

The Impact of Hypertext on Processes of Reading and Writing

Davida Charney

Department of English
The Pennsylvania State University
University Park, PA 16802

In: *Literacy and Computers.*

Eds. Susan J. Hilligoss and Cynthia L. Selfe.

New York: Modern Language Association, 1994. 238-263.

Texts and Hypertexts

Most people conceive of *text* as a collection of ideas that a writer has carefully selected, framed, and organized into a coherent sequence or pattern in hopes of influencing a reader's knowledge, attitudes, or actions.ⁱ A key element in this conception of text, from the perspective of both writers and readers, is structure. Linguists and discourse analysts have identified a host of structural patterns that writers work with (and, more frequently, against) at every level of text production, from small units such as sentences and paragraphs, all the way to grand structures that describe entire texts, such as sonnets, fairy tales, résumés, or policy arguments (Halliday and Hasan; van Dijk; Fahnestock and Secor). Indeed, readers depend on such patterns to identify a text's genre, anticipate its development, and integrate its parts. Studies of reading comprehension confirm that readers understand and learn most easily from texts with well-defined structures that clearly signal shifts between parts (van Dijk and Kintsch; Kieras "Initial Mention"; Frase). But apart from any natural disposition we may have to expect structure in text, our conception of text as an orderly succession of ideas is strongly reinforced by the constraints of the standard print medium: texts come to us on printed pages that we generally read in order, from the top down and from left to right.

Today, the constraints of the medium are being lifted by developments in computer technology. Visionaries of information technology foresee a time when most forms of written communication (from books and journals to reference manuals and mail) will be composed and disseminated electronically rather than on paper. And

rather than taking the traditional form of linear blocks of prose, these on-line texts will be presented in hypertexts that link together individual bits of text and even whole documents.ⁱⁱ Thus far, the most common application of hypertext has been for computer manuals, encyclopedias, or guide books, providing readers with immediate access to definitions of key terms, cross-references, graphic illustrations, or commentary from previous readers (Marchionini and Shneiderman; Yankelovich, Meyrowitz, and van Dam). If scholarly journals become routinely published in hypertext, readers may be able to move instantly from a citation in one article to the cited work, or to any of the author's earlier or subsequent publications.

The advent of hypertext is a new and exciting development that has important implications for researchers and teachers in English. As Jef Raskin and others have noted, there is as yet a good deal of "hype" in hypertext and its full impact will not be felt in most English departments for a number of years. But the fact remains that sophisticated hypertext systems are increasingly available--commercially as well as within specific academic and non-academic communities. Hypertext has the potential to change fundamentally how we write, how we read, how we teach these skills, and even how we conceive of text itself.

Hypertext promises to facilitate the writing process in several ways (Pea and Kurland). A writer's invention processes (generating and selecting ideas) may profit from opportunities to freely explore source material presented in a hypertext and make novel associations. The related processes of idea manipulation and organization, such as experimenting with various idea clusters or outlines, may be aided with

a system that allows writers to create electronically linked “notecards” that can be sorted and rearranged (Neuwirth et al. “Notes,” *Comments*; Trigg and Irish; Smith, Weiss, and Ferguson). Collaborative writing may be aided by systems that allow peers to annotate each other’s drafts, or that help writers to integrate individually written sections into a coherent draft (Irish and Trigg; Catlin, Bush, and Yankelovich). Hypertext systems may also be designed to meet specific pedagogical goals, for example guiding novice writers through heuristic activities that support the critical thinking and analysis necessary to writing a policy argument (Neuwirth and Kaufer).

Apart from serving as a tool for writing, hypertext promises other kinds of benefits to writers of computer manuals or reference materials. These writers typically face the problem of presenting large amounts of complex information to readers with wide ranging needs--such as experienced and novice computer users who may seek the “same” information, but who have quite different needs with respect to appropriate terminology, format, definitions, examples, and details. The task of these writers is further complicated by its subject matter, typically computer technology that changes even as writers scurry to describe it, so that printed material is outdated even as it is published--the “original sin” of computer documentation. The hypertext solution to these problems would replace printed manuals with an on-line network of information reflecting various levels of technicality (Robertson, McCracken, and Newell; Walker “Authoring Tools,” “Document Examiner”). Readers with less technical expertise may choose to follow links to nodes with definitions, examples, explanations, reminders, or advice, which more expert computer users may bypass completely. Or,

rather than leaving the choices to the users themselves, hypertexts may be designed to guide readers on defined “paths” through the network at the appropriate level for their purpose or level of expertise (Zellweger; Younggren; Carlson “Incorporating Feedback”). A hypertext reference manual would ideally be suitable for all users, from novices to experts (and for novices whose skills develop over time) and for a variety of tasks. Such a system would presumably be easier to update than printed manuals and reduce the high costs of printing and reprinting.

Hypertext thus has a strong pragmatic appeal: to facilitate the efficient creation and dissemination of complex documents and sets of documents of all kinds and to allow people “to access information in the sequence, volume, and format that best suits their needs at the time” (Grice 22). The ultimate goal of these designers is to create a system so tailored to individual preferences and task situations that every user will feel as though entering an “information universe designed specifically for his needs” (Younggren 85).

In contrast to those who aim to micromanage the presentation of information in a network are those hypertext designers who are attracted to its Romantic side (Herrstrom and Massey). As Edward Barrett notes, “Developers of hypertext systems are inspired by a highly Romantic, Coleridgean concept of writing: an infinitely evolving text that tracks momentary cognitive processes within the individual reader-author” (xv). In this modern information age, hypertext Romantics aspire to a kind of unspoiled landscape of knowledge, dotted with visual and verbal outcroppings captured electronically. They view hypertext as a means to liberate readers (as well as writers) from the constraints of text boundaries, freeing them to wander through an

array of interconnected texts, graphics, and commentary, exploring and creating topical paths of associations at will. Such open-ended hypertexts are being used in literature and other humanities courses to give students access to rich networks of cultural and historical material relevant to the primary texts under discussion (Beeman et al., Dryden).

Whether pragmatic or Romantic, the potential benefits of hypertext sketched above follow from certain assumptions about how people read or should read. The belief that readers can select for themselves which links in a network to follow rests on the assumption that readers know best what information they need and in what order they should read it. The goal of creating paths for different readers assumes that hypertext designer/writers can predict readers' needs well enough to create the "right" set of paths and direct each reader onto the appropriate one. The very notion that hypertext designer/writers can create meaningful, useful networks in the first place depends on a whole range of assumptions about how to divide up and relate parts of texts, including what segments of text constitute meaningful nodes, what types of links are meaningful and important, and what types of texts can or ought to be read non-linearly. In fact, many of these assumptions contradict current thinking in rhetorical theory, cognitive psychology, and document design, where the evidence suggests that, as currently conceived, hypertext may in fact dramatically increase the burdens on both readers and writers. My purpose in this essay is to review relevant educational and psychological research on reading that bears on the problems hypertexts may pose for readers and writers. The purpose of this evaluation is not to accept or dismiss hypertext in principle, but rather to point to specific aspects of reading and writing processes that

hypertext designers must consider if they are to serve readers and writers effectively.

Obviously, readers approach hypertexts for a variety of reasons, from purposively seeking specific facts to browsing out of sheer curiosity (Slatin). I focus here on readers with more complex motives, those who read to learn, to understand and evaluate the ideas and arguments of others, to come to new realizations about the subject matter, and to integrate what they have learned with what they already know. These purposes will push hypertext to its logical extreme--the rich interconnection of the parts of a text to each other and to other texts. What I have in mind are not so much on-line reference works or annotations of a single primary text (though the research reviewed here bears on those as well), but a fully interconnected electronic literature. Such hypertexts are currently least well developed, but are also those most likely to influence what we in English studies do as teachers and scholars.

Thinking, Learning, and the Organization of Memory

Many hypertext designers claim that hypertexts will facilitate reading and writing (and even thinking and learning in general) because, unlike linear texts, hypertexts closely resemble the networked, associational organization of information in human memory. This view probably originated with Vannevar Bush, who first conceived of hypertext, and has been carried forward in various forms to the present (Shneiderman; Carlson "Incorporating Feedback"; Smith, Weiss, and Ferguson; Beeman et al.). While Bush's view of human memory seems to have been quite advanced for his time, current hypertext proponents

tend to misrepresent modern-day cognitive psychological perspectives on information processing.

