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WRITING, THINKING, COMPUTING

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The computer has become the preferred tool for many writers. Over the next few years, it is likely to become the predominant tool. Since writing is *fundamentally* a mediated activity and since the tool inevitably affects the tool user, we need to consider how a tool as powerful as the computer is affecting writers. To address this issue, we consider the following questions:
- What are writers saying about computers?
- How are writers using computers?
- What does this mean for the teaching of writing?
- What does this mean for designers of future writing systems?
- How does the computer affect writers' thinking?

We are led to the conclusion that new, comprehensive writing environments are both needed and inevitable, and they, in turn, will lead to a form of enhanced, or amplified, thinking. But using these environments and developing this kind of thinking will also require new forms of instruction. Adapting to these changes will pose practical as well as intellectual challenges for the composition community. To meet these challenges tomorrow, we must begin considering the relationships among writing, thinking, and computing today.

1. Introduction

> So what do we do when we try to talk to people about computers? Well we don't want them to see the box any more than we want them to see a Mitchell camera or an Aeroflex, when we talk about movies. ... Computers are not boxes, they are processes.
>
> (Alan Kay (1983))

Unpredictably, the computer has become a tool for writers. Few could have guessed how quickly a machine used by scientists and mathematicians for handling large amounts of numerical data would be taken up by writers for 'processing words'. But the surprise is at least partly due to forgetting that writing, whatever else it is, is also mechanical activity requiring tools. Writers are tool users, and the history of writing is partly a history of its tools – brush, stylus, pen, pencil, typewriter, and now computers. Therefore, one way to think about the newest tool is simply to recognize that there are three major technologies that writers now use: handwriting, typewriting, and computerwriting.

Our purpose in this essay is to explore the implications of computerwriting. In doing so, we will consider the following questions:
- What are writers saying about computers?
- How are writers now using computers?
- What does this mean for the teaching of writing?
- What does this mean for designing future writing systems?

We will also consider a fifth question implicit in the other four: how does the computer affect the writer's thinking? Just as a hand tool amplifies the user's strength, so a conceptual tool amplifies the user's thinking. But what is 'amplified thinking'? Is it merely normal thought sped-up or broadened, or is it thought that is, somehow, different in kind? The latter alternative is problematic – what, exactly, is qualitatively different thought? The concept is virtually meaningless. Nevertheless, existing computer systems point us toward this choice. We will consider this penumbra of possibility by discussing what current systems can do, what future systems could be designed to do, and, finally, what it would mean for writers and educators if such systems were developed.

2. What are writers saying about computers?

Writers currently use the computer primarily to edit and format texts. Their reactions suggest that even basic activities such as entering and manipulating text affect how writers think and feel. The computer's physical attributes of kinetic screen display and immediate responsiveness are especially significant.

Novice users who have overcome initial anxieties report feeling liberated from physical and psychological constraints in writing. The following reactions are among those we have observed or those that have been observed by colleagues. [1] 'There's nothing between me and my creativity. It's just my creativity sitting there in front of the machine, working', one student writer said. Both novice and experienced users often express their new perception metaphorically – 'It's liquid text'. 'It's working in a fluid medium'. 'It's the dance of electrons'. One final observation is particularly instructive: 'When I see my words lit up, lit up there in front of me, it's a mystical experience. When I see them on the page, I think "Is this all it was?"'. For this last writer, electronic representation in light on the screen altered her feeling of power to use language and her sense of relationship to the text. William James' comment on mystical experience – 'Uncovering of some sort is the essence of the phenomenon. ... It will be of reality, enlargement, illumination, perhaps

[1] For accounts of students' learning experiences, we are indebted to colleagues attending the conference 'Writing and Thinking' held in 1983 at The University of Michigan.

rapturously so' – is not too strong a gloss on the change in her perception (James (1920: 503)).

Along with the sense of power can come confusion. But it is the confusion of unlearning, of forming new conceptions, particularly about the nature of text. Writers accustomed to the page, notecards, books and file folders know what and where text is. Writers using computers don't. Text can be displayed on a screen, recorded in the computer's memory, stored on a disk or reel of tape, but where is it 'really'? Asking where text is also asks what it is: electronically illuminated script, bits and bytes of computer memory, blips on magnetic disk or tape, all of these at once?

The metaphors used by those first encountering the computer are especially revealing. They illustrate the active constructing, not only of text but also of ideas about text, that goes on in the minds of writers using computers. The writers' internal dialogue of self as writer and reader becomes a trialogue of self as writer, reader, and tool-user. Consider the following two accounts of novices learning to use textprocessing systems from self-study materials without supervision (Lewis and Mack (1982)):

> 'A learner was attempting to enter a password when a typing mistake caused the system to halt awaiting a correction. An indicator light marked 'input inhibited' came on. The learner attributed both the delay and the light to a heavy work load on the system.'
>
> 'A learner was following instructions for a practice exercise which explained how to type in a letter. Part of the instructions required her to position the cursor at the beginning of various parts of the letter, such as date, heading, greeting, and closing. Because of flaws in the manual she skipped the instructions which covered the actual typing, and carried out only those which moved the typing point around to these various locations on the display screen. At some point she tried to make sense of the fact that she had not actually typed anything: she concluded that she was creating an invisible template into which a letter would later be typed.'

Notice the 'storying' effect – the attempt to create a coherent narrative of the experience. These novices, typical of the species, learn actively by constructing hypotheses, interpretations, metaphor. This active process is particularly apparent in the second account where we also see the writer consciously directing her intellect just as she must direct the technology.

