The Shape of Text to Come: The Texture of Print on Screens

Stephen A. Bernhardt

Changes in the technology of text invariably trigger changes in the shape of text. Texts are undergoing monumental transformation as the medium of presentation shifts from paper to screen. We need to constantly appraise the broad drifts in the shape of text—to anticipate what now constitutes and what will soon constitute a well-formed text. We need to think about how readers interact with text—what they do with it and how. We need to anticipate where text is going: the shape of text to come.

This paper suggests some of the dimensions of change in how text is structured on the page and on the screen. It is necessarily speculative, since the topic is just beginning to receive systematic attention (Bolter; Brockmann; Horton; Kostelnick; Merrill; Rubens, "A Reader's View" and "Online Information"; Rubens and Krull; Special Issue of *Visible Language* 1984).

We have a good theoretical understanding and a highly developed practical art of the rhetoric and text structure of paper documents, and this praxis exerts a strong shaping influence over texts produced via electronic media. We are in a state of rapid evolution, with heavy borrowing on the history of text on paper, applied sometimes appropriately and sometimes inappropriately to the new medium. Because electronic text does not create a totally new rhetoric but depends for its design on the strategies of paper texts, the starting point in this analysis is not "How do screen-based texts differ categorically or essentially from their paper-based counterparts?" but "What is a framework for understanding dimensions of variation in texts across the two media?"

This paper uses a text analytical approach to identify nine dimensions of variation that help map the differences between paper and on-screen text. Screen-based text tends to exploit these dimensions to a greater degree than does paper text.

To a relatively greater extent, then, on-screen text tends to be:

> *Situationally Embedded:* The text doesn't stand alone but is bound up within the context of situation—the ongoing activities and events that make the text part of the action.

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Interactive: The text invites readers to actively engage with it—both mentally and physically—rather than passively absorb information.

Functionally Mapped: The text displays itself in ways that cue readers as to what can be done with it.

Modular: The text is composed and presented in self-contained chunks, fragments, blocks.

Navigable: The text supports reader movement across large pools of information in different directions for different readers and purposes.

Hierarchically Embedded: The text has different levels or layers of embedding; text contains other texts.

Spacious: The text is open, unconstrained by physicality.

Graphically Rich: The text exploits and integrates graphic display to present information and facilitate interaction.

Customizable and Publishable: The text is fluid, changing, dynamic; the new tools of text make every writer a publisher.

As academics with a commitment to certain kinds of discourse, we may not see as desirable all of these developments in the ways text is structured, but they appear to be inevitable. We need first to understand the directions that computers are taking written language, and then to consider these changes as we teach our students strategies for reading and writing text in a new age.

Situationally Embedded Text

When people voice doubts about whether computers will take the place of books, they are generally expressing doubts about readers' tolerance for extended reading on screen. Reading from screens tends to slow people down and fatigue them, in part because the contrast of print on page is much better than that of text on screen. But when reading is viewed as a sub-task within a larger task environment, the issue of fatigue is not so critical. Extended reading will continue to rely on print, while other functional sorts of reading will rely on screen-based text.

Screen-based text differs from paper text in many ways, and not just because the two media are different. We use text on screens under different conditions and for different purposes than we do paper texts, and it is these differences in use and purpose that will ultimately determine the key points of difference between the two media (Barton and Barton, "Simplicity"; Duchastel).

A real virtue of paper text is its detachment from the physical world. We can read on planes or in the car; we can put books in our backpacks or leave them at home. We can pick up a book or magazine or a newspaper and read in every imaginable situation, no matter what else is going on about us. In fact, reading allows us to escape the immediate situation, to enter other worlds.

In comparison with paper text, screen-based text tends to be more tightly embedded in the context of situation; it is more likely to be bound up as a part of ongoing activities. Reading screen-based text is often integrated with other forms of action—learning to use software, constructing texts from separate files, or searching a database. A reader might search for relevant text, retrieve information in the form of procedures or syntax, and then return to the task environment. In such situations, reading becomes a second-level activity, resorted to when the higher-level task activity hits a snag.

This kind of task-oriented reading stands in contrast to, say, reading imaginative literature or magazines, where readers enter a world of text that impinges little on their real-time situation. Readers of screen-based text are not so much *readers* as *doers* or *seekers:* they read to find out how to do something or to retrieve some bit of information. People tend to read screen-based text to play games or to program; they read-to-write, or read-to-operate, or read-to-look-up. We don't really have language for this kind of reading—it's more like *using* text than *reading* it. Such reading-to-do is more like making raids on print than having extended engagements with a writer's ideas or arguments. It is driven by the pragmatic situation; it is exploitative; it is manipulative (see both Sticht and Redish).

The shape of screen-based text is influenced heavily by one specific development: *help systems*—those word files that attempt to rescue computer users who encounter difficulties. Nobody reads this kind of text in anything like linear order, but many users make incursions on it as they struggle to work with their machines, reading bits and pieces as needed. The help text is simply part of the machine.

But reading that is situationally integrated with other activities is typical not just of help systems for using computers. The electronic writing classrooms of Project Jefferson at the University of Southern California (Chignell and Lacy; Lynch) or Project Athena's Educational Online System at MIT (Barrett, "Introduction," *Society*) exist to support not so much reading activities as writing activities: researching, keeping track of information, drafting and revising text, sharing text through collaboration, or sharing texts and notes with others in the class. Pieces of text get used, copied, borrowed, annotated, clipped, revised, and passed around in the interest of some governing activity—in this case, the improvement of writing. Text is read throughout the process, but reading is not the primary or ultimate goal. The computer structures an environment, where the writer, a set of texts, and a group of people interact in desirable ways. The screen-based text is interwoven with the larger activity of producing work in a group setting. Text is inseparable from the situation.

Such applications of technology take reading and writing beyond simple interaction with the computer; the computer scaffolds social interaction within an electronic environment. In his Introduction to *The Society of Text,* Barrett describes the use of computers to structure interaction (as opposed to modeling cognition) in MIT's Athena-supported network:

> [T]he internal workings of the mind were not mapped to the machine; instead, we conceived of the classroom as a "mechanism" for interaction and collaboration and mapped those social processes to the computer. In essence, we textualized the computer: we made it enter, and used it to support, the historical, social processes that we felt defined the production of texts in any instructional or conferencing environment. (xv)

In such situations of use, text is embedded within systems—it is not separate like a book or a magazine. Its texture is shaped by both the machine and the instrumental purposes and social interactions to which the text is put. Screen-based text becomes part of a physical system that governs where it can be used, who can access it, what is needed to access it, and so on. Text is inseparable from the machine.

Notice how different this tends to make screen-based text from paper text. While books are self-contained, portable, and usable within almost any situation, screen-based text becomes dependent on a larger technological and social environment, to be used under delimited circumstances, typically as an integral part of other ongoing events. This is an important contrast in the pragmatics of paper vs. screen, underscored by the contrast of *text-intensive* books vs. *situationally embedded* screen-based language.

Interactive Text

It is commonplace to characterize the reader's role in a text as being active or transactive, constructive or constitutive. In this view, readers construct or reconstruct a text in their own image, bringing as much to a text as they take from it. When we talk in these ways, we often have in mind private encounters with text in physically inactive settings. We are talking primarily about mental processes, or language processes, or sometimes social processes, but not necessarily physical processes.

It is useful to view the reading of electronic text in similar terms, only more so, or at least, more variously so. Readers of on-screen text interact physically with the text. Through the mouse, the cursor, the touch screen, or voice activation, the text becomes a dynamic object, capable of being physically manipulated and transformed. The presence of the text is heightened through the virtual reality of the screen world: readers become participants, control outcomes, and shape the text itself.

