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SESSION VI
HUMAN COMPUTER INTERACTION

Paper Session

Computer aids that writers need

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What problems are faced by office workers when they write documents? Are computer aids for writing available to meet their needs? These questions are answered here by: (1) describing recent research on writing processes, (2) listing various types of computer aids that either are currently marketed or are under investigation, and (3) reviewing studies that speak to the effectiveness of these aids. Numerous aids are available for problems that arise in planning, translating, and reviewing text. However, the few reported evaluation studies do not indicate that computer aids improve either the quality or the efficiency of writing.

Writing is a difficult task. Adults spend large amounts of time and effort in preparing letters, memoranda, reports, proposals, manuals, and books. For instance, personnel in business offices estimate that an average of 19% of their working day is spent writing (Klemmer & Snyder, 1972); those in professional and technical occupations report an average of 29% (Faigley & Miller, 1982). Documents vary in demands placed on the writer, but only the briefest and most routine items achieve an acceptable degree of quality without a large investment of mental effort. Consequently, many writers are interested in computer aids that promise to make tasks easier.

In this paper, I describe theoretical distinctions among writing processes, list various types of computer aids being investigated or marketed to help with specific processes, and review studies on the effectiveness of these aids. Two perspectives emerge, one hopeful and one pessimistic. On the hopeful side, computer solutions for problems facing writers are abundant. On the pessimistic side, few solid evaluation studies have been conducted and few clear benefits from computer aids can be cited.

WRITING THEORY

Prewriting, doing the first draft, and the subsequent draft phases of writing include numerous activities and require long periods of time to complete, sometimes months or even years. Current theories of the writing process find it useful to categorize these various activities as examples of collecting information (reading, listening, and searching bibliographic sources), planning text (creating ideas, organizing ideas, and setting goals), translating plans into text (creating acceptable sentences— actual language production), and reviewing text (reading, evaluating, editing errors). A central and well-documented fact is that collecting, planning, translating, and reviewing generally do not occur in a simple linear sequence. Instead, the processes occur recursively during prewriting and on drafts. Any process can call any other process during any phase of writing. Detailed theoretical accounts of these processes and evidence on their recursive nature are available from several sources (de Beaugrande, 1984; Hayes & Flower, 1980; Nold, 1981).

Another central fact is that collecting, planning, translating, and reviewing seriously strain the limitations of cognitive effort and working memory. These processing limitations are seen most easily in children who have not yet developed ways of coping with these demands (Daiute, 1984). Yet, even relatively experienced writers find writing effortful. This is so in spite of the skills that such writers have for reducing writing demands, such as performing subprocesses automatically, concentrating on only a single process at a time, and using external representations to ease the load on working memory.

Case studies of individuals suffering from "writer's block" (Boice, 1982), as well as interviews with novelists (Cowley, 1957) and surveys of academic writers (Green & Wason, 1982), suggest that writing is effortful. I recently tried to measure in the laboratory this investment of cognitive effort in planning, translating, and reviewing. Collecting was not examined because the subjects were required to write from memory only. In a single setting, college students wrote a persuasive essay concerning the United Nations. Directed introspection was used to track the occurrence of each process, and secondary task reaction times were collected to measure the degree of cognitive effort given to each process. On a variable-interval schedule, the subjects heard an auditory signal while writing. This was a signal for the subjects to say

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"Stop" as quickly as possible, and their reaction times were recorded. After each signal, the subjects pressed one of four buttons to indicate whether their thoughts at that moment reflected planning, translating, reviewing, or some other process unrelated to these. The subjects had been trained to identify their thoughts in terms of these four categories. The purpose of the study was to examine the relations between the writing process and the resulting written product. Here only the results documenting the degree of effort given to each process are reported.

The mean reaction times for cases when subjects reported planning, translating, and reviewing are shown in Figure 1. Baseline reaction times, collected when the subjects were not writing, are also shown to indicate the extent to which writing processes interfered with the reaction time task. An analysis of variance on these data showed that the baseline reaction times were significantly lower than the times associated with all three writing processes [$F(3,87) = 96.06$, $p < .001$]. The increase of a third of a second or more indicates that the subjects devoted substantial degrees of cognitive effort to writing. For comparison purposes, I show the mean reaction time obtained from a different group of subjects who tried to learn a list of words. Their baseline reaction times were indistinguishable from those shown in Figure 1. The increase for intentional learning is only 170 msec, about half that observed for the writing task.

