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Using computers to disseminate scientific information: The potential of optical disk based journals

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Several potential advantages of computerized scientific journals delivered on erasable optical disks are explored, including the availability of hypertext functions; databases of evaluative peer ratings and comments, as well as of author responses; keyword, rating, and text searching; author revisions or retractions of articles; availability of original research data to other researchers; and the possibility of incremental construction of journal-based computer expert systems. Problems associated with current editorial review processes that are likely to be obviated or alleviated by computerized journals are also discussed.

More than any other type of communication medium, scientific and scholarly journals provide the means of knowledge transfer and storage in academia. As the physical embodiment of both novel and historic scientific and scholarly information, paper journals currently represent the knowledge base of the academy (Seiler, 1989). Yet despite their revered status in academe, in a relatively short time, paper journals in their current form may no longer exist.

I will argue here that academic journals will very soon undergo a revolutionary transformation. Currently limited and tethered by the very paper on which they are printed, journals will soon be delivered on a new, and vastly more functional medium: updateable and erasable optical disks. Such digital storage will offer powerful new functions and benefits to journal readers, authors, researchers, editors, and publishers. The technological components required for this revolution—affordable personal computers, erasable optical disks, and software for full text and graphics retrieval and management—are all gradually lowering in cost. The current cost of this equipment and software is well within the budget constraints of most libraries, and even some academic departments. But within the next decade, costs are likely to decrease further, so that individuals will be able to afford to subscribe to journals on optical disks.

This publishing revolution will transform academic journals into full-text and graphics information bases, as well as original research databases. In addition, the editorial process itself will be transformed, and will likely become more open and fair.

Since few in academia have anticipated that "the print medium would become a primary factor inhibiting further progress" (Seiler, 1989, p. 69), the limitations of paper journals are still not salient in the minds of most journal readers. Thus, the revolution will not only be technological, but also cultural; it will involve a restructuring and expansion of the ways in which researchers think about scholarly communication and publishing.

Below I will discuss some criticisms of current journal review processes (many of which may be obviated by disk-based journals), the limitations of using paper as a medium for journals, and some of the new capabilities that will soon be available to users of disk-based journals. Due to limitations of length, this paper will offer a broad overview, in outline format, of this coming revolution in scholarly publishing. Readers who desire more detailed information about specific topics may wish to consult one or more of the references referred to in each section.

CRITICISMS OF CURRENT JOURNAL PEER REVIEW PROCEDURES

Journal rejection rates are too high. Rejection rates are about 90% in many psychology journals. The clear consequence of this is that many worthwhile papers are delayed in reaching the academic community (due to the delay involved in resubmission to other journals, etc.), or, more tragically, that these articles simply remain unpublished. Worthwhile ideas and valuable data are thereby lost.

There is only low to moderate interjudge agreement between reviewers. In one study, previously published papers were submitted again (with minor cosmetic modifications) to the same journal. Eighty-eight percent of these previously accepted papers were rejected, primarily because reviewers cited "methodological flaws" (Peters & Ceci, 1982). Clearly, given this lack of interjudge reliability, the acceptance of papers is partly a function of chance events.

Reviewers can be biased, subjective, and/or overly critical. Perhaps one reason for this lack of interjudge reliability is that some reviewers are biased. Peters and Ceci

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(1982) reviewed research in which it was found that in nonblind reviews, a paper identified as being written by authors from a prestigious institution was more likely to be recommended for publication than was the same paper identified as being written by authors from a less prestigious institution. Bradley (1981) surveyed psychologists with regard to their perceptions of the journal review process. Seventy-six percent felt pressure to conform to strictly subjective reviewer preferences, 73% perceived false criticisms, 67% perceived inferior expertise, 60% identified concentration on trivia, 43% felt that the reviewer(s) displayed a condescending attitude, and 40% perceived careless referee reading.

LIMITATIONS OF USING PAPER AS A PUBLISHING MEDIUM

Page limitations. Given the expense of publishing with paper, most journals must enforce strict limitations on length. One consequence of this is that a substantial number of rejected papers do deserve to be published (Lancaster, 1978), and indeed would have been accepted if the journals could afford to print more pages.

Time delays. The typical publication lag for an academic article, from submission to publication, is about 12 months (Cofer, 1985); in some cases, it may even approach 2 years (Seiler, 1989). If we combine this with the facts that (1) due to limitations of length respected journals often reject many articles worthy of publication, (2) simultaneous submission to several journals is unethical, and (3) an author may have to reedit his or her article several times to conform to each new journal's specific typescript style requirements, the delay in publication of a worthy article may be upward of 3-4 years. Such time delays may have critical consequences in some fields, particularly health care. An even greater loss may occur if, due to a series of delays and rejections, an author simply gives up and makes no further attempts to have the research published.