Figure 1 presents a screen from the Perseus project, a HyperCard application developed at Harvard and Boston Universities as an Annenberg/CPB project (Harward). The project is designed to help undergraduates understand the classical Greek world and its literature. The particular module, from "Visualizing Aristophanes," helps students visualize a staged production of a Greek play.

In the Perseus model, learning is highly interactive and manipulative: students use the mouse to assign roles, to position and move characters on stage, and to block out the plays scene by scene. The on-screen text reflects the active,

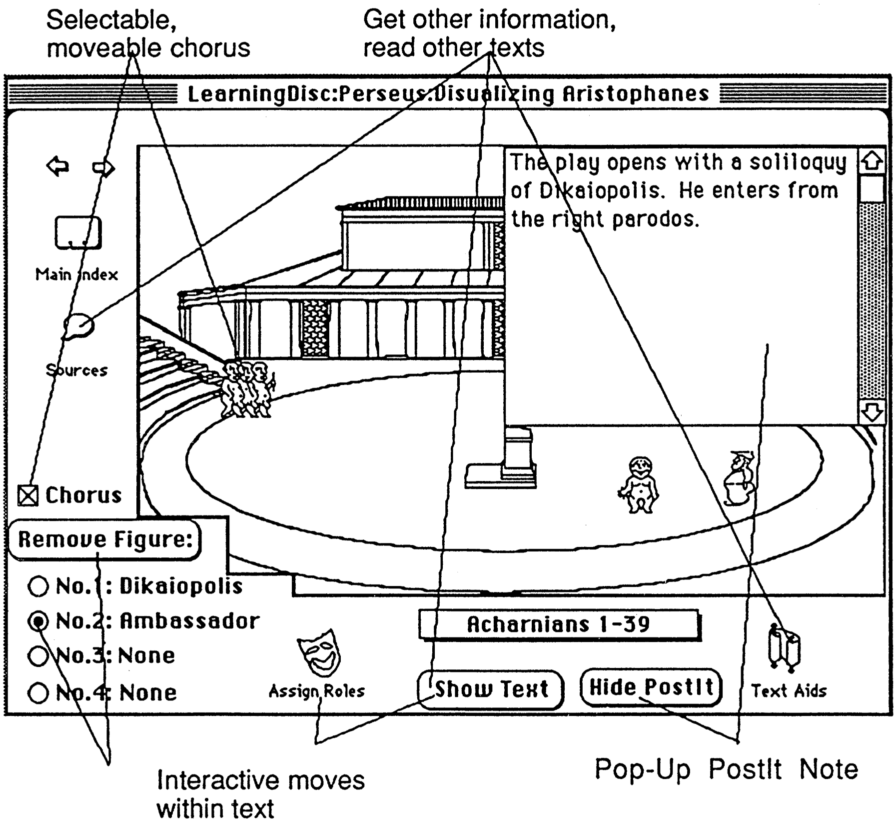

Figure 1: Interactive Screen Text: The reader interacts in multiple ways with the text by making selections, moving characters on the stage, requesting help or commentary, going to related texts, or popping up PostIt notes. From Perseus Project, hypermedia educational software under development at Harvard and Brown Universities; screen captured from Apple Learning Disk (CD-ROM). © 1988 Apple Computer, Cupertino, California.

participatory style of learning, with active, imperative verb/object commands around the perimeter of the stage drawing: Remove Figure, Show Text, Hide PostIt, and Assign Roles. Certainly, there is reading going on here—continuously—but it is fully integrated with other sorts of actions: planning scenes; reading text, translations, and commentary; checking necessary background, source, or related information; visualizing the interaction of characters as the drama unfolds; and actually moving figures about in physical space.

Here, the Perseus designers take active, constructive reading into the arena of physical manipulation and sensory visualization. They take advantage of what we have long known from learning psychology—that as opposed to learners who passively attempt to learn information, learners who are active readers, who engage with material in multi-modal capacities, are likely to remember more, to remember it longer, and to remember it more accurately. Perseus forces readers to be physically and mentally present, to interpret options, to make selections, and to construct textual, visual, and metaphoric worlds. Such materials take computer-based texts and computer-based learning well beyond simple page turning by giving readers control of flexible, interactive engagements with the text.

As Perseus suggests, reading text on screen tends to be a much more behaviorally interactive process than reading text on paper (Duchastel). The parallel activities of reading and writing create the interaction. Screen readers are actively engaged with screen text, as they key in information, or capture text from one file and move it somewhere else, or annotate or add to existing information in a file. A similar interactivity is sometimes sought in books, as writers try to engage the reader in solving problems, considering scenarios, or attempting various learning activities while reading the text. However, writers of print material cannot *force* the interaction, they can only *invite* it; readers can play along or skim past the problem sets, brain teasers, or tutorial activities. Writers of on-screen text can *force* interaction, making it necessary for the reader to do something physical in order to get to the next step.

The contrast in interactivity distinguishes other genres as well. Consider printed novels and their screen counterparts: text-based "novels" or adventure games. Readers of novels are constrained by the linearity of the text. While there are fundamental differences in how readers respond to a text, the book presents the same face to each reader, and the choices of approach are very limited. One might choose to read the ending first or to peek at various chapters, but these are fairly impoverished choices. A reader of a text-based electronic novel or adventure game, in contrast, has to make constant decisions about where to go, what to do, who to follow or question. In doing so, the reader is forced to construct not just a mental representation of the work, but a physical representation as well (the succession of screens), through concrete manipulations of the text. Out of many possible physical constructions of the text, the reader creates one, a particular chronological and experiential ordering of the text, a reading that belongs to no other reader.

I am not holding up increased interactivity as a goal of print and I am not suggesting that, for example, electronic novels are richer or more satisfying than print novels. Such is clearly not the case. However, we should not underestimate the developing genre of electronic novel: writers are discovering new forms of literary textuality and engaging in some very interesting experiments. (See, for example, the special issue of *Writing on the Edge,* with its accompanying hypernovellas on disk.) In these experiments, authors engage readers in new forms of interaction, encourage readers to take control over the text, and blur the lines separating author and reader. We need to be alert to interactivity as a deeply interwoven feature of electronic texts, one we are just beginning to exploit.

Functionally Mapped Text

Text, whether on page or on screen, performs a function of some sort: informing, directing, questioning, or posing situations contrary to fact. Such functional variation is often expressed linguistically through the grammatical systems of mood (indicative, imperative, interrogative, subjunctive). Readers can also usually make some rhetorical determination as to what a chunk of text is doing—whether it is making a generalization, committing a vow, stating a fact, offering an example or definition, offering metacommentary on the text itself, or some other text act. In many printed texts, such functional variation is mapped semantically—one interprets the functional roles of various chunks of text by inferring purpose from the meaning of the words or phrases. Often, semantic or rhetorical function shifts are mapped by cohesive devices, phrases like "for example," or "to consider my next point." When text shifts from one function to another, the rhetorical tension at the boundary tends to demand some kind of signal, and the language is rich in such signal systems (Bernhardt, "Reader").

Both sorts of text—print and screen-based—also use visual cues of layout and typography to signal functional shifts. The visual system maps function onto text, signaling to the reader how the text is to be read and acted upon. Thus tutorial writers (print or on-line) might use a numbered list of action steps, with explanations indented below each action, or they might use a double-column playscript format, with actions on the left and results or explanations on the right. Boldface or other typographical signals might highlight actions, while parentheses or italics might signal incidental commentary. The visual structuring that functionally differentiates text is reinforced by syntactic cues that highlight the action being performed—imperative or declarative grammatical structures, sequence cues like *next* or enumeratives, and explanatory phrases like "to complete the installation" or "pressing the return key enters the value."