The idea that hypertext is somehow more “natural” or more “intuitive” than linear text assumes a structural correspondence between networked information in a person’s long-term memory and the presentation of information in hypertext network. This assumption contradicts some important long-standing psychological findings about the organization of information in memory and the process by which new information is acquired.ⁱⁱⁱ First, in contrast to the view that information in memory is organized in completely amorphous associative networks, a great deal of knowledge seems to be organized hierarchically and sequentially. Second, there is no evidence that readers can grasp information more easily or more fully when it is presented in a network rather than hierarchically and linearly. The opposite may in fact be true. What people hear and see is not imported wholesale into long-term memory, but must first pass through a constraining “gateway.” In particular, the processes of thinking and learning that draw on networks of previous knowledge are crucially constrained by the limitations of working memory (also referred to as “short-term memory” or “focal attention”).

Cognitive theorists posit working memory to account for the fact that human beings can only attend to a small number of things at any one time, regardless of whether these are ideas recalled from prior knowledge or whether they constitute new information that has just been heard or seen or imagined. Further, the things that people attend to shift over time; as they recall other ideas or observe new things, items that had been in focal attention “fade” or become “displaced” or

“inactive.” The shifting of attention imposes a kind of linearity or seriality on thought processes: since we cannot think about everything at once, we have to focus on a few things at a time in some order. A useful analogy might be to imagine an auditorium full of students. Like ideas in long-term memory, we can imagine a variety of plausible principles that might lead them to sit in certain groupings, or that might cause initially accidental groupings to take on significance over time. But the students did not enter in those same configurations--their access to the room from the confused congestion in the hallway is constrained by a narrow doorway that forces them to enter in some sequence. The most efficient way to create an *intentional* configuration--one that facilitates taking attendance, for example, or that optimizes visibility for the group as a whole--may be to invest some effort in advance to organize the students while they are out in the hall (as the marshals do at commencement ceremonies). Similarly, the fact that part of human memory may be organized in associative networks does not mean that the best formats in which to read or write are also associative networks (Neuwirth and Kaufer). If the goal is to ensure that readers consider a specific set of associations, then a highly organized text format is more likely to achieve that goal than an amorphous network.

The implications for hypertext can be stated even more directly. Because readers cannot import textual (or hypertextual) structures directly into long-term memory, the putative resemblance of hypertexts to long-term memory is irrelevant. It in no way entails that hypertexts are superior to linear texts for facilitating reading or promoting learning. In fact, the development of linear text forms, with their

careful sequencing of ideas, may not reflect constraints of the print medium so much as the needs of readers and writers who depend on the text to help them sequence the flow of ideas through focal attention effectively.^{iv}

Cognitive Models of Reading A major premise of most reading theories, consistently supported by empirical studies, is that as people read, they build a hierarchically structured mental representation of the information in the text (Kintsch and van Dijk; van Dijk and Kintsch; Meyer; Just and Carpenter). As they read successive sentences, they link the ideas or propositions expressed in them to their developing hierarchical representation by means of chains of repeated concepts (or arguments). To the extent that the sentences--or larger units--of the text reuse, develop, elaborate on, and inter-relate the same arguments, the text is more cohesive. The more cohesive the text, the easier it is for readers to create a well-structured, meaningful, and useful mental representation (Eylon and Reif). The quality of the representation, and the ease with which it is constructed, crucially depend on the order in which readers encounter the propositions and on the amount of repetition and development of important concepts (or "arguments") in successive portions of the text. It is more difficult to create a mental representation of a disjointed or disorganized text. If readers come to a sentence that seems to contain no previously encountered arguments, that is, with no obvious link to the surrounding sentences, they must either retrieve from memory earlier propositions that contain one or more of the arguments, or they must infer some link between the sentence and some part of their representation of the text. Both retrieval and inferencing are relatively costly processes in terms of time

and effort. Working from the assumption that only propositions currently “active” in working memory can be linked, researchers have successfully predicted what kinds of texts are easier to read, understand, and remember than others. Bruce Britton and Sami Gülgöz have recently gone even further, using Kintsch and van Dijk’s model to identify sites for textual revisions, which resulted in improved comprehension and recall.

As Catherine Smith (elsewhere in this volume) notes, Kintsch’s model has evolved over the years. In its original form (Kintsch and van Dijk), it was fairly rigid and deterministic--allowing little into the mental representation of a text beyond literal decompositions of the sentences and necessary bridging inferences. It did, however, successfully predict what parts of a text are best remembered. In later work (van Dijk and Kintsch), Kintsch fleshed out various parts of the model in order to account for other kinds of information that readers call on regularly (such as knowledge of genre and situational knowledge). His current position (“The Role of Knowledge”) extends the model still further, allowing for many more idiosyncratic (and even inappropriate) associations to end up in the mental representation of a text (but also requiring an additional “clean-up” process). This position in no way represents a “recantation” of his earlier views, as David Dobrin suggests in his essay. To the contrary, Kintsch explicitly retains most aspects of his model--and in particular the ones relevant here--frequently referring readers to his previous work for elaboration of them (see especially 166, 167, 168, and 180). In essence, Kintsch’s innovations enrich the mental representation or “text base” by allowing more associations to the reader’s general knowledge. They do not change the

effect of the text itself on the construction of the text base and therefore do not lessen the importance of beginning with a coherent, well-structured text. In Kintsch's "revised" model, as in his original model, the sequence of sentences and sections of a text and the explicitness of their connection to one another largely determine how well and how easily a reader can construct a text base.

Several text features have been identified that consistently make it easier for readers to construct a coherent representation of a text, to reflect on its relationship to prior knowledge, and to integrate new ideas and new information with what they already know (Felker et al.; Kieras and Dechert). First, in order for readers to make appropriate connections between related ideas, the sentences expressing these ideas should appear in close proximity. Thus a text is easier to read if its points are developed in coherent sequences of sentences, paragraphs, and sections and if it contains discourse cues that signal the relationships among these ideas (Halliday and Hasan, Fahnestock, Britton and Gülgöz). Second, since readers use high-level ideas to tie portions of the text together, these should be explicitly stated early in the text and they should be clearly signaled so that readers can easily recall them as the need arises (Kieras "Initial Mention," "Model"). Thus it is easier to read, comprehend, and remember a text if it contains an informative title, headings, overviews, and topic sentences that introduce key concepts that are repeated and developed in successive portions of text (Schwarz and Flammer; Glynn and DiVesta; Mayer, Cook and Dyck; Wilhite). Reading is also easier when the text reminds readers of relevant points (normally through repetition or reference to the earlier discussion). Finally, while readers are capable of following innovative text

structures (especially when the text announces its structure explicitly), the easiest texts to read are those that follow a familiar structural pattern or genre (Meyer and Freedle; van Dijk and Kintsch).

The strategies for structuring texts described here are not unfamiliar ones. They are the product of centuries of experimentation by writers striving to make their texts more comprehensible to readers. These strategies, however, place the burden of selecting and arranging information, and providing signals to the arrangement, primarily on the writer. It should be obvious that hypertexts, by shifting a large portion of this burden to the reader, by proliferating the readers' choices about what portions of a text to read and in what order, compound the difficulties of creating a coherent mental representation.^v

Effects of Text Structure on Reading and Learning Many reading theorists believe that after reading a number of texts with similar structures, such as a series of fairy tales, newspaper articles, or research reports, people formulate generalized, abstract patterns or frameworks called "schemas" that they call on as they read new texts of the same type. As they recognize themselves to be reading a familiar type of text, readers invoke their schema for that genre, and use it to anticipate what will occur next, to make inferences to fill in implicit or missing elements, and, later, to reconstruct the text from partial memories. People often rely on the structure of the text and the expectations raised by schemas to decide which aspects of the text are most important and, accordingly, where to allocate their time and attention during reading (Just and Carpenter). Further, once a schema is invoked, information in the text that fits the pattern is integrated easily, but information that seems peripheral or incongruous tends to

drop out--either it is never linked to the mental representation of the text or, if it is encoded, the link to it is so weak that it effectively is lost (Bartlett).

Schemas have been posited for other cognitive processes besides reading. Many cognitive theories assume that much of the knowledge in long-term memory is organized around such hierarchical frameworks, referred to in various theories as “schemas,” “frames,” or “scripts,” that capture familiar patterns of relationships among elements. There may be schemas for events, for genres of text, for characteristics of a species, for the elements in a system. As Catherine Smith points out in her essay in this volume, Kintsch (“The Role of Knowledge”)--along with other psychologists--has come to reject the schema as a cognitive *mechanism*, that is, as a way to formalize or model the way in which encountering a familiar proposition reliably evokes a pattern of related propositions. Neither Kintsch nor other psychologists, however, dispute the consistently observed *behaviors* that schemas are meant to capture.^{vi} Regardless of what cognitive mechanism is ultimately selected as the best formalism for the phenomenon, the concept of a script or schema remains a useful one.