All three processes interfered substantially, but not equally, with the secondary task. An interference score was computed for each subject by subtracting the mean baseline reaction times from the mean for each writing process. These interference scores differed significantly, according to an analysis of variance [$F(2,58) = 5.98$, $p < .01$]. Translating demanded the least cognitive effort, and reviewing the most—planning fell midway between these two. This ordering could vary across writing strategies and tasks.

The above results underscore the importance of designing computer aids that make writing less demanding of cognitive effort, particularly for reviewing and planning processes. In the next section, I describe particular problems that arise in planning, translating, and reviewing and the computer aids that have been developed to help writers with these problems.

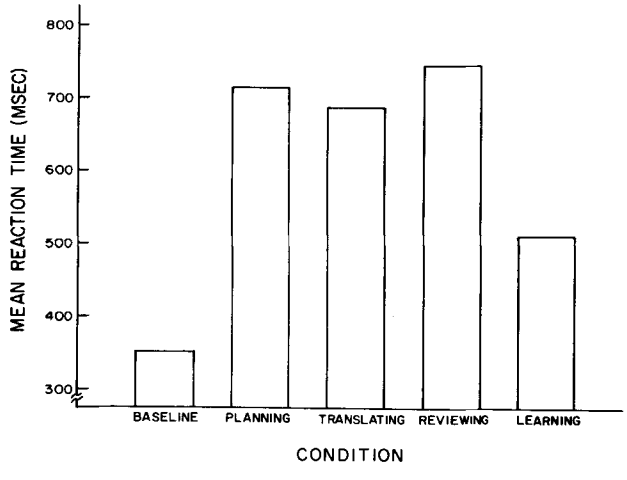

Figure 1. Mean reaction time on secondary detection task.

PROBLEMS AND COMPUTER SOLUTIONS

Without question, the so-called information explosion brings both difficulties in collecting information and technology designed to help. Online searches of data bases, data-base management software, electronic mail, and video teleconferences are a few examples of such collection aids. However, a consideration of these is beyond the scope of this paper. Also excluded are aids intended primarily for teaching children to write, such as the program Storymaker (Rubin, 1980). The focus here is only on the planning, translating, and reviewing aids that may assist adult writers.

Tables 1, 2, and 3 list computer aids that are on the market or are under investigation. I present certain problems associated with planning, translating, and reviewing, the approaches taken to solve these problems, examples of marketed software (if available), and references that provide details on the approach or software (including hardware requirements). The listings of software are illustrative, not exhaustive, particularly in the case of word processing.

Planning

In the area of planning (Table 1), there are apparently no aids for setting goals, such as deciding an appropriate tone for a particular audience, and only one aid for generating new ideas. Morphological analysis is a heuristic for creating new concepts through a dimensional analysis of old concepts (Stein, 1974). Constructing outlines is a time-honored method for organizing ideas, and, of course, any word processing package enables one to use the computer for outlining. A few programs go beyond standard word processing software, however. These organizational programs allow one to collapse the outline to the level of main headings and to expand it to more detailed levels. Lastly, there apparently is no marketed software that helps the writer to construct networks rather than outlines, as recommended by some instructors of writing (Rico, 1983). However, Smith (1982) described a program under development at GTE Laboratories that assists this process by asking the writer to specify relations among ideas and then presenting the resulting network.

Translating

Translating problems for which computer aids are available or are in process divide into two categories: starting a first draft and choosing the right words (Table 2). For the most part, aids for translating are still in the research and development stage, as illustrated by the first category. Academic writers report that making the transition from prewriting to first draft is difficult, with nearly 30% of them saying it is the hardest part of writing (Green &

Table 1
Computer Aids for Planning Problems in Writing

Problem	Solution	Software	Reference
Generating ideas	Morphological analysis	Brainstormer (Soft Path Systems)	Bonner, 1984
Organizing ideas	Outline construction	Thinktank (Living Videotext)	Hershey, 1984
		Brainstorm (Caxton)	Sanders, 1984
	Network Construction		Smith, 1982