These accounts reveal the powerful effect that the computer is having on writers. To understand this effect better, let us take a more detailed look at writers' current use of computers and, then, at future possibilities.

3. How are writers now using computers?

3.1. The computer as instrument

Most computer systems that writers now use may be characterized as instruments. That is, they are separate tools, each providing one or at most two sets

of functions. In some instances, the product generated by one tool can also be used by another, but this is usually more a matter of luck than design. In this section we will describe, briefly, the five major groups of writing instruments that are currently available: editors, formatters, spelling-checkers, outline processors, and style-checkers.

By far the most widely accepted instruments are text editors and formatters. For writers who use mainframe computers, these tools are usually two separate programs or systems; for microcomputer writers, they are usually integrated into a single system, a wordprocessor. Basically, an editor controls the creation, storage, retrieval, and modification of a text. [2] In some cases, the editor also provides the primary connection to the computer system as a whole (i.e., invokes other programs, directs output to a printer, etc.).

Editors tend to fall into two large groups: line editors and full-screen editors. Line editors consider the single line of text to be the primary unit and they permit the writer to make changes in a line or group of lines. Full-screen editors consider the block of text that can be shown on a screen at one time to be a unit and they permit the writer to move around in that portion of text, by moving a lighted pointer or 'cursor', to make numerous changes over the entire screen. Of course, both line as well as full-screen editors permit the writers to view successive portions of a text so that the entire text can eventually be viewed and modified.

Formatters add the function of typographic manipulation. They construct filled-out paragraphs and pages, control indentation and placement of blocks of text or other materials (graphs, tables, long quotations), provide conventions for underscoring and bold overstriking. When the early formatters were designed, the primary printing devices were the typewriter terminal and the large computer line printers; today, the choices are much more numerous, including photocomposers, laser printers, and a variety of print-quality dot-matrix devices. With these new technologies, the writer may see his or her text 'in print' while still editing and rewriting.

Like editors, formatters tend to be one of two types: symbolic formatters and 'what you see is what you get' formatters. To use a symbolic formatter, a writer places symbolic commands directly into the text that indicate what the text is to look like. For example, a writer using SCRIPT, a popular formatting program developed by the University of Waterloo, tells the system to center a line, such as a heading or a line of poetry, by beginning the line with the symbol/command, '.ce'. However, the command does not become active until the text along with its embedded commands is later processed by the formatting program. By contrast, most microcomputers combine the formatting functions with the editor. Consequently, the centering command for one of

[2] For an excellent description of text editing systems, see Norman Meyrowitz and Andreis van Dam (1982).

these systems produces a line that is actually centered on the screen when the command is typed, hence the name, 'what you see is what you get'. Although the second type makes it easier to visualize what a text will look like when printed, the symbolic formatters provide greater flexibility.

Outline processors, pioneered by *Think Tank*, [3] but now included in many microcomputer editors, permit the writer to construct an outline for a document and then to write the document by filling in blocks of text under each heading. When the outline is edited by moving a topic or section from one place to another, the associated text is carried along, as well. These outliners are linguistically oriented. Below we describe a system that, instead of relying on linear linguistic thinking, represents structure visually to capitalize on the more spatial mode of structural thinking described by many writers.

Spelling-check programs have become quite popular in the last few years. These programs – available on most mainframe as well as microcomputer systems – use a standard dictionary or word list against which they check each word appearing in a text. Words found in the text but not on the reference list are presumed to be misspelled. Spelling programs vary in what they do with 'misspelled' words, ranging from printing them in a list for the writer to review to displaying them in context and offering a 'guess' as to what the program 'thinks' was the intended word (spelled correctly).

A final group of writing instruments that are not currently widespread but which may become so fairly soon are the style and syntax checkers. Pioneering large-scale style-checkers were included in Bell Labs' *Writer's Workbench* (now marketed in a collegiate edition by AT & T), IBM's *Epistle*, and UCLA's *Wandah* (now marketed as *HBJ Writer* by Harcourt Brace Jovanovich). [4] More recent stylecheckers include *RightWriter*. [5] These programs typically compute statistical measures such as average word-, sentence-, and paragraph-lengths, and standard deviations for these measures. They show locations in the text of words that are found on various reference lists, such as lists of prepositions, abstract words, or cliches. Some of them also compute readability scores based on several popular formulae.

These five classes of programs are the main tools writers use today. As the computer is integrated into the schools, the office, the home, it is likely to become the near-universal writing instrument. Even if no further aids are developed, the computer will significantly change the habits of writers. But new systems for writing will be developed. The question is whether or not they will help writers. We believe that greater usefulness begins with combining

[3] *Think Tank* is available from Living Videotext, Inc.

[4] For descriptions of *Writer's Workbench*, see L. Cherry (1982) and N.H. Macdonald (1982). For *Epistle*, see G.E. Heiorn et al. (1982). For an excellent general source, see Ellen McDaniel (1987).

[5] *RightWriter* is available from Decision Ware, Inc.

separate computer instruments into a comprehensive computer environment for writing.

3.2. The computer as environment

To illustrate possibilities for writing and thinking when computer aids are designed to work together and when they reach a certain critical mass, we will look at three different computer systems or conceptualizations. The first, ARRAS, is not a writing system but a full-text retrieval and analysis system. We include it for two reasons: it is a good example of what we mean by a working environment, and it describes functions we will return to later when we describe additional capabilities that might be included in future systems. The second example is a network-based electronic publishing concept that has not been fully realized. The third is Vannevar Bush's forty year old description of a new kind of intellectual environment, which he called *memex* but which is now known as hypertext.

