to the need for some *intelligen*t tools, a feature which will be discussed later in relation to aids that help readers plan their interaction with the text.

Even when the search target can be clearly specified, readers may need assistance in modifying this target. People may need to be reminded of the importance of checking synonyms and related words, as well as searching on root morphemes (e.g., *communic* rather than *communicate* or *communication*). Knowing how to exclude those senses of the word not currently wanted (e.g., avoiding *train* in the locomotive sense and finding only those instances of its educational meaning) can be even more difficult for readers. Yet the many thesauri currently in electronic form, offer a basis for creating tools which will respond to the readers' search command by prompting the reader with synonyms and modified targets which can be included or not as the reader sees fit. A sophisticated evolution of this approach has been formally proposed as Latent Semantic Indexing (Dumais et al., 1988). Perhaps in time the availability and use of such tools may become as commonplace for the readers of electronic documents as dictionaries are for those who read printed texts.

Even when readers know precisely what they are looking for, problems can arise if the search yields no apparent instance of that target. For example, the visitor to town who is seeking a pizza for lunch near a particular museum may find no perfect match with the criteria of *pizza + location*. Computer-based tools could offer content driven suggestions about the likely consequences of relaxing criteria. Readers could be told how many targets would be found if pizza were changed to include other fast food places or if the location were moved. Without such help many searchers would have to start again in an almost blind fashion if the first search failed (Norman and Butler, 1989).

Target specificity is not the only factor which contributes to people's difficulties in finding material relevant to their reading objectives. Readers may know how to formulate their query but lack the mental capacity to apply that knowledge, perhaps because of other concurrent task demands. Readers' capacity limitations are often related to memory processes as enumerated in Table 1. Consideration of memory processes points to a cluster of problems that readers face: (a) remembering whether all of the intended locations within the text have been searched, (b) remembering what was found at those locations, (c) remembering where they have found relevant information in case they want to check it again. Search tools can offer assistance with the first of these problems by maintaining lists of the searches which can be matched against actual search attempts, hits, and locations. Assistance with the second problem, remembering what was found, requires the development of data collection tools as argued in the next section. Solving the third problem suggests the need for a different category of data collection functions, namely tools which create collections of valued locations within the text rather than of the text content.

4.0 Collecting the information found

Search tools have both an input and an output. So far we have considered the input problems (i.e, how readers specify what they want to find). From the perspective of their output, search tools fall broadly into two classes: (a) PICKERS: these pick and extract items out of the text and present them in storage locations outside the text (e.g. clipboards or notebooks), (b) POINTERS: these point to items and enable readers to return to locations in the text where relevant information was found. Figure 2 illustrates the general nature of both types of tools.

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The category of tools depicted in Figure 2a creates a collection of items found. This can be particularly useful when readers want to compare the collected items either with each other or with material in the source text. In a minimal way this is what the clickable notemaking facility of Wright and Lickorish (1990) accomplished. In that instance the information copied from the text gave only the details of a shop and the price being charged for a certain product. In principle the technique can be extended to copy much longer sections of text. By enabling serious readers to separate the activity of data collection from subsequent considerations of the items collected, extraction tools can reduce the load on readers' working memory.

In general, the information collected by readers could be displayed in separate collections rather than as a single compilation (e.g. museums, theaters, restaurants could be separated as they were collected). Extraction tools may be particularly useful when the information obtained from the text needs to be integrated with other material as part of the superordinate problem solving task. Whenever copies are made these may either sever the dynamic links that they had within the main text or they can retain them. Keeping the links solves the problem of returning to the original text. Indeed the "copy" may be a virtual window into the text itself. However, this can limit the usefulness of the tool. On the other hand, if the extracted information duplicates the source material, then the possibility exists for readers to create further links within this private workspace, and add new annotations to this copied information, without in any way perturbing the source text.

When large amounts of information are extracted, either in one "copy" or when numerous copies are made, other design issues arise. Just creating a collection of items will seldom be enough. In order to be able to use this information to reach some decision, readers will also need navigation tools for moving through the collected items. Navigation support is a more immediate property of the pointer tools as shown in Figure 2b. Among the advantages of pointer tools are that the items found can be read in context and readers can conduct further searches from the location of any item found. Existing hypertext systems have instantiated pointer tools in many different ways. For example, SuperBook™ integrates the results of any search with the display of the table of contents. This shows how the target's frequency of occurrence varies throughout the document (Remde, et al., 1987). In contrast, HyperCard™ displays the results of a search in a single window, where the location of only one retrieved item can be seen at a time. Not even the number of targets found is displayed for the reader, who must therefore check through all the places in the retrieval list hoping that the desired information will be located. NoteCards™ has the potential for graphically showing the semantic relationships among the items found, or at least the relationships of these items to some view of the text structure (Marshall and Irish, 1989). This may well have advantages over the more conventional table of contents, but even for fairly small documents it is not obvious that untutored readers will have the ability to make good use of this richer display. For larger documents, particularly those with irregular web structures, creating a usable overview can be very difficult.

The most familiar pointer tool is perhaps the bookmark. This differs from the pointer tools considered so far in that it requires deliberate placement by the reader, rather than being an automatic output of the search activity. Bookmarks have been included in some hypertext systems (e.g., Benest, 1990) as well as in a range of word processing applications (from Wordstar™ to Nisus™). In terms of their display characteristics, electronic bookmarks can differ in many ways. Bookmarks may all be visually identical (this is usually the case in word processing applications), or readers may be able to assign different typographic notations or even different icons for different purposes. This would parallel the functionality of extraction tools that allow separate collections to be formed. Another way in which bookmarks can be divided into categories by readers is through annotations. Sometimes bookmarks are numbered, but often this numbering is determined by serial order of assignment and readers may have no control over the numbers used. If readers have to rely on non-informative bookmarks as a way of moving within the information they have collected this could be cognitively onerous, particularly for reading tasks relating to multiattribute decision-making (e.g. remembering which order of visiting the museum and the art gallery fits in with having a pizza for lunch). The cognitive costs of interrupting search activities to create more informative bookmarks are not yet known. As we have mentioned, data gathering tools, whether extraction or revisiting, can either be manual or automatic. If they are manual, they require readers to explicitly "collect" the data or leave a bookmark each time a relevant item is found. In contrast, sophisticated tools would enable the data to be picked up automatically and routed to prescribed storage locations. Such tools free readers from having to remember to copy information every time an item is found, but they require people to understand their data collection needs well enough to be able to plan their data gathering in detail from the outset. Ill-defined tasks, such as planning a day in town, may not be able to benefit from the more powerful automatic tools.