When language is on-screen, readers must be able to distinguish different functions:

- Some language cues interaction with the system: how to manage files, execute commands, or control the display.
- Other language cues navigation: where one is, how to move around, or how to get help.
- Still other language offers system messages, showing that errors have occurred or that the system is currently processing some command. Some language simply reminds readers of the system status or default settings.
- And some language is informative/ideational.

The tight interworking of text and action leads to frequent system requests for action that the reader must interpret and respond to correctly (from the system's point of view). These functional discriminations are not unique to electronic text, but they tend to be much more important to efficient reading, and they tend to demand highly planned and carefully structured formatting decisions on the part of the writer.

Figure 2 shows rich functional mapping in a screen from the Jefferson Project, a HyperCard "electronic writing notebook" developed to support writing instruction at the University of Southern California (Chignell and Lacy).

Numerous buttons exist on this screen—places to click with the mouse that execute some move or operation. The screen is full of things to do, not just things to read. Icons initiate procedures and help readers recognize the hot spots on the screen. The escape hatches—HELP and QUIT—are signaled both

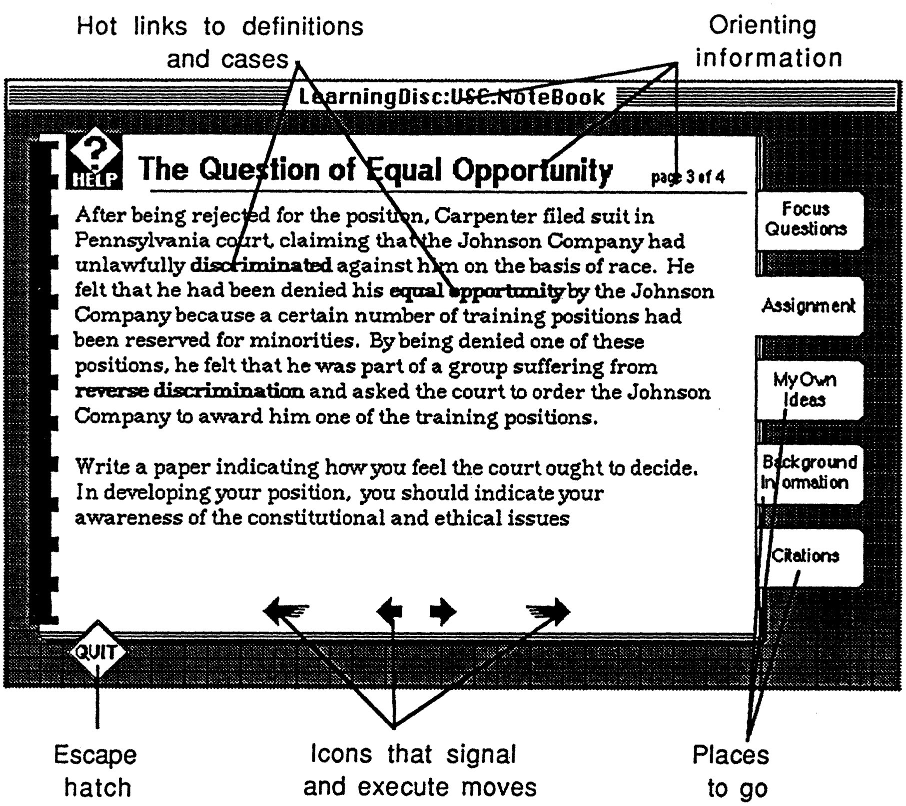

Figure 2: This screen shows rich functional mapping, with icons, bolded terms, index tabs, help and quit buttons—all signaling things to do and places to go. Screen from Project Jefferson, HyperCard stack under development at the University of Southern California; screen captured from Apple Learning Disk (CD-ROM), © 1988, Apple Computer, Cupertino, California.

iconically and verbally to show the reader that something can actually be done with the icons. The tabs, representing possible moves to other text space, are boxed and use a font that contrasts with the primary text, suggesting that they are active buttons. Within extended passages, words in bold print signal other places to go and things to do—in this case, accessing additional information and glossary definitions. Arrows signal movement—hot spots that take the reader forward or backward in the text, at normal pace or fast, using an easily understood analogy to tape recorder controls.

Not all areas of the screen are equal, and functional mapping tends to be richest on the borders—in the peripheral areas a biologist would call *ecotonic.* There is always a rich diversity and abundance of life on the edges of systems. On screens, the language is the richest, there is the most going on, there is the greatest range of things to do around the edges, on the perimeters. It is on the edge that we recognize where we are, what we can do, where we can go, or how we can get out.

Increasingly, various programs are adapting consistent functional mapping of options. With pull-down menus, for example, available options often appear in a regular or bolded black font, while program options that are not currently available are shown in a shadowy, gray font. A simple, efficient cue such as this can greatly help readers use the functional mapping of programs they have never seen before. As readers become increasingly sophisticated and as interfaces coalesce around predictable design strategies, readers will develop their skills to the point where they efficiently and correctly recognize text-as-information versus text-as-signal-that-something-can-be-done-with-it.

Unlike paper texts, screens offer a dynamic medium for mapping text in highly functional ways. Relying largely on visual cuing, readers acquire knowledge of how to do things with words and images. The traditional cues of paper texts—margins, indents, paragraphs, page numbers—appear impoverished next to the rapidly expanding set of cues that facilitate functional writing and reading on screen.

Modular Text

Most texts reflect some modularity of structure: a text is composed of other texts. Books have chapters or individual articles; magazines have articles, sidebars, letters-to-the-editors, advertisements, tables of contents, and so on. Many forms of print are in some way or another compositions, pieces of text positioned with other pieces of text, and often the individual modules are very different in type or function. A newspaper, for example, with its large pages, allows many modules of several sorts to be composed on the same page, and readers can efficiently scan large amounts of information. And the direction in popular newspapers, such as *USA Today,* is toward modularization, with pages composed of short, self-contained, highly visual exposition. An encyclopedia, too, is composed of many individual modules, each of which constitutes a text that can stand on its own.

The movement of text from paper to computer screen encourages further modularization of text structure. The screen is a window on a text base—only so much can be seen at one time. Just as an 8 1/2" by 11" sheet of paper to some extent determines the shape of printed text (titles, headings, white space, line length, indentations), the size and shape of the screen constrains the shape of electronic text. The screen, or a window contained within the screen, becomes the structural unit of prose, with text composed in screen-size chunks, no matter what their subject or function. In such systems, text is highly localized. Reader attention is arrested at the level of idea grouping—the single topic that is represented on a single screen.

Because text is fragmented and localized, on-screen text has problems with local cohesion. Closely related ideas must frequently be separated by screen boundaries. Even lists of strictly parallel, coordinate information must often bridge screen divisions, and the break from one screen to the next presents a larger gap than that from one page to the next. Consider that in a book, even when chunks of information must be broken at page boundaries, there is a 50% chance that the boundary will be at facing pages. And print layout can be manipulated to keep related information on one page. The problem is more difficult with small screen dimensions and strictly modular text fragments. Each module must, to some extent, stand on its own, interpretable without close logical cohesion with other screens. The writer must assume that a reader can arrive at a given screen from practically anywhere, so there can be no assumption that the reader has built up a model of the logical relations of the text from processing pages in a linear order.

It might be argued that since screen text can easily be scrolled, text need not be fragmented into screen-size modules. While it is true that most windows allow scrolling of text that is longer than a screen, scrolling is inherently unsatisfactory. When text must be scrolled to be viewed, readers hesitate, not knowing whether to scroll down or skip the text. And while a reader can quickly skim a stack of information if each card is completely contained within the window, it is time-consuming and ultimately wasteful to have to scroll to see if text should be read.