3.2.1. ARRAS

ARRAS is a computer system for retrieving, reading, and analyzing texts (Smith (1984)). [6] We will describe it in the context of a scholar using it to explore literary works, but the system can, of course, deal with any kind of text or large body of textual information – e.g., speeches, environmental impact statements, or collections of historical documents.

ARRAS consists of three parts: a data base of texts, a self-instruction system that tells how to use ARRAS, and the retrieval and analysis system, itself. The user informs ARRAS of the text to be considered and ARRAS directs its attention to that specific text from the set of texts available on the user's system. When the user wishes to consider a different text, he or she simply tells ARRAS to change texts.

ARRAS provides immediate access to any portion of the text. Consequently, the user may begin reading at the start or jump to any other place in the text. Since ARRAS also 'knows' each word that occurs in the text and all locations for each, the user may browse through the vocabulary of the text as well as look at the contexts for each occurrence of any given word.

One of the most powerful features of ARRAS is its generalized concept of category. The user may supply any list of words or locations in a text and a name for the set; ARRAS will then remember the category and will apply the entire set whenever the name is used in a command.

ARRAS also provides a function for locating logical combinations of words within a specified context. Thus, for example, one can ask ARRAS to find all

[6] ARRAS is available from Conceptual Tools, Inc., PO Box 247, Chapel Hill, NC 27514.

the places in a text where the word 'patent' appears in, say, the same sentence with the word 'lawyer'. However, using the category feature, one could define a category, legal-cat, to consist of the words lawyer, lawyers, legal, attorney, attorneys, counsel, etc., and a category, patent-cat, to consist of patent, patents, copyright, copyrights, copyrighted, trademark, etc. A search, then, for legal-cat and patent-cat within the same sentence would locate all locations where any *combination* of words from the two sets occurred. The set of such locations, moreover, can also be named and it becomes a category like any other category. Thus, it could be used in a more abstract configuration to look for patterns of patterns, patterns of patterns of patterns ... . To a great extent, then, analysis of a text becomes the process of defining, considering, and modifying an evolving hierarchy of categories.

ARRAS offers a number of other analytic aids, ranging from functions that produce pictorial graphs showing where categories appear over a text to functions for managing and editing the evolving hierarchy of analytic categories. But the sample described here will give the reader a feel for how it can be used to facilitate reading, analyzing, and characterizing a given text.

The ARRAS analytic system is linked with IBM's CMS environment in which it operates. The scholar can temporarily leave ARRAS by instructing it to transfer control to CMS and to await the scholar's return to continue the analysis. The scholar would then find himself or herself in CMS where he or she can do most of the things that can normally be done in that environment. Let us look at several of those CMS-supported activities.

First, the scholar may use the standard CMS editor and file system, similar to the editing systems described earlier. Suppose he or she is working on the manuscript of a journal article describing the results of the analysis being done with the aid of ARRAS. When a new insight comes from viewing concordance information produced by ARRAS – for example, the spatial distribution of a theme over a text – the user can leave ARRAS, go to CMS, and call up the file containing the text for the article. He or she may then use the CMS editor to add several paragraphs describing the new insight. Since ARRAS can make a copy of any information displayed on the screen and place it in a CMS file, the writer can also add the specific graph, concordance information, or whatever directly into the text of the article. When the writer is through making all such changes or additions, he or she can return to ARRAS and continue the analysis from the point where it was left – with all analytic categories intact.

Second, the scholar may communicate with other scholars who use the same computer system. These communications are of two kinds. They can be one-line messages delivered immediately to the colleague addressed. Thus, the individual may have a spontaneous dialogue with an associate through the computer. Communication can also take the form of sending complete files to another user. Thus, the scholar could send a draft of the article to a friend

who, in turn, could read it, add notes or comments, and send it back to the author.

Communication assumes added importance when the computer system being used is part of a network of such systems. BITNET, for example, now links most major universities in the United States, as well as some in other countries. Scholars can, thus, communicate with colleagues around the country and, in some instances, around the world as they do with others at their own institution. The concentration of effort and thought permitted by three or four exchanges of a document a day through the network versus three or four a month through the US mails can led to a new kind of collective intellectual interaction.

These functions are standard parts of ARRAS operating within CMS. Let us pause for a moment and look at those functions in the aggregate. When used with a data base of texts, ARRAS can provide rapid, flexible access to textual materials. ARRAS can also assist the writer in analyzing that body of materials, in looking for patterns, in managing the writer's evolving understanding of one or more texts. CMS, in close conjunction with ARRAS, provides powerful word processing, document formatting, and file support. CMS also provides communication and information exchange through BITNET among a larger and rapidly growing scholarly community.

Integrated systems such as ARRAS offer not just a collection of tools but rather a critical mass of conceptual aids. By linking the basic materials of a field with tools for analysis, for writing, and for communication, the computer becomes not just a component in the work environment. It becomes the environment, itself. The workplace is where the computer is or where one goes to obtain access to it.

3.2.2. Electronic publishing

The concept of the computer as environment versus the computer as instrument carries with it a number of implications. For example, one may no longer wish to think in terms of getting text into the computer so that it can be edited and formatted and a clean copy gotten out. This can be done – and many writers find editing a paper version of a document more comfortable than editing on a screen – but new computer environments make it possible for a document to spend most of its 'life' inside one computer or another. Consider the following scenario.