Path tools which kept track of places visited in the hypertext network can also be used as pointer tools. For example, in HyperCard™ the “recent” option displays up to 42 of the last cards visited and allows the user to go directly to any one. Such tools create collections of found data. Path tools can also be used to manage collections of data by providing tours through the data that has been found. For example, in Glasgow Online a visitor to the city could use a path tool to create a tour through the places that he or she is planning to visit during the day. Multiple paths could be generated as sets of packaged tours. Visitors to the city could explore these tours and decide on the one that they liked best.

Data collection tools are particularly important when several targets are involved. Readers need support in gathering the desired information and discarding that which is not needed as a preliminary part of the decision making process. Data collection tools will also help even when only a few targets are involved if each target results in several "finds", any number of which may be relevant to the current task. In some instances it may be hard to tell whether a particular item of information is going to be wanted or not. For example, in scanning a list of restaurants for somewhere to eat there may be several "possibles," some "definitely nots," but no "definite yeses". This emphasises that collecting the information is not the end of the reading activity. After several items have been collected readers may want to perform additional operations on this data, or on the pointers to it.

Not all forms of serious reading will involve data gathering operations. When the reading objective requires finding only a single target (e.g. the telephone number of the theatre) and a single match to that target is found in the text, then the information may not need to be "collected" in any tool-intensive sense. However, if the information is to be combined with other computer- based functionality (e.g. a dial-up modem) then the ability to transfer the information across applications will be needed. Furthermore, such data may serve as the input to other applications such as spreadsheets that manipulate the information and combine it with other information.

5.0 Data Manipulation

Many of the tasks that give rise to serious reading require analysis, synthesis, restructuring, or evaluation of the information collected. Readers who access texts for the purpose of making decisions and solving problems will be collecting information about what alternatives are available, what attributes are relevant, what the consequences will be of various courses of action, what obstacles must be overcome, and what constraints exist. A number of sophisticated computer-based tools for decision making and problem solving exist (e.g. MacLean and Sol, 1986) and their relevance to serious reading will be considered below. But the kinds of data manipulation that could be useful to readers include many simpler tools. Readers may want to sort the collected information in various ways. For example, the visitor to town may want to bin items into categories such as museums, theaters, and restaurants. Here attributes of the text semantics can be easily used to automate the process. This is less easy when readers want to rank order items on composite or subjective criteria such as cost, distance, and attractiveness. Such sorting will often require manual intervention by readers after the data have been collected.

Tools for sorting and classifying by user-defined criteria may be essential for managing large data sets where the amount of information collected is beyond the capacity of the reader to either remember or process without assistance. At present such functionality is missing from most hypertexts. The assumption seems to be that readers will take their collected information and go elsewhere to make their decisions. The current foreshortening of the range of reading activities that are possible within the hypertext is unfortunate because, during the course of manipulation, readers may discover that insufficient information has been gathered. If additional material needs to be located, readers will want to be able to return to the original text easily. For electronic documents read on multitasking operating systems this may not be a problem. The development of so called *hot links* between applications may offer another solution for some tasks. The point is that serious reading may involve repeated iterations of the activities of searching, collecting and manipulating information. For convenience the present paper will deal only with a single iteration.

In discussing different categories of tools for manipulating the collected information (simple tools for categorizing and displaying groups of items; aggregation and decision support tools; reauthoring tools), it becomes evident that the output from these categories differ from each other. This is shown in Figure 3, where the variation in output serves to emphasize that these different tools support the different goals that serious readers have.

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Although computer-based support for decision making and problem solving already exists, few of these tools are available to the readers of electronic documents in an integrated, seamless way. Indeed this paper's theme concerns the need for tools that support diverse reading activities. This theme is consonant with other suggestions that the slow spread of information in hypertext form has been partly due to the failure to integrate hypertexts with the other computer-based applications that readers may be working with to achieve their superordinate task goals (Meyrowitz,1989). Hypertext documents provide readers with access to relevant information but they do not help readers collect and manipulate that information easily, nor do they facilitate its integration with other software. As a start, making available to readers a toolkit of data manipulation functions would greatly reduce the cognitive effort required in using analytic methods. This in turn should enhance the quality of the decisions reached.

The nature and amount of data manipulation required will be specific to particular tasks. Consequently, readers will have to customize the manipulation tools. For those inexperienced at serious reading it will probably be beneficial to provide templates for reformatting or manipulating the information. For example, a town visitor wishing to make a historical tour may collect information about historic events and the dates of buildings or famous inhabitants, and may want the collected information displayed in a way that shows these collected items relative to landmark historical events (e.g. age of historical buildings relative to the Protestant Reformation). While the availability of customizable displays of this kind is undoubtedly an asset, programming such data formatting tools places an added burden on readers. They now have to understand not only the rationale for manipulating the data but they must also be able to operate the method(s) for sophisticated analysis of the data. It seems likely that skills in using tools that support reading activities will become a hallmark of serious readers.