Readers invoke a particular schema in part because of cues provided early in the text, such as the title or the initial sentences. The remainder of the text then may either fulfill the expectations raised by the schema or confound them. When texts set incoherent expectations or fail to confirm expectations they initially raise, they create problems for readers, especially those to whom the subject matter (or “domain of knowledge”) is unfamiliar. Bonnie Meyer studied this problem by creating texts that raised expectations for one structure (e.g.,

problem/solution) but actually developed according to another (e.g., comparison/contrast). She studied how well readers coped with such texts, including both readers who were familiar and unfamiliar with the subject matter (“domain experts” and “novices”). She found that the novices relied heavily on the text’s structure to create their representations and were therefore misled by the opening portions of the text. In contrast, the domain experts were generally able to recover from the textual miscues and construct coherent representations. Experts can draw on their knowledge of the domain’s concepts and principles to determine the centrality or novelty of textual information, regardless of where it appears in the text structure.

The structure or organization of a text thus signals the relative importance of its various parts, influencing how readers allocate their time and attention and thereby influencing what information they are likeliest to remember. But the way a text is organized can also influence the textual effects that Joseph Grimes has termed “staging”--how easy it is for readers to reflect on the ideas they have read, to juggle and compare them, to see how they relate to one another and to other ideas they have on the subject. The demands that different organizations impose on readers can be illustrated by considering the familiar problem of how to organize a comparison/contrast essay. The two most common strategies, which appear in scores of writing textbooks, are: (1) to organize around the objects or alternatives being compared, or (2) to organize around the points of comparison, that is, around various aspects of the objects being contrasted or the criteria against which alternatives are judged. In his excellent technical writing textbook, Paul Anderson schematically represents these patterns (266). The first

strategy, the “divided pattern,” uses the objects as superordinate terms, repeating the criteria (in a consistent sequence) under each object heading. The second strategy, the “alternating pattern,” sets up the criteria or aspects as superordinate terms, under which the discussion alternates among the objects under analysis (again in a consistent sequence for each aspect).

The choice between these strategies, of course, has rhetorical implications. For example, an aspectual orientation may be more appropriate for a technical feasibility report whose varied audiences may each have a specific interest in one criterion or another (e.g., cost, efficiency, environmental impact). But the choice also has important implications for readability; the two organizations impose different burdens on comprehension processes. Wolfgang Schnotz (“How Do Different Readers Learn”; “Comparative Instructional Text Organization”) argues that the aspect-oriented (alternating) organization is the more difficult because readers must switch attention back and forth between different objects; each switch requires reactivation of the reader’s prior knowledge and current representation of the object. This switching is particularly difficult when the reader is unfamiliar with the topic.

Building on the Kintsch and van Dijk model of reading comprehension, Schnotz argues that because the two organizations put different propositions into close proximity, readers will create different representations of their content in memory. In particular, readers of an object-oriented (divided) organization are more likely to create a well-integrated representation of each object but will find it more difficult to keep track of their similarities and differences. The text itself does little

to push the reader to create these interconnections (though the reader is, of course, free to do so). In contrast, readers of an aspect-oriented organization will focus on the similarities and differences and as a result will also be forced to create cross-referenced representations of each object (through the costly switching process). Schnotz studied how these organizations affect a reader's ability to recall the overall meaning of the text and make accurate comparisons between the objects. He found, as expected, that aspect-oriented text took longer to read, but readers of these texts remembered more and were better able to make sophisticated discriminations between the objects. Further, the readers' familiarity with the topics significantly affected their ability to cope with the two organizations. Readers with little previous knowledge learned more from the object-oriented texts than aspect-oriented ones, presumably because they could avoid switching. Conversely readers with more previous knowledge learned more from aspect-oriented text; they were able to take advantage of the close proximity of the comparisons across objects.

These studies highlight the importance of the order in which readers see information. Hypertexts, which proliferate the possible sequences, raise significant issues for both readers and writers. For example, it is easy to imagine a hypertext version of a comparison/contrast essay that allows readers to choose an aspect-oriented or object-oriented organization. What choices will readers make? Will those with little domain knowledge realize that an object-oriented organization will be easier to read? Will they realize that working through the aspect-oriented organization will be worth the effort for learning careful discriminations?

Implications of Cognitive Models of Reading for Hypertext

Given the cognitive view of the reading process just described, it is easy to see what potential problems hypertext may raise for readers, for the very reason that hypertext violates standard assumptions of what texts are like. Readers traditionally rely on the writer to select topics, determine their sequence, and signal relationships among them by employing conventional discourse cues. The net effect of hypertext systems is to give readers much greater control over the information they read and the sequence in which they read it. Along with greater control, of course, comes a greater burden for the readers, who must now locate the information they need and relate it to other facts in the network, often without the aid of traditional structures or discourse cues.^{vii}

Many hypertext designers recognize the problems such networks may present, especially for readers who are unfamiliar with the concepts in the text. They report informal evidence that users become overwhelmed by the choices among links and by the difficulties of maneuvering through the networked text structure (Conklin). As a result, readers lose track of where they are in the network (and where they have been), and often read a great deal of material that is irrelevant to their purpose (Foss; Yankelovich et al.; Whiteside, Jones, Levy, and Wixon). Technologies related to hypertext have also been shown to pose significant problems for users. Stephen Kerr cites one study on a menu-selection Videotex system in which 28% of users gave up without finding the information they wanted even though they knew that “the information was in there somewhere” (333). Half the users of another menu-driven system had to backtrack at least once

before finding the information they wanted. While recognizing the navigational difficulties in general terms, hypertext designers have not considered some of their deeper implications for reading and writing processes.

Consider the hypothetical case of a reader using an open-ended hypertext, one without predefined paths, who must choose what links to follow through a set of interconnected texts (each of which is also represented as a network of nodes). Assume also that the reader's goal is not to read everything in the network, but rather to gather information relevant to some particular issue. First, given that the reader must choose what to look at, she may never see all the "right" information, either because she can't find it or because, for some reason, she fails to select it. Second, even if she does see the "right" information, she may see it at the wrong time. As described above, the timing of seeing a particular bit of information could determine whether she judges it to be important or whether she sees its connection to other information she has already read or is yet to read. If she does not see it in conjunction with other relevant information, she may have to expend great effort to integrate it coherently into her mental representation. If she fails to do so, she is likely quite literally to miss the point. Third, she may see a great deal of intrusive, irrelevant information that may skew her representation. Even if she recognizes that some information she has read is irrelevant, there may still be adverse consequences of having spent time reading it. Finally, the reader may lose a sense of the integrity of any given text in the network since she may be unaware of crossing from one text to another. Lacking a sense of textual integrity, she may have difficulty relocating information she has read or

attributing the ideas correctly to their sources. In short, in addition to suffering the frustrations of disorientation or cognitive overload that hypertext designers already acknowledge, the reader may come away with a false or incomplete representation of the texts in the network or even the information relevant to her issue.

The “worst case” scenario sketched above is speculative; little research has been conducted of the actual effect of hypertext on reading. However, research is available, some using printed texts and some on-line materials, that does address the specific issues raised in this case: Can readers make appropriate selections of what and how much to read? Can readers create appropriate sequences of textual material? If readers are unable to navigate a hypertext effectively, can hypertext designer/writers reasonably expect to be able to anticipate their various needs and create appropriate paths to satisfy them?^{viii}

Can Readers Select What and How Much to Read?

Many hypertext designers assume that readers know what sequence of information is best for them, that they can tell when they have read enough, or judge whether what they are reading is important. However, the evidence suggests that readers are not very good at assessing the adequacy of the knowledge they have read and are even worse at anticipating whether important or useful material remains in the portions of text they have not read.

David Kieras (“Prior Knowledge”) found that many readers, left to decide how much to read, stop too soon. In his study, adults with varying technical backgrounds were presented with on-line, step-by-step instructions for using a mechanical device. The instructions were

presented in a hierarchical network that organized the steps according to major tasks. The bottom-most level contained the directives for specific operations, such as turning on a specific switch. At any level of the hierarchy, participants had the option of reading on to a deeper level of detail (using a menu-selection system) or attempting to carry out the steps. Kieras found that the participants tended to stop reading before discovering crucial details--presumably with the impression that they understood what to do--and failed to carry out the instructions correctly. In contrast, participants who read and carried out the instructions presented in traditional linear order were much more successful at completing the task.

David Reinking and Robert Schreiner also found evidence that readers may fail to take full advantage of useful information available to them in hypertext. In their study, fifth- and sixth-grade students were presented with a set of expository passages annotated with various on-line "aids" such as definitions, paraphrases, background information, and distilled main ideas. Students who were allowed to select at will from these aids performed significantly more poorly on various comprehension tests than students who were guided through all of the aids. In fact, the free-selection group performed more poorly than other students who read the printed version of the linear text without any aids.