Some journals now accept articles submitted in 'soft' or computer-readable form. If the author has written and revised the manuscript on a microcomputer, delivery can be in the form of floppy disks sent through the mails. The editor can, in turn, read the article on a microcomputer or print out a paper version to be read in the normal way. However, if the article is written and edited on a mainframe computer, it's easier to 'deliver' the text through BITNET or one of the other networks, presuming both editor and author have

access to the same service. Using this option, the author types a one-line command that sends a copy of the finished article over the network. Delivery usually takes only a few seconds. The editor can then read the article at his or her location, make changes, add notes directly in the text. He or she can then return the edited version to the author, if need be, in an analogous way. Edited versions can be exchanged until the article satisfies both author and editor.

When the piece is ready to 'go to press' it may just go to another computer. If the article is formatted to mark typographical components generically – a new section, an indented quotation, a footnote – a simple program can usually replace computer printer codes with photocomposer codes that 'set the type' for printing. Thus, writing, formatting, and typesetting become successive stages within an expanded computer environment.

We may soon see electronic journals that are never printed on paper. Instead of sending the finished, edited article to the photocomposing computer, the editor would pass the document to a data base somewhere in the network and record it in the standard on-line bibliographies.

Readers would learn that the article exists by searching one of the bibliographic data bases. They would then request and receive the article from the textual data base in the same way the editor received it – via network. And readers would have most of the same options – to read it on the screen, to print out a paper copy, and to store it on their computers for future reference. The reader could even re-edit it and add his or her own views.

All of the pieces exist: the editing and formatting systems, the network, the composing programs, the bibliographic and full-text data base systems. To realize an electronic journal, or an electronic publishing industry, all that is needed is to put the pieces together. Services of this sort are likely to appear in the next few years. When they do, intellectual inquiry will approach a state similar to that envisioned by Vannevar Bush nearly forty years ago.

3.2.3. Hypertext

The earliest design for a comprehensive working environment predates the computer as we know it. Writing in 1945, Vannevar Bush described a concept he called memex. Today, that same set of ideas forms the basis for hypertext. Based on microfilm technology but including in its design capabilities that didn't exist at the time, memex anticipated the computer:

> 'Consider a future device for individual use, which is a sort of mechanized private file and library. It needs a name, and, to coin one at random, 'memex' will do. A memex is a device in which an individual stores his books, records, and communications, and which is mechanized so that it may be consulted with exceeding speed and flexibility. It is an enlarged intimate supplement to his memory.
>
> It consists of a desk, and while it can presumably be operated from a distance, is primarily the piece of furniture at which he works. On top are slanting translucent screens, on which material can be projected for convenient reading. There is a keyboard, and sets of buttons and levers. Otherwise it looks like an ordinary desk.

In one end is the stored material. The matter of bulk is well taken care of by improved microfilm. Only a small part of the interior of the memex is devoted to storage, the rest to mechanism. Yet if the user inserted 5000 pages of material a day it would take him hundreds of years to fill the repository, so he can be profligate and enter material freely.

Most of the memex contents are purchased on microfilm ready for insertion. Books of all sorts, pictures, current periodicals, newspapers, are thus obtained and dropped into place. Business correspondence takes the same path. And there is provision for direct entry. On the top of the memex is a transparent platen. On this are placed longhand notes, photographs, memoranda, all sorts of things. When one is in place, the depression of a lever causes it to be photographed onto the next blank space in a section of the memex film, dry photography being employed.' (Bush (1945: 107))

The memex design also included provisions for indexing and for adding notes, comments, and other marginalia.

In addition to a textual database that could be updated as well as accessed quickly and easily, Bush also foresaw a new form of intellectual inquiry that would be possible inside the memex environment:

'All this is conventional enough, except for the projection forward of present-day mechanisms and gadgetry. It affords an immediate step, however, to associative indexing, the basic idea of which is a provision whereby any item may be caused at will to select immediately and automatically another. This is the essential feature of the memex. The process of typing two items together is the important thing.

When the user is building a trail, he names it, inserts the name in his code book, and taps it out on his keyboard. Before him are the two items to be joined, projected onto adjacent viewing positions. At the bottom of each there are a number of blank code spaces, and a pointer is set to indicate one of these on each item. The user taps a single key, and the items are permanently joined.

When numerous items have thus been joined together to form a trail, they can be reviewed in turn, rapidly or slowly, by deflecting a lever like that used for turning the pages of a book. It is exactly as though the physical items had been gathered together from widely separated sources and bound together to form a new book. It is more than this, for any item can be joined into numerous trails.

The owner of the memex, let us say, is interested in the origin and properties of the bow and arrow. Specifically, he is studying why the short Turkish bow was apparently superior to the English long bow in the skirmishes of the Crusades. He has dozens of possibly pertinent books and articles in his memex. First he runs through an encyclopedia, finds an interesting but sketchy article, leaves it projected. Next, in a history, he finds another pertinent item, and ties the two together. Thus, he goes, building a trail of many items. Occasionally he inserts a comment of his own, either linking it into the main trail or joining it by a side trail to a particular time. When it becomes evident that the elastic properties of available materials had a great deal to do with the bow, he branches off on a side trail which takes him through textbooks on elasticity and tables of physical constants. He inserts a page of longhand analysis of his own. Thus he builds a trail of his interests through the maze of materials available to him.' (Bush (1945: 107))

Bush's memex is, thus, not just a new kind of bookshelf. It is some new thing that contains both the raw materials – the text and other data – about which one thinks, as well as the record of the thought process – the trails of

associations that constitute thought, itself. We conventionally think of text or data as background material and the structure of thought that we construct and convey to others as foreground; in Bush's memex, background and foreground merge into one dynamic, evolving structure of information and thought. 'Thought' may be new texts (the recorded statements of the ideas) or it may be links among existing texts, text segments, graphs, equations, or other forms.