Table 2
Computer Aids for Translating Problems in Writing

Problem	Solution	Software	Reference
Starting a draft	Word processing	Wordstar 3.3 (MicroPro International)	Sehr, 1984
		Wordperfect (Satellite Software)	Harmon, 1983
		PFS: Write (Software Publishing)	Tyndale, 1984
	Listening typewriter		Gould et al., 1983
	Prompts and suggestions		Smith, 1982
	Automatic translation		Jensen, 1981
Choosing words	Dictionaries		Johnson, 1983
	Thesaurus	Thesaurus-Builder (Refware)	Kepner, 1983

Wason, 1982). Those suffering from writer's block find getting started absolutely impossible (Boice, 1982). Any aid that reduces the cognitive load imposed by starting the first draft might be beneficial.

The only marketed computer aid fitting this description deals with word processing. Aficionados contend that the physical ease of entering text on an electronic keyboard and the knowledge that anything written can be easily changed make word processing the only way to compose. Besides the ease factor, many packages may further reduce the workload by allowing the writer to work from an outline or to compare alternative ways of expressing an idea through the use of split screens.

Other approaches are in the research stage. The listening typewriter is one of the voice-recognition devices that individuals in the field of office automation seem to be anticipating (Lipoff, 1984). This sort of word processor recognizes speech and allows the writer to dictate rather than type. Presumably, the ease of dictating, combined with the immediate visual representation of a word processor, lessens the demands on the writer. Lastly, researchers have explored the use of prompts and suggestions that guide the writer through the first draft. Just as writing from an outline may be less effortful, so may writing from prompts and suggestions (Woodruff, Bereiter, & Scardamalia, 1982). These include specific requests (e.g., "Please state the objectives of your project"), advice on what to include in a persuasive argument (e.g., "a statement of belief, a reason for your belief"), a menu of appropriate sentence openers (e.g., "to develop concepts for," "one reason is"), and even attempts to goad the writer to continue (e.g., "Can you write some more?").

No aid can be more beneficial for starting first drafts than a machine that translates. Artificial intelligence research in the areas of text generation and expert systems has explored paragraph construction (Mann & Moore, 1981), the generation of stories (Black, Wilkes-Gibbs, & Gibbs, 1982), and stock market reports (Kukich, 1983). These systems aim to replace, rather than to assist, the writer. Research on automatic translation may lead to the development of a writer's aid, however. One stated goal of the EPISTLE system, a natural language parser, is to help with the production of a first draft by working from a brief statement of what the writer wishes to say (Heidorn, Jensen, Miller, Byrd, & Chodorow, 1982). Jensen (1981) offered suggestions on how this might be accomplished.

Choosing the right words, the other translation problem, has traditionally been aided by a dictionary and a thesaurus. Office automation companies have acquired electronic publishing rights to numerous special (e.g., *Stedman's Medical Dictionary*) and general-usage (e.g., *American Heritage Dictionary*) dictionaries (Johnson, 1983); thus, products may be on the market soon. A thesaurus is already available.

Reviewing

Reviewing aids are the most numerous in terms of products on the market (Table 3). The various aids address the following three problems: polishing a draft, proofreading for errors, and assessing clarity and style. Word processing is obviously a powerful tool for altering and formatting a draft into a final document. In the software column, I list some additional word processing packages not mentioned previously; once again, these are only representative of a large class.

Next to word processing, spelling checkers are the most abundant form of marketed aids. In fact, increasingly common are software packages that combine word processing and dictionaries for spelling analysis. Programs are also available to check for wordy phrases (e.g., "accounted for by the fact that"), sexist expressions ("chair-

Table 3
Computer Aids for Reviewing Problems in Writing

Problem	Solution	Software	Reference
Polishing a draft	Word processing	Multimate (Softword Systems)	Strehlo, 1984
		Benchmark (Metasoft)	Harmon, 1983
		The Final Word (Mark of the Unicorn)	
Proofreading for errors	Spelling check	Writer's Workbench (Bell Laboratories)	Macdonald, 1983
		Boss (Professional Software)	Walker, 1984
		The Speller (Hayden Software)	
	Diction-punctuation check	Writer's Workbench (Bell Laboratories)	Macdonald, 1983
		Grammatik (Aspen Software)	Kepner, 1984
		Punctuation & Style (Oasis Systems)	Miller, 1984
	Grammar check		Heidorn et al., 1982
Assessing style	Readability calculation	Writer's Workbench (Bell Laboratories)	Macdonald, 1983
	Style statistics	Grammatik (Aspen Software)	Kepner, 1984
		Writer's Workbench (Bell Laboratories)	Macdonald, 1983