While Reinking and Schreiner's results are based on the activities of school children, they are consistent with Kieras's results with adults. Taken together, these studies suggest that when readers are responsible for selecting what text to read, they often omit important information

altogether, perhaps because they can't find it, they don't know it's there, or they don't think it's important.

Can readers create appropriate reading orders?

The view that readers can select for themselves which links in a hypertext to follow assumes that readers know best what information they need and in what order they should read it. Hypertext designers thus assume that readers can organize information appropriately for their level of knowledge and their purpose for reading. In fact, little research has been conducted on how readers themselves choose to sequence the pieces of a text, whether reader-chosen orders are generally different from those a writer or teacher might create, and what effects these different orders have on what readers learn. As the following discussion indicates, the available evidence is mixed. Overall, it does suggest that certain kinds of readers, or readers in certain situations, may benefit from the active effort required to sequence reading material for themselves.

Sequencing an Entire Network Hans Lodewijks evaluated a variety of text sequencing systems or “presentation orders” using printed materials. The materials consisted of 16 passages written for high school students on concepts from electricity (e.g., “ampere,” “conductivity,” “electron”). The passages were presented to different groups of students in different sequences. The “teacher-regulated” sequences were similar to guided paths through a network, giving students little control over the order of the passages. These included a sequence determined intuitively by a group of physics teachers, others based on various logical dependencies or cross-references among the

concepts, and an alphabetic sequence based on the concept headings. Two “self-regulated” systems allowed students to choose a concept to study from an alphabetical list, read the passage, and then return to the list to choose the next concept. One self-regulated system also provided a structural overview of the relations between the concepts, similar in some ways to the graphical maps (or “browsers”) provided in some hypertext systems. In general, the self-regulated sequences (particularly, self-regulation with a structural overview) led to better recall and better recognition of relations and inferences among the concepts than any of the teacher-provided sequences.

However, not everyone benefited from self-regulation. In particular, Lodewijks found that “field-dependent” learners and low scorers on various logical reasoning tests performed poorly under self-regulation conditions but significantly better with teacher-regulated sequences. The converse was true for “field-independent” learners and high scorers on reasoning tests: they performed significantly better with self-regulated texts than with teacher-regulated ones. ^{ix} Thus the readers’ preferred learning strategies (or “cognitive styles”) may determine how well they can cope with charting their own path through a hypertext.

Richard Mayer conducted a somewhat similar study using instructional materials for writing computer programs, presented as a set of printed cards. He investigated how “experimenter controlled” and “subject controlled” card sequences influenced the ability of college students to solve programming problems. In the experimenter-controlled sequence group, students read the cards in either a logical order or a random order. Students in the subject-controlled group were

given a “table of contents” for the cards, in which the topics were listed either in random or logical order. They used the table of contents to pick which card to read next. Mayer found no overall differences between the sequences. However, he did find differences in the types of problems participants were able to solve. Participants who had chosen their own reading order were significantly better at solving novel, unexpected types of programming problems, while those who had read the text in experimenter-controlled sequences were significantly better at solving problems similar to those in the text. Mayer believes that allowing people to choose their own reading order “may result in deeper, more active encoding, which allowed subjects to struggle harder to relate the text to their own experience rather than memorize the information as presented” (149).

Both Lodewijks and Mayer used printed materials that simulated the conditions of hypertext in many important respects. Two researchers have recently conducted studies of reading in hypertext itself with results that are largely consistent with those based on printed materials.

Sallie Gordon and her colleagues (“Effects of Hypertext”) found that reading a text in hypertext format had negative consequences for learning as compared to an on-line linear presentation. Gordon et al. constructed hypertexts for four expository texts--two on technical topics and two on general interest topics--each about 1000 words long. The hypertexts were created by keeping main ideas on the top-most level, and creating links to elaborative text segments (such as examples, definitions, and non-central information) on a second or sometimes a third structural level (about half the text was presented in deeper

levels). A highlighted key-word in a main-level segment signalled the presence of deeper information, that readers were free to access by pressing a key. The participants, upper-level college students, were asked to use normal, casual reading processes for the general interest articles but to carefully study the technical texts. After reading both a linear and a non-linear text, the students were asked to recall as much of both texts as possible, to answer questions about them, and to express their preference for reading format. Gordon et al. found that for both types of texts, students who read in the linear format remembered more of the basic ideas and, for the general interest articles, assimilated more of the text's macrostructure than after reading in hypertext. Most students also preferred the linear presentation, perceiving it as requiring less mental effort. As a result of finding such negative results for hypertext, Gordon and her colleagues have gone on to look for more effective ways to segment texts to create more easily processed hypertext structures ("Knowledge Engineering"; "Enhancing Hypertext").

Jean-François Rouet ("Interactive Text Processing") found that 6th and 8th grade students have difficulty making appropriate sequencing selections with hypertext materials. Rouet constructed hypertexts for four general knowledge domains. A hypertext consisted of six related thematic units, each containing a title and a 50-70 word paragraph--representing a "chained list rather than a network" (253). The hypertexts differed in the availability of various cuing aids, such as markers for previously read topics, availability of the topic menu during reading, and explicitness of statements relating one topic to another. Students were asked to read all of a hypertext, selecting the

topics in any order and as often as they wished. Then students answered multiple-choice comprehension questions and wrote a summary. Each student read all four hypertexts, two in the first session and two a week later. Rouet computed various measures of selection efficiency, including the number of repeated readings of a topic (indicating global orientation difficulties) and the number of times students picked illogical sequences of topics (indicating local orientation difficulties). Although grade level and some combinations of cuing aids improved performance, Rouet found evidence of global and local disorientation at both grade levels, even with his very simple nonlinear structures. For example, in only 35% of their selections did students pick the topic that was most closely related to the one they had just read. Explicitly marking relations between topics improved students' appropriate selections only to about 50%. Practice at using the system evidently also helped somewhat; the percentage of appropriate selections in the second session increased to 58%. We should not conclude from this study, however, that students can learn to cope with any hypertext with practice. It may be that these students eventually figured out the simple and consistent structure of these hypertexts, especially when aided by explicit textual cues. Accordingly, these results may simply mean that students can improve somewhat at using well-marked and structurally predictable networks.

Obviously, these studies have several important implications. Rouet's study indicates that students may have difficulty making their way through even simple hypertexts. Gordon et al. suggest that reading from hypertext can actually impede a student's comprehension of a text, relative to a linear presentation. However, Lodewijks' and

Mayer's studies hold out the promise that at least some students (those with particular "cognitive styles" or reasoning ability) may learn more effectively when they have chosen their own reading order, rather than following sequences imposed on them by teachers or writers. Further, self-regulation forces readers to adopt more active reading strategies, which generally lead to better learning.

Several circumstances limit our ability to draw clear-cut conclusions from these studies. First, unlike most hypertext reading situations, participants in these studies knew that they had to read the whole text, that everything they needed to learn for the test was in the network, and that they needed to learn all of it, to make it all fit together. Second, in all four studies, participants used a finite list to select each successive topic. In the context of reading to understand the network as a whole, the task of ordering the segments reduces to a puzzle: looking at the topics left on the list and guessing which one would be best to read next. This is quite a different task from selectively browsing through a large messy network. Third, only in the case of Gordon et al. was the text based on an integrated piece of prose; in the other studies, the material was developed from individual modules on fairly discrete concepts. Fourth, neither Lodewijks nor Mayer described the orders students actually devised. Thus, it is unclear whether the benefits of self-selected orders were due to some feature of the orders *per se* or to the very fact that the readers were forced to think about how to sequence the text. That is, were the teacher-regulated orders deficient in some way or do learners simply benefit from actively puzzling out how to arrange the text and make sense of it?

Overall, then, these studies created conditions that encouraged the “self-regulating” students to actively seek for the connections among a finite set of textual elements. Some students in Lodewijks’s study thrived under these conditions, but not all of them. A task like this may actually be a useful exercise to give to students to encourage more active reading (though it’s not yet certain that the benefits of these exercises persist). However, for most purposes, readers are unlikely to devote the time and energy necessary to fit all the pieces of a network together and hypertext designers may not be as fastidious as these researchers about selecting appropriate information to include in the hypertext, to provide explicit relational cues, or to create relatively simple and predictable structures.

Sequencing Selected Information from a Network Another important reading situation to consider is when readers must select portions of a text, rather than having to read the whole thing. Carolyn Foss investigated the effects of self-regulation within a large hypertext, in which readers controlled both what to read and when to read it. Her participants were asked to compare and analyze information distributed across a hypertext network (Xerox NoteCards) to solve a specific problem. The network consisted of encyclopedia entries for a set of 10 countries that were not identified by name. Facts about various aspects of each country (population, climate, etc.) were available on “cards” that the user could pull out of a “file,” arrange on the screen, or refile. Given a list of the countries’ names, the users’ task was to read and compare facts about the countries in order to guess the identity of as many countries as possible within a set time period. These users, then,

had to select which cards to read, which ones to leave open, and how to arrange them.