While a personal memex would, indeed, provide a remarkable new environment for the scholar/thinker, Bush goes one step further to describe collective, shared data bases.

> 'Wholly new forms of encyclopedias will appear, ready-made with a mesh of associative trails running through them ready to be dropped into the memex and amplified. ... There is a new profession of trail blazers, those who find delight in the task of establishing useful trails through the enormous mass of the common record. The inheritance from the master becomes, not only his additions to the world's record, but for his disciples the entire scaffolding by which they were erected.' (Bush (1945: 108))

In the discussions of ARRAS and BITNET we sketched a community of writers/scholars/thinkers working in an environment of linked computer systems. In that environment, however, each computer system was autonomous. Each writer worked within his or her own 'cell' independent of others except when he or she wished to communicate or to receive communications. If we lay Bush's concept of the memex over the sketch, we would find a world as different from the earlier computer/communication world we described as that world is from the 'paper-telephone' world in which most scholars currently work. Bush's memex, realized in today's technology, would be an integrated environment in which groups of individuals worked within a growing, evolving collection of material. Each would have immediate access to encyclopedic recorded knowledge; each would have access to the trails or lines of reasoning of the others.

As facilities for manipulating and traversing textual archives become more powerful, faster, and easier to use, they will become less and less obtrusive. The gap will gradually close between intention – the desire for the computer to supply some material or to perform some action – and realization. At some point, thinking and using the system will merge symbiotically.

The symbiosis will be like a phenomenon observed in certain physical activities. Workers who routinely use mechanical arms to handle fragile or dangerous materials report that eventually the mechanical arms become, phenomenologically, an extension of their bodies. Their mental point of view shifts to a position inside the isolation chamber and they begin to 'sense' the texture – the slipperiness or the adhesion – of the vessels they are 'handling'. They no longer think of themselves as controlling mechanical devices. They are just lifting, pouring, moving objects as they would with their own hands –

reflexively. Similarly, we can foresee a memex-like environment where controlling and using the computer environment becomes reflexive. The point of view of the individual merges with the evolving mental construct to which he or she is contributing.

To date, no hypertext system has been developed that includes all of Bush's ideas. However, there have been several partial implementations. The first to incorporate a substantial number of Bush's design principles is the *Augmented Human Intellect System* developed by Douglas Engelbart some fifteen years ago at Stanford Research Institute (Engelbart and English (1968)). That design is currently being extended and will form the basis of an office automation utility to be offered by Tymshare. A second partial implementation is by a computer collective, call *Xanadu*, located in San Antonio, Texas, and Menlo Park, California. [7] The *Xanadu* system is being implemented on a large microcomputer. During the 1970's Brown University developed several experimental systems based on Ted Nelson's work during the 1960's; however, those are research systems and are not widely available (Yankelovich et al. (1985)). Within the past five years, development of hypertext systems for writing has increased significantly. Some recent systems include *NoteCards*, developed at Xerox PARC (Halasz (1988)) [8] and WE, developed at the University of North Carolina (cf. Smith et al. (1987a,b)). Interest in hypertext may soon jump sharply due to the availability of Apple's *HyperCard*.

All three systems or designs – ARRAS, electronic publishing, and hypertext – share one important feature: all consist of a number of separate components designed to be used together. At some point the number of integrated components will reach a critical mass. When that happens, we are unlikely to find just another medium for the same forms of expression that exist today. That new medium almost certainly will encourage different modes of writing. Will writers adapt naturally to paperless environments, to new and powerful conceptual tools, to protean text? Will technology lead to changes in pedagogy and educational philosophy?

4. What does this mean for the teaching of writing?

To answer these questions, the starting point must be the awareness that we are addressing a new phenomenon. We are not talking about doing familiar things in a slightly different way. We are talking about computer systems that will affect the way writers think. Consequently, pedagogy that includes the computer must account for different modes of thought as well as different

[7] Information on *Xanadu* is available from the developers: Theodor H. Nelson, Director, Project Xanadu, 8480 Fredricksburg, suite 138, San Antonio, TX 78229.

[8] For an overview of current hypertext applications, see J. B. Smith et al. (1988).

tools for handling text. What is needed is a new rhetoric for computerwriting. That new rhetoric must address three issues: the psychology of computerwriting, the nature of computer texts, and new methods and new heuristics created by the computer.

4.1. The psychology of computerwriting

Computerwriting occurs in a mental world at the end of mechanical arms. Like the handlers of fragile or dangerous materials, writers 'handle' text by directing a machine. Similarly, the writer's viewpoint shifts to where those operations are occurring – inside a fictive space containing text and the instruments used to create and to shape it. In that intangible environment, the writer's control, paradoxically, seems more tangible. The text becomes an entity that can be moved about, put away, brought out to be looked at. It can even be measured and examined in its particularity independent of its meaning.

Along with the space comes a topology – up/down, center/periphery, near/far. The writer uses these mental conceptions along with the computational tools in writing and editing. For example, to rewrite a sentence involves, first, a spatial sense of where that sentence is 'located' and, second, a sense of replacing one word/object with another, or expanding the line to make room for another word, or removing a word and contracting the line.