Other inherent limitations of paper journals. In 1985, *Psychological Abstracts* published 33,349 abstracts from 1,375 journals. In 1984 there were 535 psychology periodicals; that number had virtually doubled by 1989, when over 1,061 psychology periodicals were published (source: *Ulrich's International Periodical Directory*). In 1986, the total number of pages published by American Psychological Association journals was 9,935 (American Psychological Association, 1987). At the current rate of publication, it will soon become impossible to read every published abstract, even if a person were to allocate a full year to the task (Muckler, 1987). Astle (1989) has bemoaned that this explosion of the number of paper journals has

> created an untenable situation for academic libraries and the people who rely on them for information. Retrieving a desperately needed journal article from a library's collection has recently become more difficult, especially if it appears in a relatively new scientific title. Feeble budget increases within academe and the astronomical prices of scientific journals have curtailed the purchasing of new titles and forced the cancellation of many existing ones.... Journals have become so important to faculty research that, in order to retain as many as possible, librarians have had to sacrifice monographs to preserve serials. Many libraries devote as much as 80 percent of their materials budget to serials. (p. 13).

As a consequence of this information explosion and of the relative difficulty of storing, finding, and using paper journals, "library research still daunts all but a dedicated minority of the reading public. Libraries have evolved toward hypertext, yet the mechanics of paper still hobbles them" (Drexler, 1986, p. 224).

Unfortunately, as noted earlier, many scholars and researchers are still unaware of the additional functionality and convenience that is possible with optical disk journals. Paper journals are limited in that they cannot perform direct computerized text or document searching, hypertext linking, or direct analysis of journal contents, just as they cannot store original data for reanalysis by others, store a database of reviewer quantitative ratings and/or a textbase of reviewer comments, or provide any of the array of other functions that are performed easily and inexpensively with digital media.

POTENTIAL ADVANTAGES OF COMPUTERIZED JOURNALS

Historically, information has been stored in several incompatible formats that have made informational integration difficult or impossible. Print, audio, video, and data storage have historically required very different storage media. For example, a newspaper cannot also embody the audio and/or video from a news event. In contrast, optical disk technology can digitally store many different forms of information, including text, graphics, audio, photographs, and full-motion video. This integration of information will eventually transform journals into what might be termed multimedia information bases and databases and will greatly facilitate the control, access, analysis, storage, and integration of different forms of information and data. In contemplating this information management revolution, Seiler (1989, p. 17) visualizes "the hypermediated electronic journal [that] would be accessed from a color display with a resolution equal to that of a glossy magazine.... It could include text, sound, still and moving images."

The process by which computerized journals will replace paper ones will be analogous to the way in which the printed word eventually replaced handwriting in formal communication. Today, scholars can still communicate to their colleagues directly in handwriting, although few would want to; in the future, few scholars will want to limit their communication to printed ink on paper. Given the accelerating information explosion, as well as the limited library space, this greater control and management of information and data offered by digital storage could hardly have come at a more propitious time (Eaton, MacDonald, & Saule, 1989). The multimedia informa-

tion bases and databases that computerized journals will eventually represent will greatly facilitate the dissemination, accessibility, classification, and use of scientific data and knowledge. Digital storage will drastically reduce the physical space required to store information, reduce damage to or destruction of journal information, and significantly lower replication costs (Miller, 1987).

The evolution from paper to computerized journals during this decade will have important benefits for publishers, readers, authors, and researchers, as will be discussed below. As an additional benefit, computerized journals will help to obviate or ameliorate the current problems associated with the present practices of peer review.

Benefits for Publishers

Obviating page limitations. Erasable optical storage media can store huge numbers of documents affordably. One CD-ROM disk can store over 150,000 printed pages. However, CD-ROM equipment is unlikely to be used for computerized journals, because it is not easily updated or erasable, whereas the newer optical disks are.

Given that limitations on the number of pages will no longer limit the ability of editors to publish worthwhile information, articles that would otherwise have been rejected may be published. In addition, editors will be less reluctant to publish research with negative results or replication studies.

Reduced cost. Currently, a CD-ROM costing $10 or less stores material the equivalent of paper material costing $1,000 to print (Laub, 1986). After initial setup, the cost of publishing a computerized journal are projected to be far less than current paper journal costs (Miller, 1987).