When readers carry out several searches they will sometimes want to integrate the results of these separate search activities, whether they were conducted on the same or on different texts. Moreover, it may not be the collected information itself which is of interest, no matter how it is displayed, but rather the reader's decision making may relate to the product of some operation performed upon this information. Perhaps total cost of the day in town is a constraint on what can be done. So data aggregation tools are needed. In some instances, e.g. where the information found is quantitative, these aggregation tools might be able to combine the outcomes of separate searches to produce an overall picture. The increasing potential for providing the output of aggregation operations in graphic and pictorial forms may facilitate the use of information resources by those who otherwise find multiattribute decision making very difficult. Certainly calculating averages or finding modal values when the data are numerical is trivial for the computer and can be very helpful for the serious reader.

It has been mentioned that there already exist powerful decision support systems and problem solving aids. These fall into three broad classes. In order of increasing complexity these are: decision analysis, multiattribute decision making, expert system problem solving. All systems are based on processing of the information deemed relevant according to a theoretical approach or a standard analytic procedure. In decision analysis, for example, alternative courses of action (e.g., to visit X or to visit Y), possible states of the world (e.g., X may be closed or Y is nearby), and an associated set of probabilities and payoffs are analyzed and searched for the optimal choice on the basis of Bayesian and expected utility theory (Edwards, 1961). In multiattribute decision making, a set of available alternatives is listed with their associated attributes and the utility of having those attributes. The information about each alternative is aggregated according to multiattribute utility theory and the alternatives are subsequently ranked according to their overall weighted utilities (Slovic and Lichtenstein, 1971). Finally, in expert problem solving, such as fault diagnosis and anomaly resolution, information collected may be a set of possible states, actions, and goals (Schank and Riesbeck, 1981). The expert system would act on this information to search for a possible solution and/or to request additional information. Because expert systems require domain specific knowledge, they will be developed for subgroups of serious readers rather than being widely available. However, the other two categories of decision support (decision analysis and multiattribute decision making) could be made generally available, once it was appreciated that much serious reading is done for the purpose of decision-making. Indeed it is worth noting that from the standpoint of the needs of the serious reader, the separate psychological domains of problem solving and decision making become very blurred. This affords another example of how the focus on human-computer interaction can suggest that new perspectives are sometimes needed on traditional psychological issues (cf. Wright, 1989).

One important aspect of the activity of information manipulation can be the readers' need to keep track of which manipulations have been considered and which still have to be implemented. For some kinds of problem solving there can be intermediate solutions which, even though unsatisfactory and abandoned, can contain fragments that will form part of the final solution. It can be one of the disadvantages of an electronic medium that the problem solver may over-write these early incomplete and unsatisfactory solutions. When doing a similar task using paper, people will tend to start afresh on a new sheet of paper when one line of attack looks unpromising. As a consequence, the earlier solution attempts are preserved, without any deliberate effort on the part of the problem solver. Work by Black (1990) suggests that this record of prior problem solving activity can be very important in supporting the creative performance of typography students creating a page layout. Tools have been built that address this problem, tools such as the *Designer's Notepad* (Sommerville, et al, 1990) which allow users to designate any partial solution as a *node* from which they can then branch out in one or more directions. The benefits of such manipulation tools are likely to extend beyond information which can be thought of as *design history*. Records of the manipulations made and the products of those manipulations are likely to be found advantageous in many multiattribute decision making tasks where iterations are required before a final solution is found. Iterative problem solving, with changed parameters, can be seen even in tasks as simple as planning to spend a day in town. Each attempt to plan the day requires an adjustment of what one is willing to give up in order to do something else.

The focus on a visitor making a day trip to a city emphasizes the uses of information where the final goal is independent of the originating source. However, if two people in different locations were planning this trip together, an important intermediate goal would be the creation of a new document, whether in electronic or printed media, that afforded the means of communication between them. When material is being read in order to write, then further categories of tools for manipulating the collected information will be needed. Information in the form of whole articles, portions of text, selections of graphics, and links between objects can, in principle, be collected and reworked. Sometimes the original information provider may have had subsequent multiple uses in mind. For example, a technical reference manual may yield much of the core information around which a training manual is later created. Where the output of information manipulation is an electronic document, the operations involved may include cutting and pasting, reorganizing and relinking, and even writing new material. The kinds of tools required will include authoring tools, particularly hypertext authoring tools, where concepts can be freely linked to serve some current purpose. User adaptations of hypertexts have been studied by Chin (1989) whose work suggests that sometimes it can be better to create new links rather than use multiple copies of sections from the source material. Again the ability to integrate the data collected with other computer-based applications (e.g. word processors or spreadsheets) will be a necessary functionality for some re-authoring tools. There are many issues, both cognitive and legal, that have yet to be addressed when it comes to recycling the information gleaned from electronic documents.

6.0 Tools for Planning

Serious reading tasks require that people start out with some kind of plan concerning how to accomplish the task. These plans may not be very explicit, and not necessarily detailed, but they have to include notions about what information is being sought, how it will be found, and what will be done with it once it has been found. Sometimes previous plans can be rerun if tasks of a broadly similar nature are repeated. Sometimes the hasty problem solver may use default plans (e.g. a default plan for finding and collecting information may be to browse, noting down items of interest). However, there will be tasks for which new plans must be devised. Planning tools share with navigation tools the potential for being either completely separate from other reading tools or being highly integrated with them.

In order to formulate a detailed plan, readers must understand the task, know the resources (e.g. tools) available, and evaluate alternative methods of attack. Among the less sophisticated forms of support for planning activities, hypertexts can provide users with information about (a) the structure of the database, (b) the range of available tools, and (c) a set of general guidelines or principles for approaching the problem. Such assistance has its parallel in printed materials - e.g. student textbooks that advise on how they may best be used. However, computer-based tools can enhance readers' planning behaviour in much more powerful ways. In particular, planning tools can act as intelligent assistants which help readers transform their goals of finding, comparing and deciding into the activities of searching, collecting and applying criteria (cf. Carlson and Ram, 1990). Although there already exist demonstrations of intelligent support for navigation within hypertexts (Boyle and Snell, 1990), the major advantage of an intelligent planning assistant is that it can suggest how to do the task as well as provide tools for actually carrying out the plans once made. These two aspects of planning are depicted in Figure 4. For example, people who infrequently use large information resources do not necessarily know how to use them well. They may even be unaware that certain tools exist. Consequently, readers may welcome several kinds of advice about (a) how to search (e.g., even the Yellow Pages give *see also* advice), (b) what information to collect, and (c) how to manipulate information collected from the text.