The writer looking at a two-dimensional computer screen is really seeing/imagining a much larger three-dimensional universe. That universe includes not just what the writer can see right in front of him or her, but all of the text that is 'somewhere' off the screen at the moment. The experience is intensely absorbing and personal: to interrupt a writer concentrating on a computer screen is, literally, to bring that person back from another (mental) world.

At the same time, computerwriting is more social than paper writing. The computer makes it possible for the author immediately to share work-in-progress with colleagues and to incorporate their suggestions. In fact, publication can be viewed as a snapshot that fixes a text at one moment of a continuing organic development responsive to an extensive set of influences.

Writing in a computer environment is, thus, self-reflexive while it is social in unique ways that go beyond current rhetorical theory. As the computer alters relations among writer, text, and reader, it forces us to restate relations among the aims of discovering and communicating.

4.2. The nature of computer texts

Text is fluid in a computer environment. Distinctions between process and product loosen, perhaps disappear. Three recognized phases of writing – exploring and planning, writing, and rewriting – blend peculiarly. Even more

significant for a new rhetoric, the computer manifests an unrecognized fourth phase of writing – representation. Writers' comments, noted earlier in this essay, show the impact of having a choice for representation: writing on screen or writing on paper. The choice of mode is accompanied by a set of stylistic decisions relative to electronic script or to print. Developments in computer graphics and in devices for printing in a variety of typefonts and formats make each writer, potentially, his or her own graphic designer as well as verbal composer. The writers working in some computer environments can literally see what their work will look like 'in print' at any stage of the writing process. They can call on libraries of graphic images and they can turn data into visual charts, graphs, and other forms. Such power requires new skills. Writers and writing teachers need to learn about and to think about visual aspects of composing in a way that was unneeded and impossible before.

Thinking about representation heightens audience awareness, not by visualizing the audience, but by visualizing the product to which readers will eventually react. The diagrams and other spatial representations a writer uses during prewriting as he or she isolates components of a topic, groups and regroups them, may be useful in the end, in devising graphic representations to help the reader 'see' the same relationships. A question for research, then, is whether effectiveness in communication depends on how closely ideas map first onto the writer's, then onto the reader's visual thinking.

4.3. New methods and heuristics

The tool affects the tool-user. Consequently, writers will need new writing methods that are consistent with the way they think when using new computer writing systems.

Earlier, we talked about the computer as environment as opposed to instrument. One implication is that the computer need not offer only *one* environment. Rather, it can provide multiple environments, each tailored to the particular kind of thinking used for a particular part of the writing process. For example, the WE writing system offers four environments. A network mode offers maximum flexibility for early exploratory thinking. A tree mode helps writers build a hierarchical plan for the document. Both network and tree modes are graphics-based, providing visual representations of the information structures and direct manipulation of their nodes and links. A writing mode is a conventional text editor for writing blocks of text inserted into the nodes of the tree or network. And a fourth mode is provided for editing, particularly coherence editing of paragraphs and sections.

We have developed an approach to writing (*A Strategic Method*) that can be used by any writer. It is especially appropriate for writers using computer systems such as WE (Smith and Smith (1987)). It describes the writing process as engaging a number of cognitive modes, each representing a different way of

thinking. Each mode consists of a separate goal and a related set of cognitive processes. These modal processes (emphasized according to the particular mode) yield intermediate products toward the construction of a particular, desired form of writing. The *Strategic Method* offers procedures in each mode to help writers create these products in a step-by-step way. The intermediate products – a cluster, an organizational map, a draft – lead to the construction of the final product, a finished text. Thus, writing method and writing system complement each other and share the same underlying theoretical model of the cognition of writing.

We like to think of the *Strategic Method* as a 'mind-builder'. Using it, writers can develop mental skills like bodybuilders develop muscle groups, separately at first, but with the aim of combining and integrating them for a coherent approach to the whole task. [9]

The *Strategic Method* develops mental skills and a sense of coherence in several ways. First, it views the writing process whole. One of the strongest impediments we have observed in writers – ranging from students to working professionals – is a sense of mystery enshrouding the writing process. Many writers have no clear sense of strategy for approaching a writing task and no clear sense of how to tell whether or not they have produced an appropriate product. A viable writing method must be comprehensive but it must also be compact; it must cover the entire writing process yet it must be brief and coherent. It should resolve mysteries of procedure while leaving room for creativity and discovery.

Second, using this method and a system such as WE, the writer can think through the structure and organization of a document much more thoroughly before starting to write than is practical with paper and pencil or outline processors. The organizational map can guide drafting, for example, helping the writer keep a sense of the whole while concentrating on small, workable segments. The method can guide revisions, too. When changes in design or organization are necessary, the writer can see, precisely, where those changes must be made and the range of text affected by the changes.

This method used in a computer environment also leads to new strategies for composition. The traditional writer, after completing whatever organizational outline or form he or she uses, will normally begin by writing the first section of the document, then the second, ..., until the end. That is, most writers normally write papers sequentially, except, possibly, for the introduction or conclusion. By contrast, the writer who has produced a tree diagram or an organizational map for the document may write a one-paragraph overview of the entire piece (and record it at the root of the tree), then one-paragraph summaries for each major section (recorded at their respective nodes or

[9] For a discussion of the relations among cognitive theory, composition and rhetoric, and system design, see J.B. Smith and M. Lansman (1988).

branches). The text is complete when the working paragraphs of the main text have all been written (and recorded as the leaves of the tree). The document to be printed, however, would be assembled from the hierarchy of components recorded in the tree-structure. But, of course, by assembling only the top levels of the tree, not the leaves, one could obtain several different documents, each comprehensive but each constituting a different level of abstraction and specificity. In discussing system design next, we will consider several computer aids to support this approach.