Foss's participants varied greatly in searching skills and the ability to manage the clutter of open entries on the screen. About a third of them opened very few entries at any one time--and accordingly, kept their displays rather neat. These users read more total entries than other participants, but were unable to make effective comparisons: They identified few countries correctly, and took longer to do so. The remaining participants, who kept many entries open at once, were more successful at the task, presumably because they could view more information at the same time. About half of these users followed systematic search strategies and used the screen display efficiently. The rest were highly unsystematic, were easily sidetracked, and wasted time revisiting cards and sorting through the cluttered display.^x

Foss's study reinforces the notion raised earlier that it is crucial for readers to see relevant information in close proximity in order to make appropriate connections. The participants in this study who kept a large number of cards open were more successful at this particular task because they were able to see enough facts at one time to make useful comparisons and notice useful details. The participants who were more worried about keeping neat displays may have read exactly the same cards, but failed to make the connections--presumably because they read them at an inopportune time or in fruitless conjunctions.

It follows, as a more important implication of Foss's study, that many people are not very good at regulating their selection and organization of information. Of the participants in the study, fully a third adopted unproductive "neat screen" strategies. Another third

created wildly messy screens; this was a strategy that seems not to have cost them much in this task, but may well create problems in other tasks (just as a neat screen strategy might be more advantageous in another kind of task). It is unclear, of course, whether people maintain their preferences for neat or messy screens in different task situations, or whether people who use hypertext more often learn strategies appropriate to the task at hand.

In addition to individual preferences for how to manage a display, differences in previous knowledge of the information in a hypertext also influences selection strategies. Jean-François Rouet (“Initial Domain Knowledge”) investigated how prior knowledge influenced the efficiency of high school students looking for information in a hypertext network in order to answer specific questions. He found that students who were highly knowledgeable about a particular subject area were much more efficient at finding the relevant information than those with low or moderate knowledge. Furthermore, by showing that students’ performance declined when they moved from a familiar to an unfamiliar domain, Rouet showed that the effects were due to specific domain knowledge and not to general reading ability or practice with the hypertext system. Taken together with the studies of Bonnie Meyer and Wolfgang Schnotz described earlier in this chapter, Rouet’s findings underscore the hardships that face a hypertext user who attempts to learn about an unfamiliar domain.

These studies suggest that the best way to sequence information is not at all obvious to readers. If the goal of hypertext is to allow people “to access information in the sequence, volume, and format that best suits their needs at the time” (Grice 22), the results of these studies suggest

that a large proportion of hypertext users will need a good deal of guidance in determining the most appropriate sequence, volume, and format of information.

Can hypertext designers create appropriate paths for readers?

Anticipating that readers will have trouble charting a logical course through a network on their own, some hypertext designers have worked to create alternative paths through a network to which readers would be directed as appropriate (Younggren; Zellweger). For example, Carlson (“Incorporating Feedback”) describes how the technical documentation for an airplane may be organized into several orders depending on the reader’s task. An alphabetical order would be most appropriate for someone trying to update selected pieces of information. An order based on spatial layout would be appropriate for someone who had to work efficiently from one end of the plane to the other, performing a set of repairs. Or, alternatively, the most efficient order might be to group information according to which tools are needed for maintenance or repair. This solution assumes that designers can anticipate the set of necessary paths and can reliably determine which readers need which path.

Creating such paths is hardly a straightforward task. Various factors influence what kinds of sequences any given hypertext designer may create, including the designer’s own idiosyncrasies, her sensitivity to readers’ needs, the type of text being incorporated into the network, and the choices that the hypertext system itself allows. The best evidence of the difficulties involved comes from an attempt by three leading hypertext designers using their own systems to construct

hypertexts of one small set of documents, six articles from the proceedings of a hypertext conference. Liora Alschuler carefully analyzed the resulting hypertexts and found vast qualitative and quantitative incongruities in how the articles were segmented and linked, both within any one system and across systems. Alschuler attributed one source of difficulty to the designers' inconsistency and their, perhaps inevitable, subjectivity. However, a second source of difficulty was the nature of the hypertext systems themselves which imposed significant constraints on what kinds of segments and links were even possible. This uncontrolled variability leads to serious methodological problems for those researching the effect of hypertext on reading and writing: how can one draw generalizations about hypertexts if no two systems produce the same result from a set of source texts and even the texts in any one given system are subject to erratic treatment?

I am skeptical that a hypertext designer, even under ideal conditions, can anticipate all the paths that readers may wish to create within and between texts. As we have seen, a wide range of factors influence the appropriateness of a sequence for a given reader, including the reader's prior knowledge of the domain, the reader's task or purpose for reading, the reader's "learning style," and the nature of the information itself. Considering the huge number of possible combinations of these factors, the number of alternative paths that a designer might create becomes a practical impossibility, let alone the problem of directing the right readers to the right paths. Obviously, these are issues that only experimentation with hypertexts can resolve; my purpose here is to raise serious concerns that hypertext developers

should take into account, not to discourage the development of hypertexts altogether.

Others have raised the issue of what kinds of texts can be or should be integrated into hypertext networks. Many agree that a text with closely interwoven points is not an easy or desirable candidate for conversion to hypertext because “it destroys the subtle interconnections of theme, argument, metaphor, and word choice” (Carlson, “Intelligent Interfaces” 63; Shneiderman, “Reflections”). Darrell Raymond and Frank Tompa note that, because converting a text into hypertext makes implicit structures explicit, “the key question in conversion must be *will explicit structure be as expressive as implicit structure?* When the answer is yes, the document will gain from conversion; otherwise, conversion will degrade the representation of the document” (146, original emphasis). Despite the sense that texts with complex internal structures (including many forms of narrative, expository, and persuasive prose) may suffer from conversion to hypertext, these are the very sorts of texts that many hypertext designers want most to include.

Implications of Cognitive Processes for Hypertext Design

The evidence from cognitive psychology reviewed in this essay emphasizes how heavily we rely on systematic patterns of information, for dealing with the world. This reliance on predictable patterns creates an enormous tension between the impulse toward creativity, inventiveness, and imagination, and the more conservative, “normalizing” forces that assimilate new information to established and familiar patterns. The cognitive mechanism for encoding information

in long-term memory (a process that depends on sustained or repeated conscious attention) and the selectivity imposed by schemas (i.e., the loss of things that don't easily fit) are both strongly conservative forces. It seems quite reasonable that we have mental mechanisms such as these, given the constant barrage of observations and sensations presented to us at every moment from our senses, our emotions, our intellect. Such mechanisms may account for our ability to "make sense," to impose order on the world.

The Romantic view of hypertext that aims at enabling imaginative leaps and connections between disparate texts, facts, and images, thus puts enormous technological and creative effort at the service of preserving what might be quite rare and ephemeral associations. Some of these connections, probably quite small a proportion, may be of great value and interest to those who initially make them. However, once the insight or connection is made, it is unclear that the thinker needs or wants to store the convoluted trail of associations that led up to them, let alone those that led nowhere. Such trails are probably of even lesser value to subsequent readers. The trails of associations in a hypertext may represent the ultimate in what Linda Flower calls "writer-based prose," prose that reflects the writer's process of coming to terms with a set of ideas but that may bear little relationship to his or her final stance, and none whatsoever to the readers' needs. Some hypertext proponents (e.g., Beeman et al.) claim that allowing students to explore freely in hypertext may foster insights and critical thinking through the creative juxtaposition of ideas from multiple perspectives. However, rather than fostering truly original insights, this process may simply reduce to a guessing game, figuring out what the hypertext writer

(usually the teacher or a fellow student) had in mind when creating a link. As discussed earlier, the nature of the reading process suggests that chance conjunctions and odd juxtapositions tend to be dropped from the reader's mental representation of a text. So the most imaginative links that a hypertext writer/designer creates may have little chance to be remembered or to influence the reader's subsequent thinking in any significant way. But the consequences for the reader of whimsically following links into disparate texts or text segments may be to obstruct or hinder the more conventional but durable processes of systematically integrating new information with old.^{xi}

To the extent that readers rely on structure--that they learn by discerning and internalizing the structure of a text (Jaynes)--hypertexts that emphasize such free-form browsing may interfere with readers' efforts to make sense of the text and even with more limited and pragmatic efforts to find information relevant to some specific question. A hypertext system that promotes free exploration and browsing, then, may be effective only in certain kinds of reading situations, such as reading for pleasure, but not for scholarship. In contrast, a hypertext system that only allows readers to choose among a fixed set of paths through the network may satisfy particular readers' purposes better--though designers of these systems face significant challenges for creating the "right" paths and steering the right readers onto them. In these systems, though, the romance of hypertext disappears; the hypertext becomes functionally identical to a set of linear texts.