Also, when text is not composed in screen-size bites, readers tend to lose their places and become disoriented. An example of this occurs with the ERIC CD-ROM indexes on Silver Platter.

The *Page Up* and *Page Down* keys are used to move through lists of references, but these commands take the reader across the boundaries of individual entries. Readers (at least this reader) constantly lose track of whether entries have been read or not, since top-of-screen is not also top-of-page. Information that identifies titles or authors is frequently separated visually from other important text (such as abstracts or keywords), and a given type of information (such as title or author) is never in the same place on the screen. The whole system feels

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SilverPlatter 2.01          ERIC 1982 - September 1991        F10=Commands F1=Help

 implementation, and evaluation. The final chapter includes a summary and
 recommendations. The 12 appendixes, which constitute more than half of the
 report, include the pre- and posttests, personal data and summative reaction
 questionnaires, the task analysis, a skills and interests questionnaire,
 project PERT and Gantt charts, screen design prototypes, and a user's guide.
 Tables and figures appear throughout. Field test data are also included. (26
 references) (GL)

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 AN: ED308829
 AU: Morrison,-Gary-R.; And-Others
 TI: Reconsidering the Research on CBI Screen Design.
 PY: 1989
 NT: 20 p.; In: Proceedings of Selected Research Papers presented at the
 Annual Meeting of the Association for Educational Communications and
 Technology (Dallas, TX, February 1-5, 1989). For the complete proceedings,
 see IR 013 865.
 PR: EDRS Price - MF01/PC01 Plus Postage.
 AB: Two variables that designers should consider when developing

MENU:  Mark Record   Select Search Term   Options   Find   Print   Download

Press ENTER to Mark records for PRINT or DOWNLOAD
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Figure 3: Screen from ERIC CD-ROM Silver Platter. Notice how the scrolling interferes with reading, since top of screen is not top of module. The text also has a homogeneity problem, since the lack of typographic cues leads to a homogeneous visual surface and attendant reading difficulties. Screen from ERIC (Educational Resources Clearinghouse) CD-ROM Silver Platter. Boston: Silver Platter, 1986–91.

jumpy and erratic, and a general sense of disorientation prevails. The problem is alleviated to some extent through the use of *Control-Page Down,* which takes the browser to the top of each entry. But then text is missed that does not fit on a screen. Thus, with document databases containing huge numbers of entries that must be browsed quickly, avoiding scrolling text modules is preferable.

Where the purpose for reading is to explore as well as search and retrieve information (as in encyclopedias), scrollable windows can provide for extended passages of text. Figure 4 presents another screen from the Perseus Project.

Notice the two scroll bars, one in the left window with the primary text (in Greek) of *Acharnians,* the other in the right window with running commentary. The reader can scroll down through either text window, reading both primary text and commentary in parallel. The two windows are modules in a much larger document database that contains other plays, with associated commentary, information on sources, maps, models, diagrams, and so on. Here, the anticipated purposes and styles of readers determine an appropriate use of scrolling text modules.

Modular text does have its advantages. One distinct advantage is that the same text base can serve multiple audiences and multiple purposes for reading (Walker). When texts are composed in screen size chunks, the same modular text fragments can be used to build different documents or different paths through a document. Novice and expert tracks, for example, can be structured out of the same set of information. Texts of various sorts can be *compiled* instead of *written,* constructed out of interchangeable parts. Both the WordPerfect and

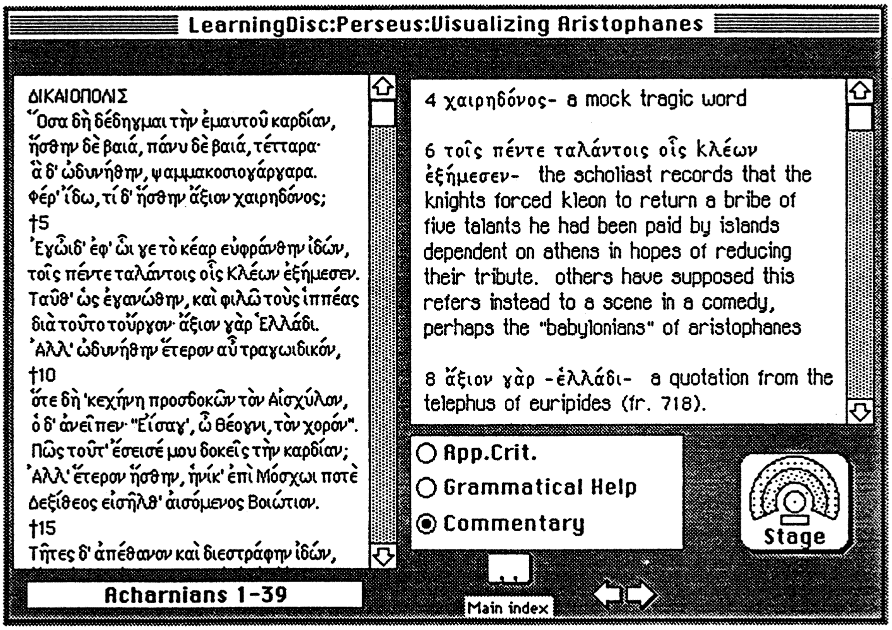

Figure 4: Modular Text. Scrolling text in the two main windows allows for side-by-side primary text in Greek with commentary in English. Note that other text modules are available at the click of a mouse—Applied Criticism and Grammatical Help. From Perseus Project, hypermedia educational software under development at Harvard and Brown Universities; screen captured from Apple Learning Disk (CD-ROM). © 1988, Apple Computer, Cupertino, California.

the Microsoft Word manuals are examples of highly modular writing, with topics arranged alphabetically under headings, so the manuals work simultaneously as alphabetically-organized tutorials and reference volumes. Each page has predictable information in predictable slots. Such a book can be written in any order, and modules can be revised as needed without much effect on the other modules. And a modular approach can work well in both paper and electronic media. (Although, of course, a printed manual needs careful adaptation to work well as an online manual.)

Whatever we may wish for, modular text is definitely the shape of text to come. For many pragmatic uses of screen-based text (such as online help), highly localized, non-sequential, fragmented pieces of text work fine. Such modularization leads to tremendous economy—a single piece of text can be written once, but read and used many times, by various writers and readers, for various purposes. It is well suited to mass storage on CD-ROM disks and to search-and-retrieve operations using keywords or browsers.

We might speculate on the effects of modularity. Will readers become less tolerant of extended arguments and reasoning? Will all texts disintegrate into fragments—a chopped up hash of language—with texts of 75-words-or-less dominating the presentation of information? Will we stop thinking of reading as an extended, engrossing transaction with a text and its author and think of reading, instead, as gleaning or grazing across a range of *textbits?* Yes and no. Some of us will continue to engage with extended, lengthy, integrated text for certain purposes under certain conditions. And all of us will be exposed to increasing quantities of textbits—bits that are skimmed and scanned, compiled and com-positioned, presented through various text databases that help us organize and exploit the information explosion.

Hierarchical, Layered, Embedded Text

To a limited extent, printed text can achieve a special sort of modularization through layered or embedded effects. Within passages of text, semantic cues signal that information is peripheral, or supportive, or explanatory, or defining. Parentheses, footnotes, asides, and facsimile or boxed text all allow writers to escape the immediately present text, to move down or across a level in the text hierarchy, to assign a different status to information, to put it next to or below the predominant text level. In longer printed texts, writers can assemble glossaries, indexes, information on authors, prefaces, notes on the edition, or notes to specific groups of readers. These devices give print some texture of hierarchy, indicating that not all information is on the same level. Readers can pursue the mainline text, but they can also read peripheral or supporting information that has a status other than mainline. Texts digress.