Benefits for Authors

Implementation of a true, open peer review system. Computerized journals can lead to a truly open and unbiased peer review system. Journal reviewers would no longer primarily operate as censors who determine the articles to which others will have access. Under computerized journal review systems, both the journal review board and general readership might rate articles and comment on them. A database of ratings and evaluative comments could be linked to each article.

Author responses to reviewer comments. A few paper journals (e.g., *The Behavioral and Brain Sciences*) currently offer significant space for reviewer comments and author responses. Journals on optical disks will allow for an ongoing dialogue between general readers, professional colleagues, and authors.

Revised acceptance standards. Peer review and evaluation typically occur before an article is published in a paper journal. Authors often feel pressure to conform to reviewer suggestions to get their papers published. This pressure will be alleviated by computerized journals, since peer review and comment may occur after the paper has been electronically "published."

In addition, journals will be able to accept much larger percentages of articles submitted. In fact, all papers topically relevant to a journal may initially be accepted. Only papers identified by reviewers with clear and major methodological flaws would be deleted from the database.

Author revision/updating of papers. Drexler (1986) has noted that

> once a bad idea reaches print, it takes on a life of its own, and even its author can seldom drive a stake through its heart. A devastating refutation of the bad idea becomes just another publication, another scrap of paper. Days or years later, readers who encounter the bogus idea will still be unlikely to have chanced upon its refutation. Thus nonsense lives on and on.... [With computerized journals,] authors will be able to retract their errors, not by burning all the libraries or by mounting a massive publicity campaign, but by revising their text and labeling the old version "retracted" (p. 222).

Less drastically, in response to reviewer's comments, and/or in light of data from new studies, computerized journals will give authors the opportunity to revise and update their papers. Journal articles, like textbooks and books, might undergo several revisions, or "editions." This would not involve storing multiple copies of the same article; only those sections of text and/or graphics that had changed would need to be saved. For those who were interested, previous editions of an article could be reconstructed by computer.

Alleviation of editorial pressure to reduce article length. Due to the intense pressure to meet limitations on the number of pages, editors often request authors to abbreviate their reports, condense their articles, and limit their reference information. Seiler (1989, p. 16) observed that "The result of these tensions is for journals to become efficient with respect to page budgets but not necessarily to serving the best interests of scholarship." For example, paper journals are often unable to accommodate the reproduction of materials (questionnaires, etc.) associated with a study that may be essential to another investigator to correctly replicate the research. The suggestion to publish original data along with an article to facilitate reanalysis or metaanalysis of the data by other researchers is at present virtually unthinkable. Computerized journals will help to alleviate or completely remove these pressures.

Academic status and evaluation. Currently, many scholars are judged for promotion and tenure not by a thorough assessment of the quality and importance of what they write, but according to how much they have published (Diamond, 1989). Computerized journals may facilitate an assessment of creativity, importance and methodological rigor of a researcher's work by providing the averaged ratings made by journal review boards and/or the general readership of computerized journals.

Benefits for Readers

Full document keyword and topic searching and retrieval. Digitally based storage will allow for far more effective document search and retrieval than is possible with paper. Gill and Woll (1986) have noted that

> the very physical nature of the printed page restricts its usefulness. The same sheet of paper cannot be filed in two

> places at once. The words are locked into the medium on which they are printed. Text is not used as a flexible asset because the printed page is static and unwieldy (p. 20).

As discussed earlier, in contrast to publishing on a paper medium, digital publishing removes the static entity of the printed medium. Published works may be produced and distributed in any desired format (Martin, 1986). Gill and Woll (1986, p. 20) state that through the use of digital storage "the content is liberated from its tangible form and can be explored and manipulated without restriction." As Zoellick (1987a) observes,

> information that is stored electronically and organized logically is a transportable and searchable commodity. You can repackage, subdivide, and rearrange it to suit a variety of purposes. Articles can be printed on demand, as needed, rather than printed in batches, distributed and stored in expensive, bulky paper form as we do at present. Like all revolutions, this paradigm shift to producing electronic databases rather than printed products requires new tools and new ways of thinking (p. 2).

Computerized journals will allow for easy document search and full text retrieval. Boolean keyword searching and newer methods using artificial intelligence will be available to find articles likely to be of relevance to a particular topic. One new approach to searching allows the investigator to rate the relevance of each keyword (and related nonkeywords). The rule-based search results in a rank ordering of documents by their inferred relevance to the search topic. Various other approaches to document retrieval have been presented by Zoellick (1987b) and by Fand (1987).

In addition, searching using averaged reviewer (and/or general readership) ratings might also be available. For example, a user might be able to make the following search request: "Show me all the articles with an average methodology rating of 4 or greater that include (these keywords, each rated by relevance) published within the past 5 years."