- -
Figure 4 about here
- -

Giving readers advice on where to look for a well- specified target is relatively straightforward and was discussed earlier in connection with search tools. Helping people structure their tasks and refine their goals so that they make best use of the information resource can be much harder, although inroads are being made into such problems (e.g. Pavlin, 1990). The need for guidance in doing the task is apparent when considering visitors to town who first decide where to have lunch and then discover that they are too far from the museum to get there before it closes. Helping readers understand the implications of relaxing criteria, or resequencing the order of their decision making, may call for advice-giving aids which can use a knowledge of the text as a basis for their advice, rather than offering context-free general solutions. Before such intelligent assistants can give powerful advice about ways of doing the task , it may be necessary for readers and planning assistants to develop a common language for discussing tasks, hopefully with a greater capacity for Doing What I Mean than is evident with many software tools at present.

As well as helping readers structure their task at the level of goals and subgoals, planning tools can also help readers cope with the constituent reading activities themselves, i.e. the details of their interaction with the text. For tasks that have been done many times previously, the nature of this support can be unobtrusive. Once the reader has specified the plan to be used, the planning device may change the tools subsequently available for certain activities. For example, if a timetable is being planned then the data collection and manipulation options may be only those relating to the organization of information on a time line. The unobtrusiveness of this kind of support can reduce the cognitive complexity of the task by removing some of the elements of choice. Nevertheless, there may be cognitive costs in learning how to set up such plans and in understanding when it is most appropriate to use them. For less familiar tasks, planning tools can provide readers with insights into the document content and its structure. Moreover, this can be done in a way that is sensitive to the context of the reader's current objectives. Such insights may help people understand what can and cannot be found easily and so modify their way of searching the text. At times there may be a need to tailor the advice to individual differences in readers' knowledge. For example, the planning tools may advise readers with certain experience that they have no need to read a particular section. In other instances generic information about the content will suffice. This would correspond to the kind of advice that might be found in the introduction to a printed document, (e.g., this material will help readers choose a suitable training course, find somewhere to live, discover local musical events).

Once readers know which sections of the text they want to look in, they could have a destination planner which allowed them to predesignate these locations of interest and then hop from one to the other. Such a tool would reduce the memory load, in that readers do not have to remember where to go or even check where they have already looked. Work currently being done by Wright and Lickorish suggests that inexperienced readers of electronic texts welcome such a tool and have no difficulties in using it selectively, i.e. just for problems making heavy demands on their working memories. In printed documents there is no counterpart to this task specific hopping functionality.

When the problem solving involves iterative cycles of searching, collecting and manipulating, then deciding where to go may depend on knowing where one has already been. In printed materials the serial order of the pages and visual landmarks within the text may provide cues that remind readers where they have looked. Peoples' non-linear progress through electronic documents often lacks many of these cues. So hypertext users require the support of tools that may be unnecessary for printed materials; but hypertexts also offer users the potential of bringing to bear powerful tools which have no counterpart for paper-based information. The extent to which the use of such novel and powerful tools may have important consequences for human problem-solving and decision making cannot even be conjectured at this stage (cf. Engelbart et al, 1973).

Planning tools can assist not only with structuring the task and with finding relevant information, but also with the collection and manipulation of that information. For example, readers who wanted to know about eating places within half a mile of a particular location could preplan that the results of such a search would be displayed in a particular way. In this sense, *preplanning* appears to be an antithesis of the direct manipulation interface. This is not necessarily the case. In direct manipulation, users manipulate representations of objects rather than the objects themselves. Similarly the activity of creating the plan may, given a graphical user interface, feel as direct a form of interaction as does manipulating the collected data.

As the categories of tools that may be needed for serious reading increase, so the interface for displaying the texts being searched, the sets of information collected and the products of manipulation is likely to involve windowing environments. Given the increasing complexity of multiwindowing systems, the issues about how window displays of private workspaces are related to each other and how they relate to the display of the source material becomes a nontrivial matter. Norman, Weldon, and Shneiderman (1986) suggest that the surface layout of inter-related windows be made congruent with readers' mental models of their tasks or with other cognitive processing systems. Thus, the spatial arrangement of windows (e.g., left to right, overlapping top to bottom) might helpfully reflect the inferred relation of information sets (e.g., first to last, temporary workspace to long term results). Extending this idea, an intelligent planning assistant could offer its services in tidying up a cluttered screen. Of course the reader may need to have advised the assistant on a suitable scheme for tidying up (clearing away everything into the trash, or shrinking all windows that have not been accessed for 5 minutes may not fit the reader's preferred way of working). But the point is that planning ahead includes planning the use of the working environment as well as the use of the text itself. This underscores the way in which the concept of hypertools is derived from a careful consideration of serious reading. Hypertools are not just a collection of miscellaneous aids for using electronic documents.

7.0 Conclusion

Computer-based interaction with electronic documents represents a significant advance in reading technology. The economic advantages of mass storage in an electronic medium will increase the number of electronic documents available, but availability is not enough. The information within those documents needs to be accessible and easy to use. This paper has introduced the concept of *Hypertools* to denote a vast network of powerful, computer-based tools whose function is to facilitate the use of electronic information in serious reading tasks. It has examined the constituent activities that arise when people undertake serious reading and shown that readers can be given assistance in many, perhaps all, of these activities.