man''), and incorrect constructions (''must of''). Besides detecting mistakes, these programs can suggest replacements to improve diction. Punctuation errors can be flagged by computer, as can consecutive occurrences of a word (''the the'') and split infinitives. A relatively complete check for correct grammar is not yet on the market. However, EPISTLE is a text-critiquing system under development at IBM Research Center that provides such a check for business letters (Heidorn et al., 1982). It can detect errors in subject-verb agreement, pronoun case, noun-modifier agreement, nonstandard verb forms, and nonparallel structures.

Approaches to assessing clarity and style fall into two groups. Numerous statistics can be compiled through text-analysis programs. For example, average word length, average sentence length, the number of simple, compound, and complex sentences, the percentage of words that are judged to be abstract, and the number of passive constructions can be compiled. A profile of style presumably emerges from these numbers. The second approach makes use of some of these numbers to calculate readability formulas. In addition to readability standards, the text can be compared with a set of standards based on similar documents that were judged to be well written. Writer's Workbench includes such standards for technical papers and prose training materials. Other useful references on assessing clarity and style are: Cherry (1982) and Macdonald, Frase, Gingrich, and Keenan (1982), who described the Writer's Workbench; and Kincaid, Aagard, O'Hara, and Cottrell (1981), who described CRES, the Navy's system for reviewing training and technical manuals.

EFFECTIVENESS OF COMPUTER AIDS

Computers will undoubtedly be used for preparing documents even if they do not effectively aid writers. An organization gains by automating secretarial and typesetting functions in publishing documents. Moreover, the thrust of office automation is to integrate office functions, including writing, into a computerized workstation (Minicucci, 1984). But what about the overworked writer? Is there evidence that computer aids help?

As one would expect, the extent to which the products and approaches listed in Tables 1, 2, and 3 have been evaluated vary considerably. Some have been developed by software companies that do not conduct psychological research, whereas others come from large research-oriented organizations. Some are still in the early stages of development; others have been on the market for years. This mix is presented to show the wide range of aids available for writers. It is difficult to draw conclusions about effectiveness that apply to all of these aids. However, two observations are generally applicable.

Little Evaluation

The first observation is that remarkably little evaluation research has been reported, especially work that combines field and laboratory methods. Whether a writing aid improves the efficiency of the writer or the quality of the resulting document is chiefly a matter of speculation. Efficiency can be measured by the amount of time and effort required to produce a document of a given type and length. Quality is difficult to measure, but judgments by readers and analyses of text characteristics can be fruitfully employed (Brown, 1981; Hirsch & Harrington, 1981). In examining the effects of computer aids on writing efficiency and quality, converging evidence from field studies and laboratory studies is needed. Case studies (interviews and laboratory observations), surveys, informal field experiments, and formal laboratory experiments provide corroborative evidence that is critical in studying complex cognitive tasks such as writing.

Formal laboratory experiments are necessary to allow the drawing of causal conclusions. By necessity, however, such experiments are artificial—they do not match the task environment of workaday writing. The deadlines and competing demands on a writer's time illustrate the real-world constraints that are difficult to simulate in the laboratory. Informal field experiments are less controlled but offer greater realism than those conducted in the laboratory. Surveys are also useful in establishing the generality of

conclusions based on the experimental method. Lastly, case studies reveal what are likely to be enormous individual differences in the effectiveness of computer aids for writing.

To substantiate this first observation, consider these facts. The most common type of evaluation of computer aids is what I call a testimonial case study. A writer uses a product and describes his/her impressions for potential users (Hershey, 1984; Moran, 1983; Zinsser, 1983). For example, Moran (1983, p. 113) evaluated word processing in the following way:

> You can imagine what the word processor has done for me. Now the words fly up the screen, not ink on paper but images that, with a single keystroke can be erased, filed, moved, changed. "Nothing permanent here," I feel. "What I'm putting up on the screen is just images; no need to worry." And so the editor retires to the sidelines, allowing the creator to produce language, both good and bad. The editor is recalled later, at the appropriate time, to cut, paste, add, delete .... I produce more, and I produce that more with less effort.