Hypertext. Computerized journals will allow for both hypertext and hypermedia linkages. *Hypertext* as a term refers to computerized linkage among different documents. For example, using a computerized hypertext system, one could simply select or click on a reference in a paper to see the full reference citation from the reference list, the abstract of that paper, or the entire text of the document. A technical glossary might also be included, so that technical terms used in papers could be presented to the user with the click of a button. *Hypermedia* extends the concept of hypertext to include connections among all types of material, including text, photos, graphics, audio, and full-motion video contained within a multimedia information base.

Access to critical reviews (ratings and comment) and author responses. Using standard article review criteria (e.g., creativity, importance, methodology, writing style, etc.), a database of ratings by both the journal review board and general readership may be linked to each paper. Mean (and/or median) reviewer rating scores could be calculated, which would then be accessible via a document search query. Averaged ratings made by specific groups (e.g., the journal review board, specialty area colleagues, and the general readership) might also be accessible.

In addition to reviewer ratings, reviewer comments could also be linked to the target paper. Authors would then have an opportunity to respond to reviewer comments, which would also be linked to the target paper. Drexler (1986, p. 225) noted that "As authors expound and critics argue, they will lay out their competing worldview networks in parallel, point by point. Readers still won't be able to judge ideas instantly or perfectly, but they still will be able to judge them faster and better."

Hardcopy. Any article on a computerized journal may be printed by the subscriber. As laser printers become increasingly affordable, such printing can be done quickly and quietly. Some computerized journals might continue to be printed in a limited paper edition. For example, only articles with the highest peer ratings might be published in paper form. In addition, a listing of new articles contained on the disk version of the computerized journal could be published in the limited paper version of the journal.

Reduced cost to readers. Because the costs associated with publishing a computerized journal will be less than that of publishing an equivalent paper journal, publishers will be able to pass the savings on to readers. The initial cost of the optical disk drive, and the original optical disk database, amortized over several years, would probably be less expensive than the equivalent paper journal. Updates might be sent quarterly or monthly on inexpensive floppy disks. Software will be available to integrate the new articles and data into the existing text and database, and automatically update the indexes and hypertext links.

Benefits for Researchers

Notification of relevant new articles according to area(s) of interest. Computerized journals will have the ability to assess the relevance of new articles to a subscriber by a comparison of his or her expressed interests and the article itself. As new articles are added to a computerized journal, software could be utilized to notify the user of relevant articles and rank them according to their inferred interest to the subscriber.

Elimination of studies with fraudulent data. Currently, studies identified to be fraudulent remain in bound journals in libraries (Broad & Wade, 1983; Diamond, 1989). These articles could be easily erased from computerized journals.

Access to original data. Authors of empirical articles would be encouraged or required to submit original data, in computer-readable form, for "publication" along with their paper. Access to the raw data of other researchers allows for confirmatory analysis, secondary data analysis (George & Landerman, 1985), metaanalyses (Hedges & Olkin, 1985), and Bayesian analyses (Stock & Kulhavy, 1989). However, due to increasing demands for page space in journals, journal editors have pressured investigators not to include tables of raw data, and even to delete many summary statistics (Stock & Kulhavy, 1989). In addition, rates of author responses to requests for both

primary data (Craig & Reese, 1973; Wolins, 1962) and summary statistics (Eaton, 1984; Hyde, 1981) are relatively low. Eaton (1984) found the typical response rate to be 71%. Stock and Kulhavy (1989) conclude that "investigators ... are poor choices to distribute data sets" (p. 741).

To manage this problem, Greenwald (1976) suggested that authors should agree to maintain their data sets for articles published in the *Journal of Personality and Social Psychology*. Bryant and Wortman (1978) and Johnson (1964) suggested that data sets should be stored in central archives under the management control of a journal.

Computerized journals will allow for the archiving of original data sets along with the text of the associated article.

Facilitation of collaboration. A searchable biographical database of researchers, which would include their publications, interests, and current research projects, could be distributed with any computerized journal. This would facilitate collaboration as well as avoid "duplication" of very similar studies.

Management and Summarization of Knowledge: Building Expert Systems Incrementally

The knowledge base of any scientific discipline or specialty is embodied primarily in its journals. Yet in this form it is an informational quagmire—a cryptic, amorphous tangle, unsummarized and largely unorganized and unlinked, of both current and obsolete facts and theories. In this form, there is no clearly summarized knowledge base for a discipline. Drexler (1986, p. 218) has stated that "our trouble in spreading, correcting, and organizing information leaves our shared knowledge relatively scarce, incorrect and disorganized." To the extent that a coherent knowledge base for a discipline does exist, it exists only in approximate form, in textbooks that are rapidly outdated, and in the minds of its most educated specialists, who thus form an intellectual elite.