As part of a literate society, we are familiar with traditional text structures. We have time-tested cognitive and rhetorical theories to bring to bear on describing effective printed texts and we have derived

from these theories a wealth of practical advice to convey to writers--students and professionals alike. But we lack corresponding theories for how to deal with hypertexts--especially those that push the limits with complex linkages within and between a complex set of texts. In this essay, I have sketched the challenges that an effective hypertext would face. Much work remains to fulfill the promise of hypertext for readers and writers.

Some hypertext designers are attempting to overcome problems of disorientation and cognitive overload (e.g., Utting and Yankelovich; Rouet, "Interactive Text Processing"; Gordon; Gordon and Lewis), but more research is needed. The critical issues fall into two broad categories, the construction of hypertexts and the effects of hypertext on the reading process. The first order of business may be to create, and study the creation of, large, complex, sophisticated hypertexts, involving a range of kinds of text. Like Foss's study, some should contain expository information intended to help people solve research problems. Others should be constructed to explore the effect of hypertext on existing imaginative literature, to supplement the work of "interactive fiction" writers who are designing literary works specifically for the hypertext environment (e.g., Moulthrop). Finally, in spite of the fact that hypertexts were originally intended as resources for scholars, few complex networks yet exist for scholarly literatures, such as books and journal articles. These studies on the construction of hypertexts should, like Alschuler's, investigate the constraints imposed by different hypertext technologies. Drawing on rhetorical, linguistic, psychological, and literary theories of text structure, these studies should confront the issue of what kinds of texts can or should be

presented in hypertext environments and, for those that are appropriate, should systematically explore different ways to partition and interrelate a set of texts. Formative evaluation of such hypertexts with readers should be on-going. Research with readers must eventually involve the full range of factors identified in the research reviewed here, involving readers with different purposes, different cognitive styles, different amounts of background knowledge. The goal of the larger research agenda must be to find ways within hypertext to provide appropriate discourse cues, cues that will help readers decide what to read, how much to read, and when to read the rich array of information available in the network. These cues may be manifested in hypertext design in a variety of ways--many of which have been inadequately explored in current systems (as discussed by Wright and Lickorish). Hypertexts are here to stay, but it is up to researchers, teachers, and software designers to ensure that they promote the work of writers and readers.

REFERENCES

- Alschuler, Liora. "Handcrafted Hypertext: Lessons from the ACM Experiment." *The Society of Text: Hypertext, Hypermedia and the Social Construction of Information*. Ed. Edward Barrett. Cambridge, MA: MIT Press, 1989. 343-361.
- Anderson, Paul. *Technical Writing: A Reader-Centered Approach*. 2nd ed. San Diego: Harcourt Brace Jovanovich, 1991.
- Barrett, Edward, ed. *Text, ConText, and HyperText*. Cambridge, MA: MIT Press, 1988.
- Bartlett, F. C. *Remembering*. Cambridge: The University Press, 1932.

- Beeman, William, Kenneth Anderson, Gail Bader, James Larkin, Anne McClard, Patrick McQuillan, and Mark Shields. "Hypertext and Pluralism: From Lineal to Non-linear Thinking." *Hypertext '87 Papers*. Proceedings of Hypertext '87, November 13-15, 1987, University of North Carolina, Chapel Hill. Ed. John Smith, Frank Halasz, Nicole Yankelovich, Mayer Schwartz, and Stephen Weiss. New York: ACM, 1989. 67-88.
- Borland, Katherine. "Orality and Literacy: Thoughts About the Evolution of Consciousness." *Constructing Rhetorical Education*. Eds. Marie Secor and Davida Charney. Southern Illinois University Press, 1992, 43-62.
- Bransford, John. *Human Cognition: Learning, Understanding and Remembering*. Belmont, CA: Wadsworth, 1979.
- Britton, Bruce, and Sami Gülgöz. "Using Kintsch's Computational Model to Improve Instructional Text: Effects of Repairing Inference Calls on Recall and Cognitive Structures." *Journal of Educational Psychology* 83 (1991): 329-345.
- Bush, Vannever. "As We May Think." *The Atlantic* 176.1 (July 1945): 101-108.
- Carlson, Patricia A. "Hypertext: A Way of Incorporating User Feedback into Online Documentation." *Text, ConText, and HyperText: Writing with and for the Computer*. Ed. Edward Barrett. Cambridge, MA: MIT Press, 1988. 93-110.
- . "Hypertext and Intelligent Interfaces for Text Retrieval." *The Society of Text: Hypertext, Hypermedia and the Social Construction of Information*. Ed. Edward Barrett. Cambridge, MA: MIT Press, 1989. 59-76.

- Catlin, Timothy, Paulette Bush, and Nicole Yankelovich. "InterNote: Extending a Hypermedia Framework to Support Annotative Collaboration." *Hypertext '89 Proceedings*. Proceedings of Hypertext '89, November 5-8, 1989, Pittsburgh, PA. Ed. Norman Meyrowitz. New York: ACM, 1989. 365-78.
- Charney, Davida. "A Study in Rhetorical Reading: How Evolutionists Read 'The Spandrels of San Marco.'" *Understanding Scientific Prose*. Ed. Jack Selzer. University of Wisconsin Press, forthcoming.
- , "Comprehending Non-Linear Text: The Role of Discourse Cues and Reading Strategies." *Hypertext '87 Papers*. Proceedings of Hypertext '87, November 13-15, 1987, University of North Carolina, Chapel Hill. Ed. John Smith, Frank Halasz, Nicole Yankelovich, Mayer Schwartz, and Stephen Weiss. New York: ACM, 1989. 109-120.
- Conklin, Jeff. "Hypertext: An Introduction and Survey." *IEEE Computer* 20.9 (1987): 17-41.
- Eylon, Bat-Sheva, and F. Reif. "Effects of Knowledge Organization on Task Performance." *Cognition and Instruction* 1.1 (1984): 5-44.
- Fahnestock, Jeanne, and Marie Secor. "Teaching Argument: A Theory of Types." *College Composition and Communication* 34 (1983): 20-30.
- Fahnestock, Jeanne. "Connection and Understanding." *Constructing Rhetorical Education*. Eds. Marie Secor and Davida Charney. Southern Illinois U P, 1992, 235-256.
- Felker, Daniel, Frances Pickering, Veda Charrow, V. Melissa Holland, and Janice Redish. *Guidelines for Document Designers*. Washington, D.C.: American Institutes for Research, 1981.
- Flower, Linda. "Writer-Based Prose: A Cognitive Basis for Problems in Writing." *College English* 41.1 (1979): 19-37.

- Foss, Carolyn. *Detecting Lost Users: Empirical Studies on Browsing Hypertext* (INRIA Technical Report No. 972, Programme 8). L'Institut National de Recherche en Informatique et en Automatique, Sophia-Antipolis, 2004 Route des Lucioles 06565 Valbonne, France. February 1989.
- Frase, Lawrence. "The Influence of Sentence Order and Amount of Higher Level Text Processing upon Reproductive and Productive Memory." *American Educational Research Journal* 7 (1970): 307-319.
- Glynn, Shawn, and Francis J. Di Vesta. "Outline and Hierarchical Organization as Aids for Study and Retrieval." *Journal of Educational Psychology* 69 (1977): 89-95.
- Gordon, Sallie, Jill Gustavel, Jana Moore, and Jon Hankey. "The Effects of Hypertext on Reader Knowledge Representation." *Proceedings of the Human Factors Society, 32nd Annual Meeting*, Anaheim, CA, 1988.
- Gordon, Sallie, and Vicki Lewis. "Knowledge Engineering for Hypertext Instructional Systems." *Proceedings of the Human Factors Society, 34th Annual Meeting*, Anaheim, CA, 1990.
- . "Enhancing Hypertext Documents to Support Learning From Text." *Technical Communication*, 39 (1992): 305-308.
- Grice, Roger. "On-line Information: What Do People Want? What Do People Need?" *The Society of Text: Hypertext, Hypermedia and the Social Construction of Information*. Ed. Edward Barrett. Cambridge, MA: MIT Press, 1989. 22-44.
- Grimes, Joseph. *The Thread of Discourse*. The Hague: Mouton, 1975.
- Halliday, Michael, and R. Hasan. *Cohesion in English*. London: Longman, 1976.