Such testimonials can provide useful insights. But more detailed case studies, in which the writer is carefully monitored over long time periods, would add to these testimonials. Such work, happily, is now in progress. Bridwell, Nancarrow, and Cross (1984) reported preliminary results from case studies of eight doctoral candidates who wrote on word processors in the laboratory. They employed a retrospective thinking-aloud method. Their early results suggested that (1) planning by drawing diagrams is still best done with pen and paper, (2) planning during prewriting may simply be abandoned, with writers instead composing a first draft to see where their ideas are headed, and (3) revising is frequent on a word processor, with some writers polishing their first draft as they compose it. Surveys are needed to document the generality of observations such as these. Experiments are needed to explore the consequences of writing with a word processor. Does the abandonment of planning, for example, help or hurt the efficiency and quality of writing?

The most intensively studied writer's aid appears to be the Writer's Workbench. Hartley (1984) compared Writer's Workbench and human editors in the task of reviewing a technical article. He found that Writer's Workbench is certainly more consistent than human editors in detecting errors in spelling, punctuation, diction, and style. Only the human editors, however, could detect ambiguities, controversial points, errors of fact, inconsistencies, and other mistakes that require expertise regarding the article's content. Gingrich (1982) reported the findings of a field study of office workers in which questionnaires, data on program usage, performance on standardized revision tasks, and interviews with participants were collected. Key outcomes were that writers enjoyed the immediate feedback and suggestions offered by the programs and that they found more errors using the programs on the revision tasks than they did without the help.

Although the results on Writer's Workbench look encouraging, important questions remain. Are there improvements in the quality of writing samples when reviewing aids are used? Using college students as subjects, Kiefer and Smith (1983) failed to observe such improvements in their evaluation of Writer's Workbench. Do writers spend less time and effort to produce an acceptable document when using reviewing aids? The evidence is unavailable. Yet, assuming future work does show benefits in quality or efficiency, to what extent can they be attributed to the subjects' expectations about the power of computer aids? Would writers improve using just any computer software because they believe it should help them? Experiments should be designed to control for such nonspecific effects.

No Panacea

The second observation is that computer aids should not be viewed as a panacea for all that ails writers. The tools that a writer uses are only one aspect of writing method. Work scheduling (Boice, 1982), behavioral rituals (Green & Wason, 1982), and cognitive strategies (Flower & Hayes, 1980) are other aspects of method that affect writing. Besides method, personality factors such as motivation partly determine a writer's productivity (Pelz & Andrews, 1976). And, of course, what writers know about their language, audience, and topic is critical (Applebee, 1982). The relative contribution of these factors is still uncertain, but it is unreasonable to expect too much from tools.

This point finds support in an experiment comparing the simulated-listening typewriter and longhand methods of composition (Gould, Conti, & Hovanyecz, 1983). The variance in time spent composing among individual participants was 2.5 times greater than the variance among the methods of composition studied. The tools used are only a small part of the story.

Moreover, the tool effects that are obtained do not necessarily favor computer aids. Gould's (1980) program of research shows that writers compose slightly faster when they dictate than when they write longhand. A simulated-listening typewriter, at least one that can handle a large vocabulary and continuous speech, falls between dictation and longhand (Gould et al., 1983). Finally, the word processor studied by Gould (1981) was actually 50% less efficient than longhand. Only when the secretarial time needed to transcribe longhand was added in did an advantage appear for word processing. One could argue that this finding is limited to the particular system studied. However, the generality of these findings is enhanced by a survey that I recently conducted with academic writers. I found a significant, moderate correlation between reported productivity and the frequency with which authors reported using dictation ($r = .39$, $p < .001$). In contrast, no significant relationship was obtained between productivity and use of a word processor ($r =$

.13, $p < .20$). Woodruff et al. (1982) reported that students wrote at least as good if not better papers with a pencil than with a computer. Interestingly, however, the students liked writing with a computer better.

Need for Evaluation

The most glowing evaluations of computer aids come from testimonial case studies. The results of Woodruff et al. (1982) indicate that liking computer aids is not the same as benefiting from them. Although numerous aids are available, additional research is needed to show whether current computer aids clearly improve the quality or efficiency of writing. Such research will undoubtedly prove useful in designing future aids.

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