Computerized "expert systems" or "knowledge-based systems" attempt to represent knowledge in such a way that the system embodies a summary of knowledge and can make reasonable, even expert, inferences. Expert systems consist of a knowledge base (composed of many linked if-then-else rules, which may have associated probabilities), and an "inference engine." The inference engine software has the capacity to reason under uncertainty, present a rationale(s) for its conclusions, and even "learn."

Computerized journals will offer a platform and forum to use expert system "shells" to incrementally build an expert system for a specialty area, and eventually, for an entire discipline. To build such a system, authors might be requested to submit proposed knowledge rules (as derived from their research and/or theories) to be submitted to the expert system, in much the same way as they are currently asked to submit keywords to be used to index their article.

After such a system has been developed, one could quickly obtain answers to specific questions (e.g., "What are the most likely causal factors in manic depression?" "What variables appear to be most related to the development of international economic conflict?"). The probability of the veracity of the conclusions can also be presented. If a consensus was not yet reached, the system would indicate it. Advanced research expert systems might even assist investigators by suggesting new hypotheses or variables to consider, critiquing research design, suggesting appropriate statistical analyses, and so forth.

Winokur, Rann, and Thornburg (1987) have described the first medical database distributed on CD-ROM, the Computerized Clinical Information System (CCIS). This database and expert system is written, summarized, and regularly reviewed by an international board of medical specialists. The system provides diagnostic and treatment information to users, as well as an expert system to recommend drug dosages. Since the information provided by the CCIS must be as current and as accurate as possible, the entire CD-ROM databases are updated quarterly, and each database carries an expiration date.

THE TRANSITION TO COMPUTERIZED JOURNALS

Initial Attempts to Develop Systems Similar to Computerized Journals

Several pioneering attempts to develop systems somewhat similar to computerized journals on optical disks have already been made. A particularly successful example has been the TIES (The Interactive Encyclopedia System) system, which has been in development since 1983 at the University of Maryland (Shneiderman, 1987). This is a hypertext information exploration, exhibit, explanation, and expert system, in which conceptual knowledge is linked in a network wherein readers are free to explore hypertext pathways. Other initial, but rather primitive, experimental systems were the Electronic Information Exchange System (EIES) and the Birmingham and Loughborough Electronic Network Development (BLEND) (Shackel, 1987).

More currently, *Psychological Abstracts* (PsycLIT) and *The Human Relations Area Files* have started publishing on CD-ROM. Text and keywords can be searched using a variety of Boolean operators. The *Cross-Cultural CD* will publish two databases each year, each of which will contain from 6,000 to 12,000 pages of text. Other CD-ROM titles that are currently available include *Biological Abstracts*, *Medline*, and *Sociofile*.

However, as I noted earlier, it is likely that CD-ROM technology will be replaced in the near future by erasable optical disk technology. The latter storage medium offers the opportunity to easily and inexpensively append and reindex the information and data on the disk. This will allow disks to be easily updated on a regular basis.

Steps in Developing a Computerized Journal

With the decreasing cost of mass storage media and the widespread use of microcomputers, computerized journals will be feasible very soon (Case, 1985). Journals that

wish to initiate the transition from paper to optical disk media can take several steps now to facilitate and expedite the process. For example, optical scanners can be used to capture text and graphics electronically from previous, and current, editions of the journal.

A board or committee might be established to examine various erasable optical disk systems to keep abreast of current costs and capacity. As of late 1989, several high-capacity erasable optical disk drives were commercially available (Stephens, 1989). They included a 928MB drive for approximately $8,000 (LAN-Stor from Storage Dimensions) and a 600MB drive for about $5,000 (Cosmos 600 from Racet Computers Ltd.). The former offers a 35-msec access time; the latter a 50-msec access time. It is likely that the cost of this technology will drop drastically, even below current prices of CD-ROM, as personal computer hard disks are replaced by erasable optical disks with vastly greater storage capability.

In addition, full text and graphics management and retrieval software can be evaluated. These software systems are currently available from several commercial vendors (e.g., SilverPlatter Information Retrieval System for the PC from SilverPlatter, Inc., Wellesley Hill, MA; Topic from Verity, Inc., Mountain View, CA; and so forth). These systems currently have the capacity to implement many of the functions of the basic disk-based journal that have been noted in this paper.

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