Books, however, are imperfectly suited to hierarchical or embedded text. They essentially are a flat medium, meant to be read in linear fashion. Readers can escape linearity; they can jump around or use different sections of a text in different ways. (For a provocative presentation of ways that texts can escape two dimensions, see Tufte). The programmed textbooks that reflected behavioristic models of learning, such as Joseph C. Blumenthal's *English 2600,* were one attempt to escape the linearity of print. These books took learners on various tracks through the text. Short quizzes over material would assess learner knowledge and then send the learner to appropriate pages for explanation and practice. Advanced learners would speed along on the advanced track. Such books were always a little odd. The habits of approaching text in linear fashion were too ingrained on learners. As one worked through such texts, one wondered what was being skipped and whether learning was being accurately evaluated.

Unlike books, computers *are* well suited to nonlinear text. *Nonlinear text* is, in fact, probably the best definition of the kind of text generated by the rapidly expanding technologies of hypertext. Hypertext programs allow texts of various sorts to be combined into large text bases, allowing readers to move freely across various sorts of information in nonlinear ways.

Though two-dimensional, screens offer the compelling illusion of depth. In a windowing environment, active files and various kinds of text can be displayed and stacked up on the screen. Somewhere behind an active file, help can exist, to be called with a simple command or click of the mouse. Glossaries can exist behind words, levels of explanation and example can exist below the surface of the text. Text can be put on clipboards or pushed out to the side of the work area. Information can be present without being visible except through subtle reminders: a shaded term suggesting a connection to another text, a dog-eared page icon pointing toward a personal annotation on a file, a pull-down bar offering access to other texts. The reader can be in two (or more) places at once, with a definition popped up alongside an unknown text or with a palette of shading patterns placed alongside a graphic. The desktop can be stacked with open files—multiple applications running simultaneously—each with its own text in its own screen areas.

Paper text must embed signals of hierarchy within the linear text itself or in some remote location, such as a table of contents. But electronic text can actually be hierarchically or loosely structured, and it can show its structure schematically or in full detail. A screen-based technical manual, for example, can have a cascading design, with top-level screens offering statements of purpose, scope, and audience definition. At a next level of detail, overviews of steps in a process can be offered. Each step can be exploded to show detailed procedures, and behind the detailed procedures other sorts of information can reside—troubleshooting advice, specifications, or code (Herrstrom and Massey). Such hypertext features essentially allow text to escape linearity—there need not be a Chapter One because there need not be a declared linear order of information. Text can be loosely structured, built by association, linked in networks or multidimensional matrices.

Linguists have long noted that syntax is deeply recursive. Sentences can contain sentences, clauses can contain multiple other clauses, and phrases can themselves contain clauses, so that, in effect, lower-level units within a hierarchy can contain higher-level ones. With electronic text, what is true at the syntactic level—the recursion that gives language extreme structural flexibility—is true at the discourse level. Like Chinese boxes, text can be nested within text, and huge texts can reside within tiny fragments. With the combination of both hierarchical subordination and lateral links from any point to any point, hypertext offers greatly expanded possibilities for new structures characterized by layering and flexibility.

Navigable Text

Readers of all text must navigate; they must find their ways through sometimes large or diffuse collections of information. And they have developed navigational strategies for print—using signposts such as tables of contents, indexes, headings, headers, pagination, and so on. Print readers can flip around in a text, scan very quickly, size up the whole, and generally learn from physical and directional cues where they are in the text and where information they need is likely to be.

Imagine your own strategies for reading a newspaper: how it is you decide what to read and how much of it, how your eyes work the page, how quickly and efficiently you take in information. There are highly developed skills operating here, and it shouldn't be too surprising that the early forms of teletext news, presented as a simple scrolling panel of information, did not enjoy much acceptance since they did not allow readers to exercise existing, efficient strategies for using print. People do not want to read extended text on screen, especially when the machine controls the content and the pace. Readers want control.

Books are highly evolved forms: what they do, they do well. A reader can come to a book with highly evolved strategies for getting information from print, but users of computer systems are often handicapped by not having useful, productive strategies for approaching computer-based text. They are often frustrated when they apply learned strategies from print or from other software, only to find that one system doesn't work the same way another one does. Because the screen lacks the total physical presence of a printed text, screen readers have difficulty sizing up the whole, getting a full sense of how much information is present and how much has been viewed. One knows immediately where one is in a book, but it is often difficult to maintain the same intelligence in screen-based text. And so readers of on-screen text have a difficult time navigating. They must read through a window onto a text, and that window limits what the reader sees at any one time. The window is a flat, two-dimensional space, and it is notoriously difficult to know exactly where one is, where one has been, or where one is going. And when an on-screen text is complicated by multiple windows and multiple active files, levels of embedded texts, or a hypermedia environment, navigation poses significant threats to coherence.

A critical threat to the usefulness of on-screen text is the *homogeneity problem* (Nielsen 299). Text on a computer screen tends to be uniform; because of consistent display fonts, spacing, margins, color, design, and size of text modules, it all starts to look the same. Contrast a book with a newspaper or a shopping list to get a sense of the variation in surface that print presents and it becomes clear why on-screen readers are frequently lost in textual space. The challenge of designing text on screens rests in large part on overcoming the machine's tendency toward a homogeneous surface.

Many initial attempts to provide navigation aids for screen-based text are analogically borrowed from paper text. Menus are something like tables of contents, except that when one makes a decision about where to go for information, the page turning is automatic. Indexes look similar in both media and work equally well if designed well. Still borrowing on paper cues, screen headers and footers—as well as titles on menus, pop-up windows, or text modules—can tell readers of screen text where they are, much as one can tell in many books what chapter or what article one is reading by looking to a title or a page header. Screens can be paginated (borrowing even the term *page* for *screen*), often in the form *Page 3 of 6*, but also iconically as in PageMaker documents, with sets of tiny, numbered pages on the lower left of the screen that can be clicked on to move through the document. Readers need a sense of how much they have viewed and what is left in the set of related screens they are scanning.

In Figure 4 above, notice how much of the screen is devoted to navigation. Titles at the top of the screen show one's place in the overall system, and line numbers on the text itself help locate the reader. The bull's eye on *Commentary* suggests the current location, with targets on *App. Crit.* and *Grammatical Help* suggesting there are other places one could be (critical commentary or grammatical help in understanding the primary text). The index is always available, as are arrows for moving forward or backward. If the student wants to exit to the graphic stage—effectively moving from text to performance—the link is there. The environment is rich with cues for locating oneself in textual space and for navigating to new areas.

While some navigation aids are borrowed from print, other navigation options work best only within electronic media. Graphical browsers (looking like cluster diagrams) can offer readers a visualization of the structure of information, so that one can see at a glance the scope and nature of large collections of information. The information contained in a large text base is mapped onto a network representation—with key terms constituting nodes and lines showing relationships among the nodes. Each node represents a group of related information. Like electronic menus and indexes, such browsers offer more than a cue to structure; they facilitate interaction with the text base. Readers can point and click their way from one node to another, explode a node to explore sub-nodes, and so build mental models of the structure of information in interactive, highly intuitive ways. Books might provide similar browsers, such as timelines or the *Encyclopaedia Britannica's* Topicon, but these devices simply do not have the fluid or interactive qualities of electronic browsers.