- Harpold, Terence. "Hypertext and Hypermedia: A Selected Bibliography." *The Hypertext/Hypermedia Handbook*. Eds. Joe Devlin and Emily Berk, New York: McGraw-Hill, 1991.
- Hayes, John R. *Cognitive Psychology: Thinking and Creating*. Homewood, IL: Dorsey, 1978.
- Herrstrom, David S., and David G. Massey. "Hypertext in Context." *The Society of Text: Hypertext, Hypermedia and the Social Construction of Information*. Ed. Edward Barrett. Cambridge, MA: MIT Press, 1989. 45-58.
- Irish, Peggy, and Randall Trigg. "Supporting Collaboration in Hypermedia: Issues and Experiences." *The Society of Text: Hypertext, Hypermedia and the Social Construction of Information*. Ed. Edward Barrett. Cambridge, MA: MIT Press, 1989. 90-106.
- Jaynes, Joseph. "Limited Freedom: Linear Reflections on Nonlinear Texts." *The Society of Text: Hypertext, Hypermedia and the Social Construction of Information*. Ed. Edward Barrett. Cambridge, MA: MIT Press, 1989. 148-161.
- Just, Marcel, and Patricia Carpenter. *The Psychology of Reading and Language Comprehension*. Boston, MA: Allyn and Bacon, 1987.
- Kerr, Stephen. "Finding One's Way in Electronic Space: The Relative Importance of Navigational Cues and Mental Models." Paper presented at the Annual Conference of the Association for Educational Communication and Technology. Atlanta, GA, February 1987.
- Kieras, David. *The Role of Prior Knowledge in Operating Equipment from Written Instructions* (Technical Communications Technical Report 19). University of Michigan, Ann Arbor. February 1985.

- , "A Model of Reader Strategies for Abstracting Main Ideas from Simple Technical Prose." *Text* 2.1 (1982): 47-81.
- , "Initial Mention as a Signal to Thematic Content in Technical Passages." *Memory and Cognition* 8.4 (1980): 345-353.
- , and Christiane Dechert. *Rules for Comprehensible Technical Prose: A Survey of the Psycholinguistic Literature* (Technical Communications Technical Report 21). University of Michigan, Ann Arbor. June 1985.
- Kintsch, Walter. "The Role of Knowledge in Discourse Comprehension: A Construction-Integration Model." *Psychological Review* 95 (1988):163-182.
- , and Teun van Dijk. "Toward a Model of Text Comprehension and Production." *Psychological Review* 85 (1978): 363-394.
- Lodewijks, Hans. "Self-Regulated Versus Teacher-Provided Sequencing of Information in Learning from Text." *Discourse Processing*. Eds. August Flammer and Walter Kintsch. Amsterdam; New York: North-Holland, 1982. 509-520.
- Maki, Ruth. "Memory for Script Actions: Effects of Relevance and Detail Expectancy." *Memory and Cognition*, 18 (1990): 5-14.
- Marchionini, Gary, and Ben Shneiderman. "Finding Facts and Browsing Knowledge in Hypertext Systems." *IEEE Computer* 21.1 (1988): 70-80.
- Mayer, Richard E. "Some Conditions of Meaningful Learning for Computer Programming: Advance Organizers and Subject Control of Frame Order." *Journal of Educational Psychology* 68 (1976): 143-150.
- , Linda K. Cook, and Jennifer L. Dyck. "Techniques that Help Readers Build Mental Models from Scientific Text: Definitions Pretraining and Signaling." *Journal of Educational Psychology* 76.6 (1984): 1089-1105.

- Meyer, Bonnie J. F. "Text Dimensions and Cognitive Processing." *Learning and Comprehension of Text*. Heinz Mandl, Nancy L. Stein, and Thomas Trabasso, eds. Hillsdale, NJ: Lawrence Erlbaum Associates, 1984. 3-51.
- Meyer, Bonnie J. F., and Roy O. Freedle. "Effects of Discourse Type on Recall." *American Educational Research Journal* 21.1 (1984): 121-143.
- Mitterer, John, Gary Oland, and J. S. Schankula. *Hypermedia Bibliography* (Computer Science Tech Report CS-88-02). Brock University, St. Catharines, Ontario. June 1988.
- Moulthrop, Stuart. "Hypertext and 'the Hyperreal.'" *Hypertext '89 Proceedings*. Proceedings of Hypertext '89, November 5-8, 1989, Pittsburgh, PA. Ed. Norman Meyrowitz. New York: ACM, 1989. 259-267.
- Neuwirth, Christine M., and David Kaufer. "The Role of External Representations in the Writing Process: Implications for the Design of Hypertext-Based Writing Tools." *Hypertext '89 Proceedings*. Proceedings of Hypertext '89, November 5-8, 1989, Pittsburgh, PA. Ed. Norman Meyrowitz. New York: ACM, 1989. 319-342.
- , David Kaufer, Rick Chimera, and Terilyn Gillespie. "The Notes Program: A Hypertext Application for Writing from Source Texts." *Hypertext '87 Papers*. Proceedings of Hypertext '87, November 13-15, 1987, University of North Carolina, Chapel Hill. Ed. John Smith, Frank Halasz, Nicole Yankelovich, Mayer Schwartz, and Stephen Weiss. New York: ACM, 1989. 121-141.
- , David Kaufer, Gary Keim, and Terilyn Gillespie. *The Comments Program: Computer Support for Response to Writing* (Technical Report CMU-CECE-TR-2). Carnegie Mellon University, Pittsburgh, PA. January, 1988.

- Pea, Roy D., and D. Midian Kurland. "Cognitive Technologies for Writing." *Review of Research in Education*, vol. 14. Ed. Ernst Rothkopf. Washington, D.C.: AERA, 1987. 277-326.
- Raskin, Jef. "The Hype in Hypertext: A Critique." *Hypertext '87 Papers*. Proceedings of Hypertext '87, November 13-15, 1987, University of North Carolina, Chapel Hill. Ed. John Smith, Frank Halasz, Nicole Yankelovich, Mayer Schwartz, and Stephen Weiss. New York: ACM, 1989. 325-330.
- Raymond, Darrell R., and Frank W. Tompa. "Hypertext and the *New Oxford English Dictionary*." *Hypertext '87 Papers*. Proceedings of Hypertext '87, November 13-15, 1987, University of North Carolina, Chapel Hill. Ed. John Smith, Frank Halasz, Nicole Yankelovich, Mayer Schwartz, and Stephen Weiss. New York: ACM, 1989. 143-154.
- Reinking, David, and Robert Schreiner. "The Effects of Computer-Mediated Text on Measures of Reading Comprehension and Reading Behavior." *Reading Research Quarterly* 20 (1985): 536-552.
- Robertson, G. Kamilla, Don McCracken, and Alan Newell. *The ZOG Approach to Man-Machine Communication* (Computer Science Technical Report CMU-CS-79-148). Carnegie Mellon University, Pittsburgh, PA. October, 1979.
- Rose, Mike. "Narrowing the Mind and Page: Remedial Writers and Cognitive Reductionism." *College Composition and Communication* 39.3 (1988): 267-302.
- Rouet, Jean-François. "Initial Domain Knowledge and Comprehension Strategies in the Use of an Interactive Reading Software." Paper presented at the 3rd European Conference on Learning and Instruction, Madrid, September 4-7, 1989.

- , "Interactive Text Processing by Inexperienced (Hyper-) Readers." *Hypertexts: Concepts, Systems, and Applications*. Eds. A. Rizk, N. Streitz, and J. André. Cambridge, UK: Cambridge University Press, 1990. 250-260.
- Sanford, Anthony, and Simon Garrod. *Understanding Written Language: Exploration in Comprehension Beyond the Sentence*, Chichester, UK: Wiley, 1981.
- Schnotz, Wolfgang. "How Do Different Readers Learn with Different Text Organizations?" *Discourse Processing*. Eds. August Flammer and Walter Kintsch. Amsterdam; New York: North-Holland, 1982. 87-97.
- Schnotz, Wolfgang. "Comparative Instructional Text Organization." *Learning and Comprehension of Text*. Heinz Mandl, Nancy L. Stein, and Thomas Trabasso, eds. Hillsdale, NJ: Lawrence Erlbaum Associates, 1984. 53-81.
- Schwarz, Maria N., and August Flammer. "Text Structure and Title--Effects on Comprehension and Recall." *Journal of Verbal Learning and Verbal Behavior* 20 (1981): 61-66.
- Shneiderman, Ben. "Reflections on Authoring, Editing, and Managing Hypertext." *The Society of Text: Hypertext, Hypermedia and the Social Construction of Information*. Ed. Edward Barrett. Cambridge, MA: MIT Press, 1989. 115-131.
- Slatin, John R. "Reading Hypertext: Order and Coherence in a New Medium." *College English* 52.8 (1990): 870-883.
- Smith, John, Stephen Weiss, and Gordon J. Ferguson. "A Hypertext Writing Environment and Its Cognitive Basis." *Hypertext '87 Papers*. Proceedings of Hypertext '87, November 13-15, 1987, University of North Carolina,