Undoubtedly readers can experience difficulties when using information from an electronic document in support of problem solving or decision making tasks. Many of these problems relate to moving around within the material. Although navigation has been the major problem addressed by researchers concerned with hypertexts it is but one of the tools within a much broader repertoire that can support the cognitive activities of the serious reader. People interact with texts because of goals they are trying to achieve. Their interaction will typically involve reading activities such as finding, gathering, and manipulating information from one or more texts. Printed materials have few tools that are integrated with the text to assist readers in such tasks. This perhaps accounts for why the absence of adequate support has not been missed by the readers of electronic documents. But many of these tools already exist within some computer application packages and could be made more widely available. The importance of providing such assistance has seldom been apparent either to those developing hypertext architectures or to authors using these architectures in order to make information resources available to readers. The need for a wide range of support tools becomes apparent when the constituents of serious reading are examined in detail. Moreover, as people become more familiar with materials in a variety of electronic forms (word processors, spreadsheets, databases) they will begin to expect that computer-based tools available in one working environment are also present in another. There is no reason why this expectation should not be met. However, it lies beyond the scope of this paper to examine the issues relating to where the onus lies in providing these tools (e.g. the information providers, the designers of databases and hypertext architectures, independent software developers). Economic and political factors will undoubtedly play a part in determining who seizes the opportunity to meet the needs of serious readers for adequate support.

The present discussion of tools for enhancing the use of electronic documents has been illustrative rather than exhaustive. For multimedia information resources, there will exist other tools and other categories of tools for supporting serious reading. In particular there is scope for the development of intelligent tools which can help readers structure their task and their working environment, as well as helping them exploit the potential of simpler tools. It will be the existence of these powerful tools that will make hypertexts and other forms of electronic documents such a valuable resource for the serious reader.

Undoubtedly readers will need to acquire skills in using these tools, and in understanding the demands and potential of multimedia databases. This is what Laurel et al (1990, p139) call "a new kind of information literacy". Perhaps the advent of hypertools for hypertexts may in time lead to new insights into serious reading.

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Figure Captions

Figure 1. Categories of tools that can support reading activities. Issues regarding detailed functionality of the tools are listed within each category. Navigation tools differ from many other tools in that they can be incorporated into other tool sets.

Figure 2. Two categories of tools for data searching. The tools in 2a create a list, or set(s) of copies, of items found. The tools in 2b store the locations of items found and provide navigation to them in the electronic text.

Figure 3. Data manipulation tools for sorting collected data (top), outputting aggregated data (middle), and reauthoring new electronic documents (bottom).

Figure 4. Planning tools to help readers structure their approach to the task (e.g. deciding what to find) and to their reading activities (e.g. deciding how to find it, and what to do with it then).