Third, the *Strategic Method* encourages writers to edit by plan, rather than attempting to edit all factors – from organization to diction – at the same time. It does this by encouraging the writer to follow a top-down strategy for editing. Using this approach, the writer will look for and verify only a small set of specific features at a time and will revise only those aspects until they conform to intention. He or she begins by verifying overall criteria and structure. When the writer is satisfied that the right sections are present and that the sections are in the right order, the writer will then examine the individual paragraphs, then sentences, then diction, and, finally, format and graphics. By following this strategy, the writer gains an overview of the editing process as discernible stages. This develops justified confidence in the writer that he or she can turn a draft into an acceptable final product.

While the computer can offer fresh insights into writing as well as new techniques and heuristics, these elements do not constitute a rhetoric. A rhetoric for computerwriting will have to integrate conceptual and psychological perspectives, notions of protean computer texts, and the methods and heuristics suggested by the computer. This synthesis will be a formidable task. But, if it can be done, it will raise new possibilities for writers.

5. What does this mean for designing future writing systems?

Computer systems already developed have outstripped our understanding of their impact on the writer. Nevertheless, new systems are being developed, to be followed by still others. What principles and what features might they adopt that would make them most useful?

Computer systems that aid writing usually consist of separate, unrelated tools that support one or at most several activities of the process. As a principle, computer systems for writers should be comprehensive – they should assist all phases of writing and they should be viewed as the constituents of an integrated working environment. In considering potential tools, we will divide them according to the phase of the writing process they are primarily associated with, but we do so with the understanding that writing is a recursive activity. A product generated in one phase can be used in the others, as well.

5.1. Exploring and planning

Early phases include a number of different activities, ranging from gathering information to designing the structure for the piece to be written. The computer can assist with most of these steps. Consider, first, the gathering of information. The writer can use a number of on-line bibliographic data bases to help locate sources of pertinent information but cannot, except in a few specific subject areas, gain direct access to the documents, themselves. What is needed by student writers as well as scholars and other professionals is a basic research library of one to two million volumes with associated scholarly periodicals. Cost for encoding such a collection would be approximately one to two billion dollars. This is obviously a large sum, but for a permanent national resource, it is not extravagant or unrealistic. A writers' data base for educational and professional use is a first priority for design and development.

Second, to gain maximum benefit from such collections, writers need computer systems that make it easy to access information and to incorporate it in work-in-progress. Specifically, writers, need more convenient utilities for down-loading sources so that they may read, manipulate, and analyze them locally. ARRAS is an example of one such system, but its analytic power can and should be extended. We hope to see other systems of this general type developed.

Third, writers need more and better *visual* aids for writing. For many, the exploratory and organizational tasks of writing draw heavily on abstract, spatial forms of thinking, rather than linguistic thinking. For these writers, graphics-based structure editors provide a more natural environment in which ideas can be represented as icons and manipulated directly to form clusters, simple relational structures, even large trees representing the hierarchical organization of the entire document. WE and *Storyspace* are examples of writing systems that provide visually-oriented structure editing. [10] Many of these systems are still experimental or just appearing on the market, but they represent an important new development for computer writing.

Fourth, writers need a more developed topic-exploration system. The issue of 'not having anything to write about' we believe is an artificial one. It exists for some younger students, but it is cured by knowledge and experience. We have never met a professional who needed to write but had nothing to write about. Hugh Burns' *Invent* [11] is a prototype topic-exploration program (although a writer's sketch pad system and heuristics can assist in this area, as

[10] *Storyspace* is available from Jay D. Bolter, Department of Classics, The University of North Carolina, Chapel Hill, NC 27599.

[11] Hugh Burns, 'INVENT', *Word/Writing Process News*, distributed with *ACH Newsletter* 5(2) (Summer, 1983).

well). *Invent* engages the student in a dialogue based on classical rhetorical models, gradually leading the student into a consideration of the structure and implications of the topic. We hope to see extensions of the basic concept. For example, we can imagine a system with similar intent but containing an artificial intelligence component that would build an evolving 'understanding' of the topic along with the student writer. We don't foresee this in the near future, but the application would provide a fertile ground for testing AI systems. Perhaps those working in AI could be engaged in a collaboration with those working on computerwriting.

5.2. Writing

Computer systems to support drafting should include several components: improved 'natural' editors, generic text markers, and graphic libraries and editors.

For the traditional writer, we suggest more flexible, easier to use full-screen editors. All line editor and many full-screen editors are awkward, intrusive control mechanisms. To accomplish some actions the writer must 'leave' his or her conceptual frame of reference, shift to a surface-feature view of the text, formulate an intent, generate the control sequence that will realize that intent, evaluate the results to be sure the system did what was expected, and then try to regain one's original train of thought. Analog controls that make traversing a text as reflexive as driving a car would greatly facilitate writing.

During composing, writers should not have to think about format on an *ad hoc* basis, as with the Macintosh, but rather as part of the logical structure of the information. This concept is realized in the notion of document architecture, found in IBM's *General Markup Language* and Microsoft WORD's style sheets. The writer identifies a long quotation, or a first-level heading, or a footnote reference. These systems then translate the generic identifiers into the specific command sequences necessary to produce appropriately formatted output.