Ties, or links, or buttons—hot spots in the text that link one screen or term with other screens or terms in the text base—work much better in screen-based text than in paper texts. Some books achieve a limited level of such linking through, for example, endnotes or references to appendices, but the general mechanism is much better suited to electronic text. (Students of mine have read and used Joseph Williams's *Style* for months without recognizing that boldfaced terms are defined in the glossary.) The links in screen-based text announce themselves by their typography or visual character; clicking on a link takes one immediately to some related text. The links can be visually distinguished by function—links from an index to relevant text, from a term to a glossary definition, from a menu to a chosen activity, from an overview to more detailed information, and so on. Links serve as *anchors* to a given screen; one is anchored to the screen icon while going off for an exploratory cruise. For navigating large text bases, the single device of links with anchors in a present screen provides a powerful control over text that cannot be approached within paper texts.

Standard navigation devices are quickly emerging, so that screen readers can bring learned strategies to new interfaces and new texts. In many programs, the perimeter of the screen is defined as a wayfinding area, containing cues about where one currently is (as in the title on the screen) and about where one can currently go (as represented primarily in the choices of active icons). Having worked with a few programs that use similar devices, readers come to expect the icons to be active—to respond to a point-and-click. They realize, too, that cues will generally allow them to determine where they are and where they can go. They relate to the home menu—the familiar, top-level screen that offers a breakdown of wayfinding options at the broadest level. Such screens constitute *landmarks* to the navigator—familiar, easily recognizable locations. Readers come to expect to be able to do certain things, and well-designed systems use the navigational knowledge readers have naturally acquired through interaction with other programs, just as book designers offer readers an index, or a page number, or a chapter title.

Spacious Text

Print is constrained by sheer physical bulk. Consider the constraint of bulk on the compact *Oxford English Dictionary,* with its print compressed to the point of practical illegibility to the naked eye, crammed onto pages full of abbreviations and omitted information. Or consider the sheer bulk of paper documentation necessary to run a complex piece of machinery—an aircraft carrier or an airplane. The sheer weight of paper makes a strong argument for online information. The tons of paper documentation that burn the precious fuel supply of a submarine have a negligible weight in electronic form. The same physicality that makes books easy to use—portable, handy, laptop—makes them impossible to use as systems grow larger and more complex, and as the need for documentation increases proportionately (or geometrically).

No similar physical constraint shapes electronic text. The result is a spaciousness in both the amount of information that can be recorded and in the design of information display. Steven Jobs can include the *Oxford English Dictionary* and Shakespeare's plays in the NEXT computer's memory—no problem. The price of memory has been decreasing quickly while new technologies increase storage limits. Large stacks of information can be duplicated for the price of a disk; huge quantities of information can reside on a single compact disk. A CD-ROM disk might hold 550,000 pages of text with 1,000 characters per page. But it weighs only ounces, fits into your pocket, and will soon be replaced by more compact storage media.

Writers of paper texts are always contained by length (as I am here!): writing is a process of selection, cutting, paring away at what is non-essential or redundant. Paper text forces absurdities upon writers—squeezing text into narrow margins and using smaller fonts to keep the overall page count within limits. But screens introduce the luxury of open space. There is no demand to run unrelated text together in the interest of saving page space. If a writer hasn't much to say about something, space can be left blank without worrying about cost. The effect on prose is liberating, freeing it from the economic constraints of inscription.

Graphically Rich Text

Print is a graphic medium; it displays its meanings in the spread of ink on page (Bernhardt, "Seeing the Text"). Writers of printed text have many options at their disposal to make texts visually informative: white space, font sizes, line spacing, icons, non-alphabetic characters like bullets and daggers, margins, and the whole range of pictorial displays—graphs, charts, drawings, etc. The use of computers for word processing has heightened our awareness of the graphic component of meaning. Both student writers and experts have at their command a wide range of graphic tools and an expanding base of research and aesthetic insight to guide the design of text on page (see Barton and Barton, "Trends"). Wholly new products—desktop publishing and graphics software—give authorial control over text/graphic integration. More than ever before, writers are page designers; they are com-position specialists.

Electronic text extends visual composition by offering a surface with more graphic potential and greatly augmented options for text/graphic display and integration. Some of these display options are shared by print and screen-based text. White space (though often not white), space breaks, and margins actively signal divisions within a text, showing what goes with what and where the boundaries are. Bullets and numbered lists cue sequences of information. Font sizes and varieties, headings, color, boldface and italics show hierarchies within a text, cuing subordinate and superordinate relations. Headings, text shape, and callouts in the margins can provide filters for readers, tracking them toward or through various information paths so that each reader is guided to appropriate text for the task at hand.

But screen-based text goes beyond print in its visual effects. Readers can zoom in and out on screen text, editing graphics at the pixel level or looking at facing pages in page-preview mode, with Greeked text downplaying verbal meanings in favor of a visual gestalt that allows writers to evaluate design. Sequences can be animated, procedures can be demonstrated. Text can flash or take on spot color or be outlined or presented in inverse video. With CD-ROM integration, video, voice, or musical sequences can be part of a text, achieving effects that print can only struggle to suggest. Exploded diagrams, so important to technical writing, can actually explode, and readers can view technical illustrations at varying levels of detail, with high resolution on close-up shots of delicate mechanisms (Jong). Readers can travel in virtual space, examining an object such as a building or an automobile from various perspectives, moving around the object in three-dimensional CAD space.

Screen-based text takes information in iconic, visually metaphoric directions. We know people learn about complicated systems best when they have organizing metaphors. Electronic information allows us to exploit metaphors, so that the screen is a *window* onto a *desktop* and information is kept in *files*. We use *control panels*, complete with *gauges, switches, bells*, and *alarm clocks*. We relate easily to the icons of control, throwing text into the *garbage can* or moving icons for pages (representing files) from one location to another.

We seem to adapt easily to metaphoric designs. Figure 5, the drawing palette from DrawPerfect, is thoroughly iconic and metaphoric.

We use *palettes* to choose colors and patterns and use *brushes, pencils*, and *erasers* to draw objects. We enter a metaphoric world, one reliant on the objective correlates of an artist's workspace and tools. The knowledge and manipulation is visual, physical, and immediate; it exploits powerful, metaphoric knowledge based on the screen's correspondence to other objects and activities. At its best, the interface is intuitive, and we move easily from one application to the next, relying on our sense of metaphor to identify similar functions and

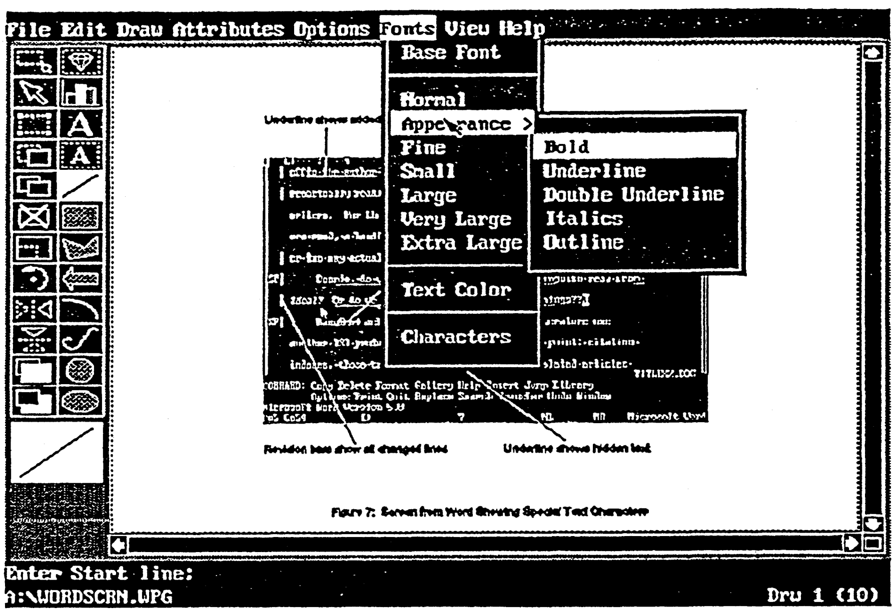

Figure 5: Screen from DrawPerfect, published by WordPerfect. This screen is thoroughly metaphorical and iconic, relying on a system of visual cues related to the tools of drawing and painting. Notice the rich environment on the periphery: things to do and places to go. The pull-down, point-and-click menu interface represents the convergence of design around a single standard. Screen from DrawPerfect 1.1. © 1991 WordPerfect Corporation, Orem, Utah.

to make guesses, building a visual, interpretive intelligence as we go along. Once one knows how to read a book, one can pick up any book from any publisher. We are getting closer to such intuitive convenience in software applications and interface design.