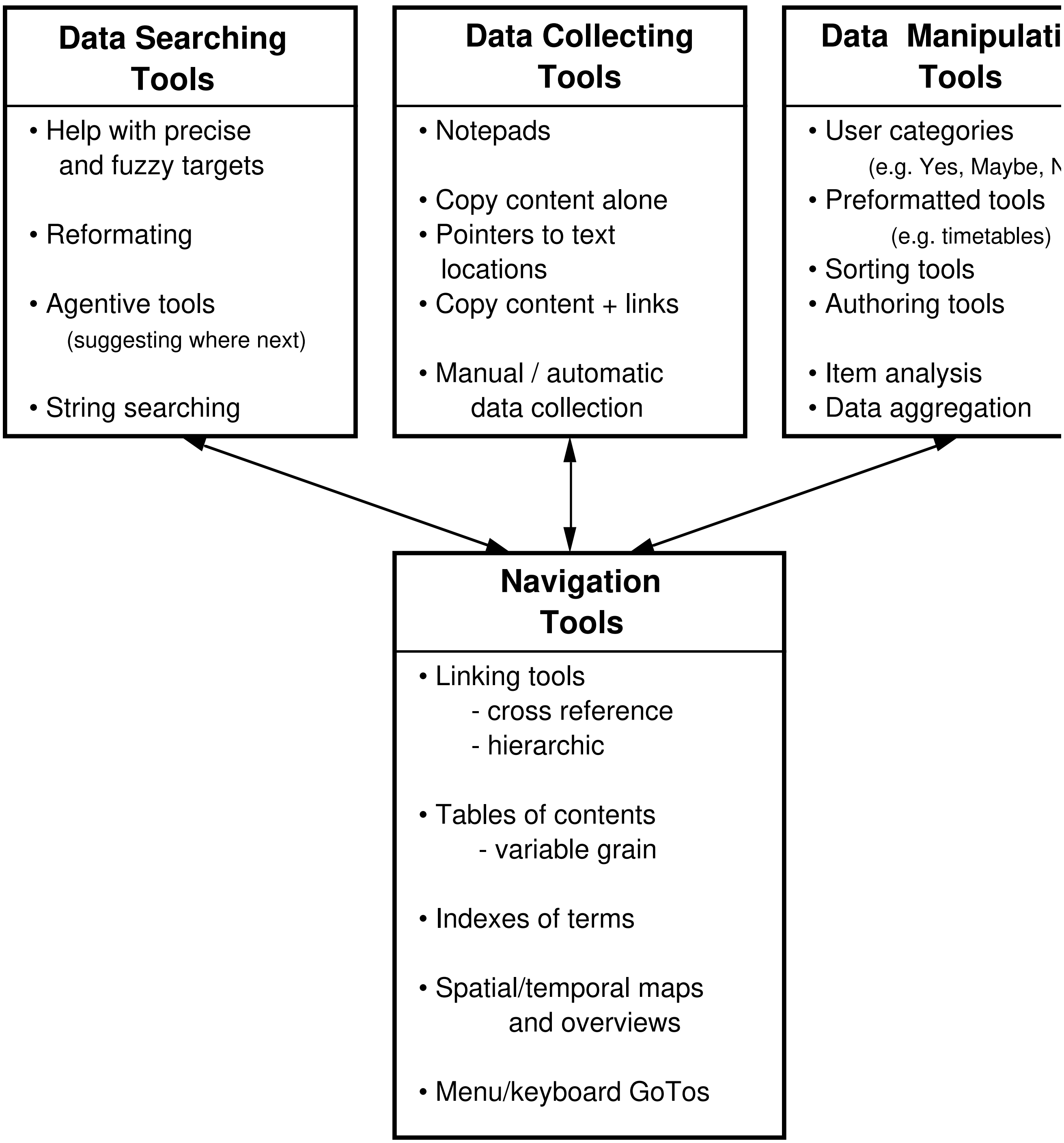
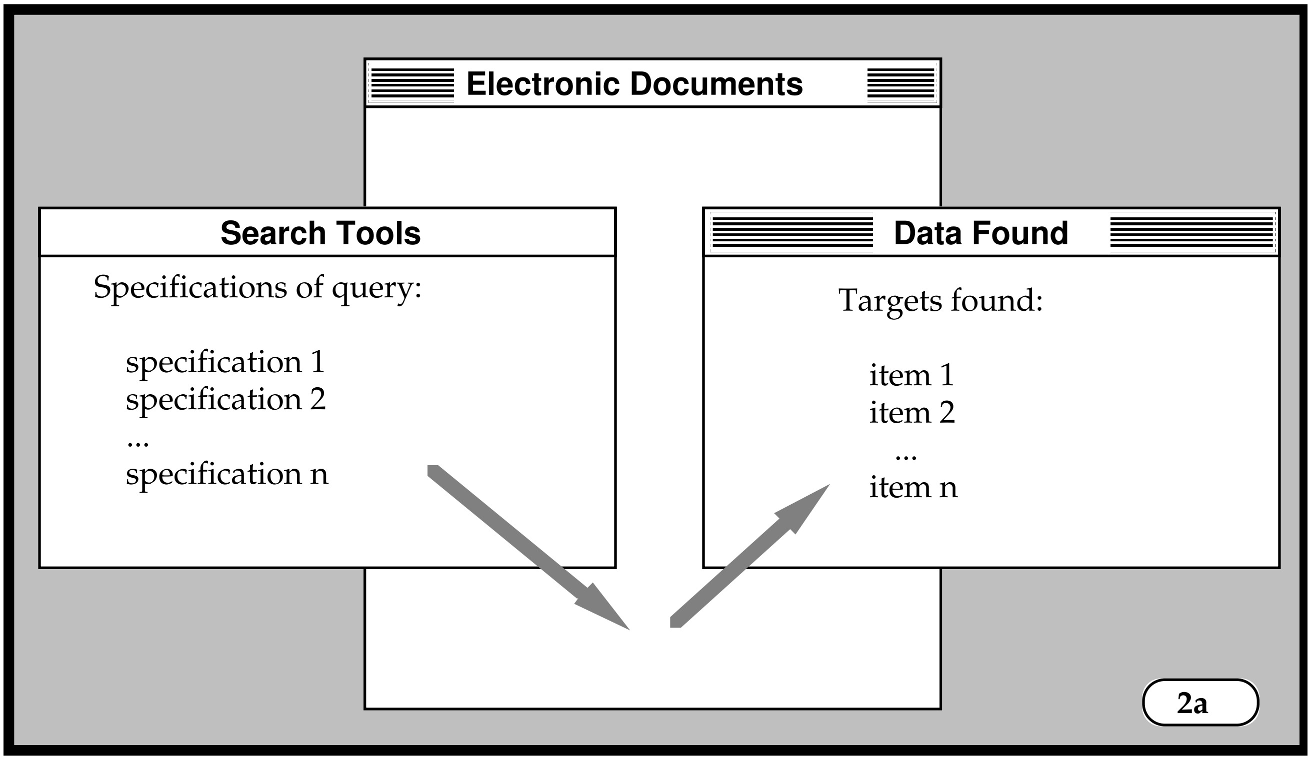

Data Searching Tools
• Help with precise and fuzzy targets
• Reformating
• Agentive tools
(suggesting where next)
• String searching
Data Collecting Tools
• Notepads
• Copy content alone
• Pointers to text locations
• Copy content + links
• Manual / automatic data collection
Data Manipulati
Tools
• User categories
• Preformatted tools
(e.g. timetables)
• Sorting tools
• Authoring tools
• Item analysis
• Data aggregation
Navigation Tools
• Linking tools
- cross reference
- hierarchic
• Tables of contents
- variable grain
• Indexes of terms
• Spatial/temporal maps and overviews
• Menu/keyboard GoTos

Figure 1.


Electronic Documents
Search Tools
Specifications of query:
specification 1
specification 2
...
specification n
Data Found
Targets found:
item 1
item 2
...
item n
2a