A final aid for composing should be better facilities for incorporating graphics. Graphic design should be part of overall document design, not an afterthought. Design decisions should be regarded as strategic: what content requires a graphic supplement, what content can be expressed entirely in a visual mode, what can be expressed best in words alone? To facilitate the decision making as well as the creation of graphics, writing systems should provide collections of images or image components that can easily be recalled, edited, and included in a document. While graphics can be inserted into the linear text on the Macintosh and several other systems, writers using hypertext-like structure editors need the capability of inserting graphics, as well as text, into nodes.

5.3. Rewriting

Except for editing and formatting, more writing aids have been developed for rewriting than for any other stage of the process. *Writer's Workbench, Epistle, HBJ Writer* and others provide commentary on various stylistic and grammatical aspects of text. However, all of these systems seem guided more by what the computer can do rather than what it should do. To be truly useful, the analytic programs in a rewriting system should have some 'sense' of normative expectation. They should be able to relate measures of specific features for the purpose of revealing patterns of structure and style in an individual document. Through comparing measures of different documents, they should infer norms leading to an abstract view of document types. And they should provide the writer with a general critique instead of just marking individual words or features or reporting the numeric results of a formula. An analytic aid with this degree of sophistication is also in the realm of AI. Again, this seems a worthwhile goal and a profitable area for collaborative research by AI and writing theorists.

5.4. Browsers

A major distinction in document types lies in whether the end product is to be read on paper or on screen. For paper versions of a 'paper', the writer needs flexible, easy-to-use formatting, as just discussed. But we also outlined a scenario in which a document might reside *only* within the computer. This second alternative will be practical only if we have better on-line browsers that facilitate reading and traversal through the text.

Earlier, we described systems such as WE that visually represent the structure of a document as a tree. That system could serve as the basis for more powerful browsers. To read the document, the user would traverse the tree displaying the blocks of text or graphics associated with each node in the structure. The reader could read the document in the 'normal' beginning to end sequence, but he or she would have other options, as well.

The reader could also start at the 'top' and read a 'paragraph' composed of the consolidated summary statements for each major section, then choose a section – not necessarily the one the author would have thought of as 'coming first' – and read its overview. The reader might go all the way down one branch of the tree to the bottom-level paragraphs and thereby gain a detailed view of one aspect of the subject, or the reader could work his or her way one level at a time and thereby gain a progressively more detailed but comprehensive view of the subject.

Such a browser could be used with many existing documents in addition to those designed for it. For example, *The Encyclopedia Britannica*, structured hierarchically with its Propaedia, Macropaedia, and Micropaedia organization,

would lend itself naturally to an interactive hierarchical display system. Consequently, the reader would find hierarchical traversal a natural mode of reading. But at times the reader will undoubtedly be reminded of something and want to 'look across' the hierarchy to find passages located throughout the encyclopedia that relate, associatively, to the point being considered. To do this will require random, as well as hierarchical, access. The ARRAS system, described above, currently provides very quick random access for large texts; it could be modified to provide this function in conjunction with a browser.

The realization of such browsers will change the way readers use large texts and visualize their structure. We are reminded of Henry James' metaphor, the house of fiction (1963: 7). An author may view reality through many different windows, each offering a different point of view, each potentially leading to a different fictional portrayal. The situation is reversed for a hierarchical display system: the document, itself, has many different windows through which the reader may look in on it and through which he or she can see many different texts. A cornerstone of writing pedagogy is that the writer must work from a strong sense of context, purpose, and audience. But for this dynamic new form of on-line document there is no single context. Using a browser, the reader may come to a given paragraph or a given section via many different paths. There is no way the writer can anticipate what his or her reader knows or has read prior to reading a given section. And that is a new world for writers.

6. Conclusion: Enough! or Too Much

William Blake, *The Marriage of Heaven and Hell*, plate 10.

With computers as their tools, writers stand potentially in new relationship to their own knowledge and to world knowledge. A computer environment for writing and thinking both enables and demands:

- new creativity, through control over detail beyond the capacity of the individual mind;
- new critical thought, through managing more information categorized in more fluid ways to ask different kinds of questions with answers so inclusive or so precise as to create new conceptions;
- new literacy, through integrating verbal and visual media, and through learning the limitations as well as the opportunities of electronic composition and communication;
- new joy in language, through an aesthetic of language processing as both an art of expression and a technology of the intellect.

Constraints on these possibilities affect writing teachers more than systems designers. The designers will likely find the funds they need to overcome technical problems. The crunch comes when educators who want to use good writing systems confront:

- economic problems of purchasing and supporting systems;
- administrative challenges in meeting writers' computing needs along with competing demands by scientists;
- legal problems of copyright;
- cultural stratification based on access to computing;
- ignorance and fear of the machine.

But that's always the case, isn't it? Vision is always bound with reality. Vision, William Blake (1965: 544) observed, 'is seen by the *Imaginative Eye* of Every one according to the situation he holds'. As we write this essay, we know that growing numbers of educators share our particular situation – teachers interested in computing, in teaching writing with computers, in developing software for writing, and in working with planning groups at our respective institutions. For such educators, Blake is perhaps a good guide. (Philosophically speaking, *The Marriage of Heaven and Hell* is a good computer manual, too.) He was an engraver and printer, as well as graphic artist and poet, who was keenly aware of the effect of his tools on his thinking. He profoundly observed the effect of a technological revolution on his own era, the late eighteenth and early nineteenth century. He struggled to identify the human in experience, particularly technological experience. Writers, writing teachers, and systems designers attempting to use and to produce more powerful tools are engaged in a Blakean task: to keep the human at the center of the new computerwriting environments.

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