- Chapel Hill. Ed. John Smith, Frank Halasz, Nicole Yankelovich, Mayer Schwartz, and Stephen Weiss. New York: ACM, 1989. 195-214.
- Trigg, Randall, and Peggy Irish. "Hypertext Habitats: Experiences of Writers in NoteCards." *Hypertext '87 Papers*. Proceedings of Hypertext '87, November 13-15, 1987, University of North Carolina, Chapel Hill. Ed. John Smith, Frank Halasz, Nicole Yankelovich, Mayer Schwartz, and Stephen Weiss. New York: ACM, 1989. 89-108.
- Utting, Kenneth, and Nicole Yankelovich. "Context and Orientation in Hypermedia Networks." *ACM Transactions on Information Systems* 7.1 (1989): 58-84.
- van Dijk, Teun. "Relevance Assignment in Discourse Comprehension." *Discourse Processes* 2 (1979): 113-126.
- , and Walter Kintsch. *Strategies of Discourse Comprehension*. New York: Academic Press, 1983.
- Walker, Janet H. "Authoring Tools for Complex Documents." *The Society of Text: Hypertext, Hypermedia and the Social Construction of Information*. Ed. Edward Barrett. Cambridge, MA: MIT Press, 1989. 132-147.
- Walker, Janet H. "Document Examiner: Delivery Interface for Hypertext Documents." *Hypertext '87 Papers*. Proceedings of Hypertext '87, November 13-15, 1987, University of North Carolina, Chapel Hill. Ed. John Smith, Frank Halasz, Nicole Yankelovich, Mayer Schwartz, and Stephen Weiss. New York: ACM, 1989. 307-324.
- Whiteside, John, Sandra Jones, Paula Levy, and Dennis Wixon. "User Performance with Command, Menu and Iconic Interfaces." *Human Factors in Computing Systems*. Proceedings of the CHI '85 Conference, April 14-18, 1985, San Francisco, CA. Eds. Lorraine Borman and Bill Curtis. New York: ACM, 1985. 185-191.

- Wilhite, Stephen. "Headings as Memory Facilitators." *Practical Aspects of Memory: Current Research and Issues*, Vol. 2. Eds. Michael Gruneberg, Peter Morris, and Robert Sykes. Chichester: Wiley, 1988. 531-536.
- Wright, Patricia, and Ann Lickorish. "The Influence of Discourse Structure on Display and Navigation in Hypertexts." *Computers and Writing*. Eds. N. Williams and P. Holt. Worcester, Great Britain: Billing and Sons. 90-124.
- Yankelovich, Nicole, Norman Meyrowitz, and Andries van Dam. "Reading and Writing the Electronic Book." *IEEE Computer* 18.10 (1985):15-30.
- Younggren, Geri. "Using an Object-Oriented Programming Language to Create Audience-Driven Hypermedia Environments." *Text, ConText, and HyperText: Writing with and for the Computer*. Ed. Edward Barrett. Cambridge, MA: MIT Press, 1988. 77-92.
- Zellweger, Polle T. "Scripted Documents: A Hypermedia Path Mechanism." *Hypertext '89 Proceedings*. Proceedings of Hypertext '89, November 5-8, 1989, Pittsburgh, PA. Ed. Norman Meyrowitz. New York: ACM, 1989. 1-14.

ⁱ This essay develops and extends ideas first presented at Hypertext '87 (Charney, "Comprehending Non-Linear Text"). The research was generously supported by a Penn State Research Initiation Grant and by Tektronix Inc. I am grateful to Christine Neuwirth, Rich Carlson, and Mark Detweiler for comments on earlier versions of the manuscript.

ⁱⁱ There is an extensive and growing literature on hypertexts. For a history and overview, see Conklin; for bibliographies, see Mitterer and Schankula or Harpold.

ⁱⁱⁱ For a straightforward, general introduction to cognitive psychological perspectives on memory and learning, see Bransford. Many of the issues to be raised here are also discussed by

Just and Carpenter and by Sanford and Garrod, who all focus on those aspects of cognition that relate to reading. For a brief review of the history of cognitive psychology, see Hayes.

^{iv} Some hypertext proponents assume that these cognitive limitations somehow result from the limited forms of writing available through print technology. They believe that a revolution in technology will lead to a revolution in cognitive capacity--on analogy with the advances presumed to have taken place when oral cultures became literate. In fact, many researchers have concluded that literacy did not change human cognitive capacity, but rather how that capacity is used (for general discussions, see Borland and Rose). In particular, technology is unlikely to influence the way in which we visually process written texts (or auditorially process speech), both of which are linear (for reviews of relevant research, see Just and Carpenter). We read in linear sequences of words and sentences. Hypertext may change which sequences are available--and may well impose more frequent decision points for which sequence to follow--but it will not change our basic mental architecture.

^v The shift in burden also has consequences for writers. Carlson ("Incorporating Feedback") raises the issue of whether and how writers can create segments of text that will make sense to any reader who encounters them, without knowing what previous segments he or she has read: "...since nodes may be 'threaded' into different paths, they must be reusable, requiring research into the requisites (as well as the effects) of free-standing, rhetorically 'neutral' prose" (96). The concept of "rhetorically 'neutral' prose" is one that many rhetoricians, such as Mary Beth Debs find troubling (personal communication).

^{vi} In fact, the mechanism that Kintsch adopts, spreading activation within a network with links of various strengths, in effect functionally reproduces the evocation of a schema. It works by activating a set of propositions that are most strongly linked to some other proposition--presumably including many previously assumed to reside in a schema--while also allowing for the activation of additional, less predictable kinds of knowledge and associations. It is evident from the recent research literature that cognitive psychologists do not take Kintsch's

current position as rendering the terms “script” or “schema” meaningless--researchers who cite and build on Kintsch’s 1988 article continue to explore how schemas and scripts influence learning and memory (e.g., Maki).

vii A more familiar and analogous case of the increased burdens imposed by technological “liberation” is the advent of desk-top publishing. Such systems do indeed free writers to make their own choices concerning details of typography, page layout, graphics, and the like. However, the price of greater control to individual writers is the responsibility (and sometimes the sheer necessity) of acquiring some expertise in effective graphic design and printing.

viii Of course some of these problems apply to conventional printed text too. People don’t have to (and don’t) obediently read in order (Charney, “A Study in Rhetorical Reading”). Active readers often break out of a linear order to seek an overview of the paper--perhaps by reading the abstract, introduction and conclusion and then skimming over the headings and looking at diagrams and tables. Depending on their purpose, they may content themselves with an overview constructed from skimming for the main points of each paragraph, or only read sections relevant to their goal. The point is that hypertext makes the situation much worse. Readers of printed texts can scan the page or thumb through the text to see how much is there, to see whether anything further down the page looks important or useful, or to see how much elaboration the writer considers it worthwhile to include. This is a lot harder to do in hypertext because readers must consciously choose to look at something (i.e., by clicking a button), because new information may displace other information on the screen, and because making such a choice may make it harder to get back to where the reader started.

ix “Field dependence/independence” are widely used but little understood characterizations of “cognitive style” that are based on a person’s strategies of visual perception, and that purportedly reflect the manner in which he or she attempts to solve problems. “Field independent” people are characterized as more individualistic, more self-motivating, and less dependent on external cues than “field dependent” learners. For a review and critique of field

dependence/independence, see Rose. Such measures of cognitive style may be most reliable, as here, when they are used in conjunction with correlating measures of individual differences.

^x While Foss examined important issues and reported interesting observations, the available report of her research is frustratingly incomplete in terms of methodological details and analysis of the results. The number of subjects in the study was small (n=10) and no inferential statistics were reported. It is therefore impossible to tell whether the differences described here were statistically significant.

^{xi} As the research described here suggests, a reader's (or writer's) tolerance for the confusion engendered by hypertext is clearly situation-specific. Readers' attitudes will vary depending on their reasons for reading, their cognitive abilities and familiarity with the content area, their deadlines, the type of texts involved, and so on. Many people enjoy some confusion when they read a modern novel--but not when they read a political treatise or an instruction manual. Hypertext, of course, has effects that go beyond thwarting comprehension on the most basic level. Elsewhere in this volume Stuart Moulthrop and Nancy Kaplan describe other consequences--some positive and some clearly negative--of the deliberate use of hypertext to break down the boundaries between writer and reader, between previously autonomous texts, and between texts and interpretations. Their purpose was both playful and didactic--to encourage students to become active, "strong" readers of any text, even those presented in a seemingly closed, authoritative, linear, hard cover publication. As they discovered (and as Johndan Johnson-Eilola remarks in his essay), hypertext may subvert even these intentions--silencing where it was intended to give voice.