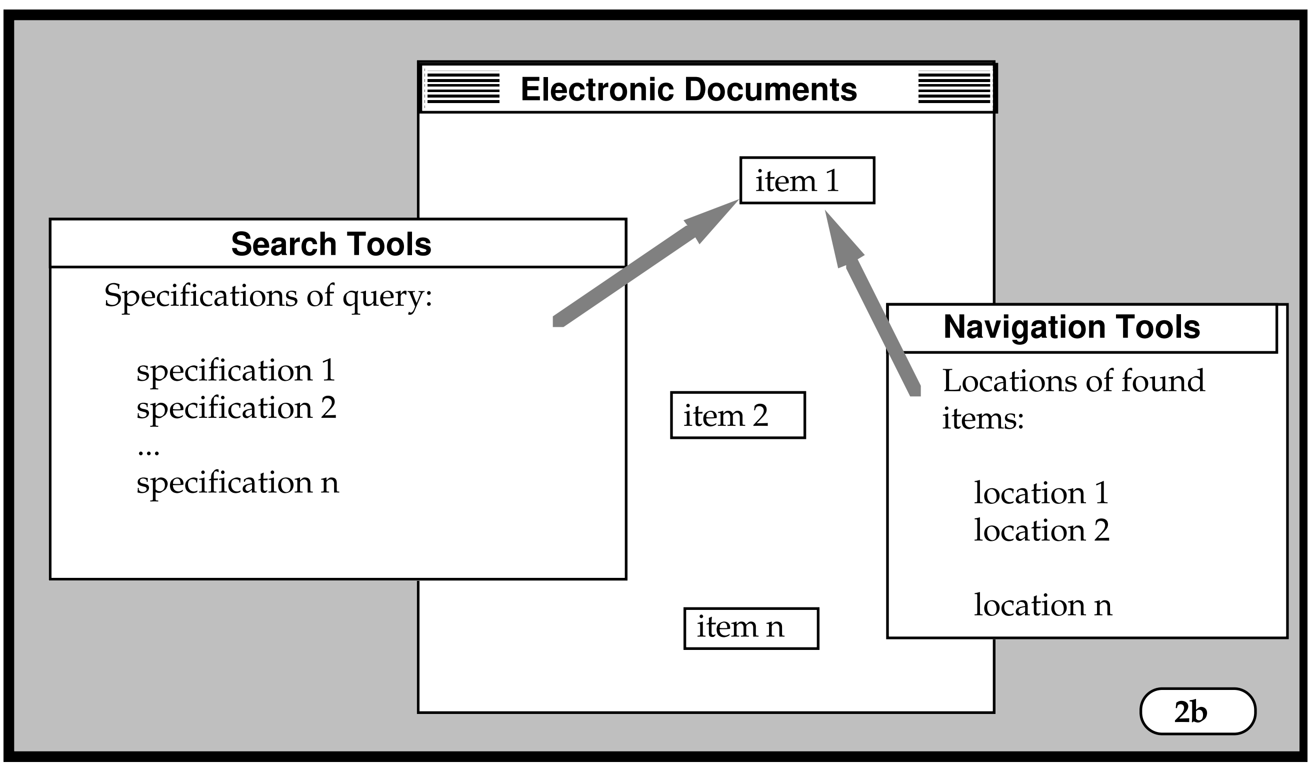

Electronic Documents
item 1
Search Tools
Specifications of query:
specification 1
specification 2
...
specification n
item 2
Navigation Tools
Locations of found items:
location 1
location 2
location n
item n
2b

Figure 2.