One striking fact about the interface in the DrawPerfect palette, a DOS program, is its similarity to applications on the Macintosh. DrawPerfect represents the convergence of design around mouse-driven, point-and-click, windowed, pop-up interfaces. It is the product of rapid evolution and reflects the dominance of a single, strong design model over many applications from many different companies. The convergence on a design standard is a wonderful convenience, since the reader can make an easy transition from one application to the next, from one system to the next, relying on learned strategies for interacting with on-screen text. (Conversely, it is the points of divergence, when the program looks like a Macintosh application but doesn't work like one, that drive people crazy.)

Of course, the phosphor glow of screen text causes its share of problems. We are subjected to flicker, glare, and electronic interference. The screen image suffers, and so we do, from non-optimal light conditions. Our eyes complain of fatigue from attempting to maintain focus on a curved screen. We are hampered by screen size and resolution. But that same phosphor offers a fluid, dynamic medium, with many more options than print has for displaying information and exploiting visual intelligence.

Customizable, Publishable Text

Little can be done by the reader of paper text to customize the text itself. The few customizing devices are well exploited: turning down the corner of a page or leaving a bookmark or a self-stick note, writing notes in the margin, or highlighting and underlining passages. Such modest adaptations of the static text to the uses of an individual reader make the book more valuable to the owner but less valuable to other readers.

Electronic text, in contrast, benefits from being infinitely more fluid, expansive, and adaptable to individual uses. Readers can annotate without the boundaries of hard copy. Text on screens can be changed—that is one of its essential properties. Lines can be written between the lines, notes can be appended to the text itself or as pop-up annotations behind the screen. Figure 6, from Microsoft Word 5.0 for the IBM PC, shows some of the ways text on screen can be adapted to individual preferences.

This particular passage is the result of collaboration that involved passing the disk with the text back and forth with my collaborator with Word's revision marks turned on. These marks show up on the screen, and they can then be accepted or rejected, printed or suppressed during printing. Revision bars on the left margin signal edits and additions, while the codes in the same margin

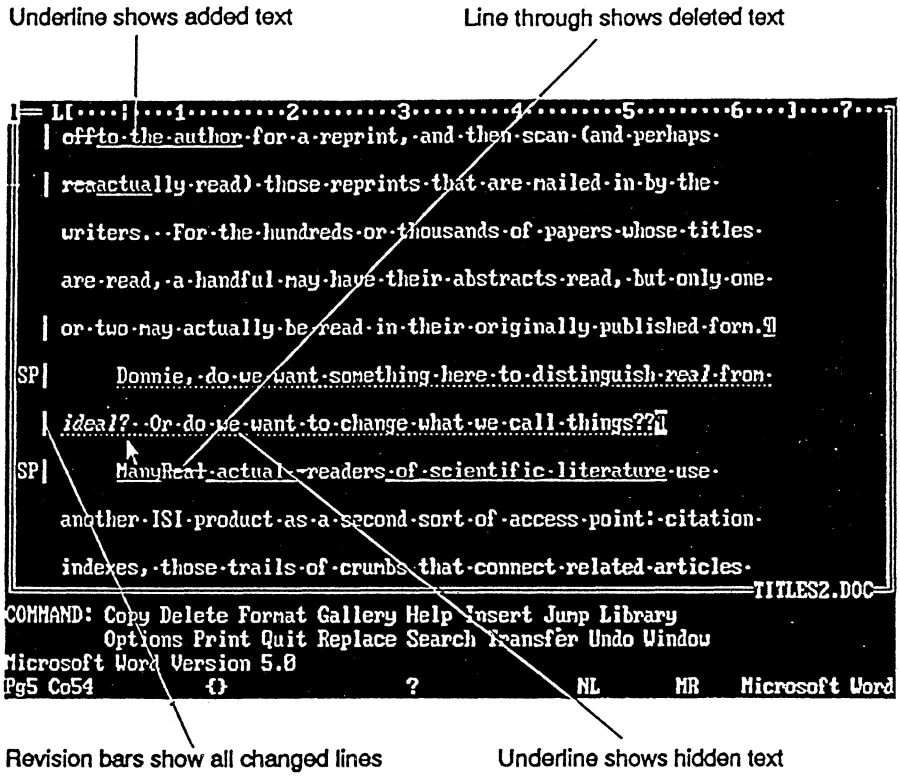

Figure 6: Screen from Word 5.0. The text is individualized, with comments from one co-author to the other in hidden text and the history of passback edits represented by strikethroughs, revision bars in the left margin, and underlined text. Screen from Word 5.0. © 1989 Microsoft Corporation, Redmond, Washington.

signal the style tags on blocks of text (either could be suppressed). Struck-through text signals deletions even while the deleted text is present; hidden text (dotted underline) allows commentary so authors and editors can talk to each other below the surface of the text.

I just wrote (or "spoke") metaphorically about authors and editors "talking" to each other below the surface of the text, but it need not be read as metaphor. The Macintosh extends the media of textual metacommentary in wholly new ways by offering voice "post-its"—little sound bites that can be attached to files. The reader clicks on the sound button and hears the voice of the author: "Note that I changed the figures here to give you some budget flexibility" or "Don't let George know I'm telling you about the meeting." Here's a new form of textual presence—the author present in voice, embedded in the textual surface. These tools—ones that introduce multiple voices, allowing editing and commentary at various levels and in various modes—are recognizably wonderful tools for writers, who respond to the fluidity of the text, but they work correspondingly well for readers, whose interaction with the text is not restricted to mental activities but can be executed physically within the text itself.

The display of the text itself can be customized. Readers can reduce screen clutter by suppressing the display of rulers, spaces, returns, mark-up language, stylebars, borders, and menus. Or readers can show properties of screen text—with every space and return signaled in a fashion that has no print equivalent. (In Figure 6, note the dot between words and the paragraph symbol at the end of each paragraph.) Readers can decide the level of on-screen prompting they want, with menus and help cues displayed or suppressed. Background colors, screen borders, audio messaging, cursor speed—any number of features of the display can be set to individual parameters. Individual user profiles can be stored that automatically adjust the parameters based on predetermined settings. This means the "same" text can display itself differently, depending on the preferences of individual readers.

Screen-based text has the potential to adapt to individual users automatically by keeping histories on users and responding in intelligent ways to likely scenarios based on what a particular user has done in the past. Individualized glossaries, dictionaries, macros, indexes, authoring levels, search procedures, bookmarks, and stylesheets all give the readers of screen-based text real ownership of their texts. Readers own the text because they can do what they want with it; they can make it their own, unlike any other reader's texts.

The controls over fluid, customizable text are shared by the system designer and the user. Systems can be made sensitive to user context, providing help based on best guesses about where the user is in the program and what sort of help might be needed. Shortcuts that allow individual control can be built into the system. For example, many programs offer novice and expert paths, with menus and on-screen prompts for new users. Such prompting speeds learning for new users. But power users want menus and cues suppressed—they know what they need to do and want to do it in the fewest number of keystrokes. Good design allows both types of user to coexist.