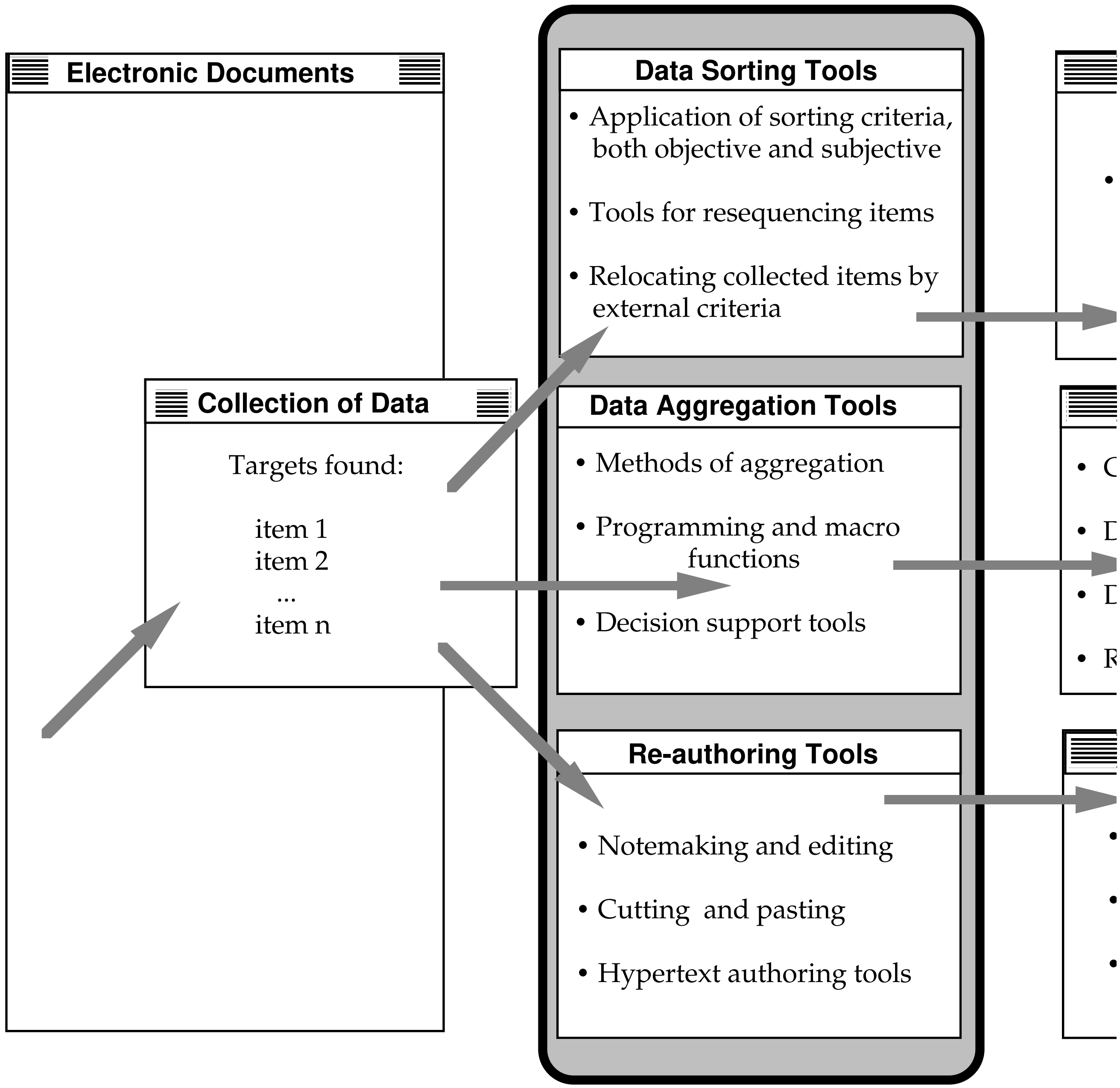
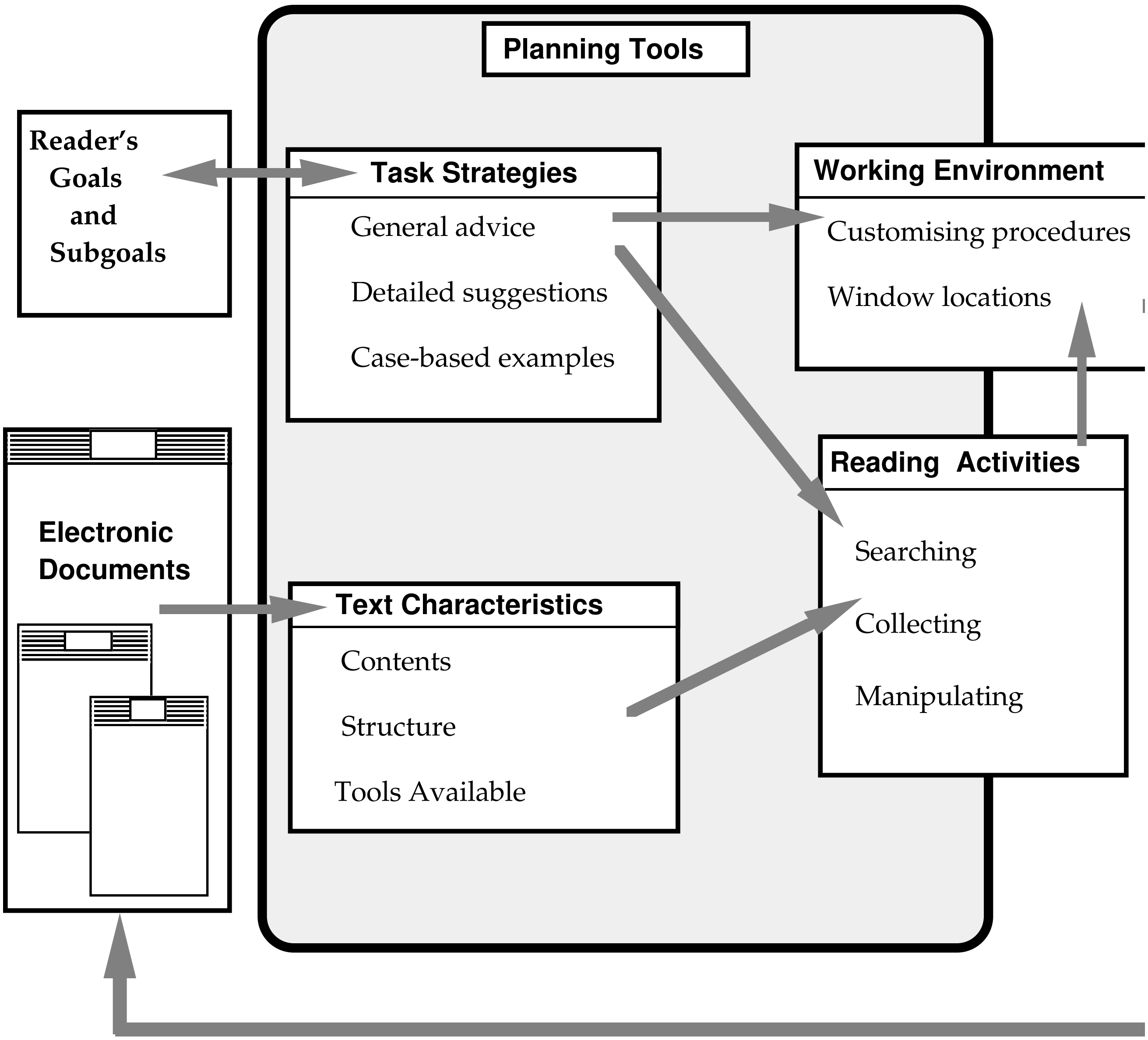

Electronic Documents
Collection of Data
Targets found:
item 1
item 2
...
item n
Data Sorting Tools
• Application of sorting criteria, both objective and subjective
• Tools for resequencing items
• Relocating collected items by external criteria
Data Aggregation Tools
• Methods of aggregation
• Programming and macro functions
• Decision support tools
Re-authoring Tools
• Notemaking and editing
• Cutting and pasting
• Hypertext authoring tools

Figure 3.



Planning Tools
Reader's Goals and Subgoals
Task Strategies
General advice
Detailed suggestions
Case-based examples
Working Environment
Customising procedures
Window locations
Reading Activities
Searching
Collecting
Manipulating
Electronic Documents
Text Characteristics
Contents
Structure
Tools Available

Figure 4.

Table 1
Potential Tools That Can Support The Cognitive Demands Of Serious Reading

SUBTASKS OF SERIOUS READING	ELEMENTS OF COGNITIVE DEMAND	FUNCTIONALITY OF POTENTIAL TOOLS
SEARCHING	1. Formulating the query	1. Search aids: automatic query genera dynamic target lists
	2. Perceptual demands: scanning the text detecting organisation	2. Links within the text; indexes; text formating
	3. Memory demands: what targets to look for, where you have looked, record of success	3. Memory aids: dynamic lists, path histo
	4. Knowledge and skill demands	4. Search plans; strategies
COLLECTING	1. Memory demands: what was found where it was found	1. Memory aids: notepads for free annot clipboards - "snapshots
	2. Transfering information	2. Live copies - retaining dy links within text pipelines for data
MANIPULATING	1. Setting criteria	1. Bins/categories, filters - discarding information
	2. Comparing items	2. Sorting/prioritising - by physical details - by subjective value
	3. Integrating information	3. Aggregating functions
	4. Evaluating outcomes	4. Utility functions