The control over the shape of text that microcomputers grant users leads inevitably toward not just customizable but publishable text. Just as the printing press eventually put books into everyone's hands, desktop publishing systems put the printing press into everyone's hands. Anyone can now design, display, and print work that is potentially indistinguishable from professionally printed work.

Traditionally, much of the cost of print has been in the production stage—the human and machine costs of typesetting, paper, binding, and distribution. Longer length or fancier graphics meant higher prices. The high production cost per unit for books and magazines made copies fairly expensive, but highly portable and accessible to anyone who could read. With screen-based text, however, much of the cost of production is shifted from the printer to the author and the audience. It is cheap and easy to duplicate disks. And disks (whether floppy or hard) hold immense quantities of information in a small format, so issues of length are no longer so important to overall cost. A disk can hold graphics and animated sequences, color diagrams and fancy fontography, interactive tutorials and reference materials. Once the information is coded to the disk, reproduction is a simple, inexpensive matter.

But the more complicated the on-screen text, the higher the overhead demands on authors and readers. Instead of printers needing high-priced equipment and expensive materials to produce fancy texts, writers need high-priced equipment to author texts, and readers now need high-priced equipment to run the disk. And whereas there never were compatibility problems between readers and books, there are now multiple and vexing problems of matching hardware and software.

Once printed, paper text is fairly static. It presents the same face to all readers, so that my copy of a book looks just like yours. In contrast to the static quality of paper text, on-screen text is fluid and customizable, updatable and expandable. These qualities lead to multiple versions, to individually adapted texts, and give an elasticity to electronic text that changes the nature of publication. And with the advent of desktop publishing, the movement from screen-based text to paper is eased, so even print loses its static quality. A writer can produce papers or books in multiple versions, easily redesigned and updated. Print is no longer permanent, because the cost and effort of updating editions is negligible. The fluidity of the screen has begun to overcome the static inertia of print.

The Shape of Text to Come

The shape of text changes as it moves from paper to screen. On-screen text is eminently interactive, closely embedded in ongoing action in real-time settings. It borrows heavily on the evolved strategies readers possess for interacting with printed texts, but provides a more fluid, changeable medium, so that the text itself becomes an object for manipulation and change.

As texts change, we will develop new strategies for reading and writing. Text bases will grow, becoming huge compilations of information stored on disk with no corresponding printed versions. It will feel natural to move through large pools of information, and we will rely on learned strategies for knowing where we are, where we want to go, and what we want to do when we get there. We will develop new sorts of reading skills, ones based around text that is modular, layered, hierarchical, and loosely associative. We will demand control over text—over its display, its structure, and its publication.

We are now at a point of transition of the sort described by Ong, similar to transitions from orality to literacy or from handwritten manuscripts to printed. The computer is becoming increasingly dominant as a primary medium for presenting and working with texts. As we take control of computer-based texts, the existing lines between reading and writing will tend to blur into a single notion of use (Slatin). Texts will have multiple authors and grow incrementally as readers individualize and structure text for their own uses. The presence of screens will become increasingly common, a part of our daily lives, close at hand in a variety of situations.

As with the interrelation of spoken and written media, so between paper and screen-based text: we will see crossbreeding, with the uses and forms of one medium shaping the uses and forms of the other, so that as the predominance of and our familiarity with screen-based text increases, the dimensions of variation discussed here will have a greater and greater shaping influence on paper text. But the real potential for full exploitation of these dimensions of variation lies in text on screens. It is the dynamic, fluid, graphic nature of computer-based text that will allow full play of these variables in shaping the texture of print on screens.

Works Cited

Barton, Ben F., and Marthalee S. Barton. "Simplicity in Visual Representation: A Semiotic Approach." *Journal of Business and Technical Communication* 1 (1987): 9–26.

_____. "Trends in Visual Representation." *Technical and Business Communication: Bibliography Essays for Teachers and Corporate Trainers.* Ed. Charles Sides. Urbana: NCTE, 1989. 95–135.

Barrett, Edward, ed. *The Society of Text: Hypertext, Hypermedia, and the Social Construction of Knowledge.* Cambridge: MIT P, 1989.

Bernhardt, Stephen A. "The Reader, the Writer, and the Scientific Text." *Journal of Technical Writing and Communication* 15.2 (1985): 163–74.

_____. "Seeing the Text." *College Composition and Communication* 37 (Feb. 1986): 66–78.

Bolter, Jay David. *Writing Space: The Computer, Hypertext, and the History of Writing.* Hillsdale: Erlbaum, 1991.

Brockmann, R. John. *Writing Better Computer User Documentation: From Paper to Hypertext.* Version 2. New York: Wiley, 1990.

Chignell, Marc H., and Richard M. Lacy. "Project Jefferson: Integrating Research and Instruction." *Academic Computing* 3 (Oct. 1988): 12–17, 40–45.

Duchastel, Philippe C. "Display and Interaction Features of Instructional Texts and Computers." *British Journal of Educational Technology* 19.1 (1988): 58–65.

Harward, V. Judson. "From Museum to Monitor: The Visual Exploration of the Ancient World." *Academic Computing* 2 (May/June 1988): 16–19, 69–71.

Herrstrom, David S., and David G. Massey. "Hypertext in Context." Barrett 45–58.

Horton, William. *Designing and Writing Online Documentation: Help Files to Hypertext.* New York: Wiley, 1990.

Jong, Steven. "The Challenge of Hypertext." *Proceedings of the 35th International Technical Communication Conference.* Washington: Society for Technical Communication, 1988. 30–32.

Kostelnick, Charles. "Visual Rhetoric: A Reader-Oriented Approach to Graphics and Design." *Technical Writing Teacher* 16 (Winter 1989): 77–88.

Lynch, Anne. "Project Jefferson and the Development of Research Skills." *Reference Services Review* (Fall 1989): 91–96.

Merrill, Paul F. "Displaying Text on Microcomputers." *The Technology of Text.* Ed. David Jonassen. Vol. 2. Englewood Cliffs: Educational Technology Publications, 1982. 401–13.

Nielsen, Jakob. "The Art of Navigating through Hypertext." *Communications of the ACM* 33 (March 1990): 296–310.

Ong, Walter J. *Orality and Literacy: The Technologizing of the Word.* London: Methuen, 1982.

Redish, Janice. "Writing in Organizations." *Writing in the Business Professions.* Ed. Myra Kogen. Urbana: NCTE, 1989. 97–124.

Rubens, Philip M. "Online Information, Hypermedia, and the Idea of Literacy." Barrett 3–20.

_____ . "A Reader's View of Text and Graphics: Implications for Transactional Text." *Journal of Technical Writing and Communication* 16.1/2 (1986): 73–86.

Rubens, Philip M., and Robert Krull. "Application of Research on Document Design to Online Displays." *Technical Communication* (4th Quarter 1985): 29–34.

Slatin, John M. "Reading Hypertext: Order and Coherence in a New Medium." *College English* 52 (Dec. 1990): 870–83.

Sticht, Thomas. "Understanding Readers and Their Uses of Text." *Designing Usable Texts.* Ed. Thomas M. Duffy and Robert M. Waller. Orlando: Academic Press, 1985. 315–40.

Tufte, Edward R. *Envisioning Information.* Cheshire, CT: Graphics Press, 1990.

Visible Language. Special issue on adaptation to new display technologies. 18.1 (Winter 1984).

Walker, Janet H. "Authoring Tools for Complex Document Sets." Barrett 132–47.

Writing on the Edge. Special issue on hypertext. 2.2 (Spring 1991).