The Use and Value of Scientific Journals: Past, Present and Future

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Introduction

Although scholarly journals have enjoyed three and one-half centuries of valued use, there is a great deal of ambivalence and controversy concerning their use and value. Otherwise careful researchers may repeat the myths that scholarly journals are seldom used and are of little importance. This paper presents some highlights from research studies that present insights into how scientists use scholarly scientific journals and the value they derive from reading journal articles. The studies summarized here were done mostly in North America, with some respondents in the United Kingdom and other European countries.

Details of these studies are found in *Towards Electronic Journals: Realities for Scientists, Librarians, and Publishers* (Tenopir & King, 2000). The information presented here is the result of three decades of surveys -- first by King Research under grants from the U.S. National Science Foundation and contracts with many organizations, and more recently by grants from several organizations, including the Special Libraries Association. This past year, we conducted additional surveys of scientists as we continue to bring our data up-to-date. Results from two of these recent surveys, a survey of scientists at the Oak Ridge National Laboratory and the medical faculty at the University of Tennessee, are compared to results from earlier surveys. In all, the surveys from 1977-2001 include responses from nearly 14,000 scientists in all fields of science, including physical, life, social sciences, and engineering, and from both university and non-university settings (including industry and government laboratories). We also have data from over one hundred publishers, both for-profit and not-for-profit, and libraries.

Since decisions for the future are best made with an

understanding of the realities of both the past and the present, all participants in the scholarly journal system must work together to resolve problems to make a better future. We have aimed our work at four main audiences: 1) scientists; 2) publishers; 3) librarians; and 4) the funders and funding agencies of these three. All are participants in scholarly communication.

This article addresses only the use and value portions of our studies (although Tenopir & King includes data on cost and pricing as well). The findings address some key myths about the use of scholarly journals, including:

- **Myth #1:** Scholarly journals are not read;
- **Myth #2:** There are too many journals being published;
- **Myth #3:** Journals are only for authors, not for readers (and mostly for university tenure and promotion);
- **Myth #4:** Researchers always know the information before it appears in a journal, and
- **Myth #5:** Electronic journals make editors, publishers, and librarians obsolete.

Amount and value of reading

There is a widespread myth that scholarly journals are seldom read, yet surveys of thousands of scientists from the 1970s, 1980s, and 1990s and now into 2000 and 2001 consistently show that journal articles are considered to be the most important information resource by scientists and are widely read. In the early studies the format was, of course, print-on-paper. Now, it is increasingly also in various digital forms.

As can be seen in Figure 1, scientists surveyed from 1993 to 1998 averaged 120 readings of scholarly journal articles per year. In our latest surveys from 2000-2001, that average is now up to 130. These averages are averages for all work settings. University scientists read more – an average of 188 readings per year-- whereas non-university scientists average 106 articles per year. Three-fourths of readings by university scientists are for research purposes and over half of those readings are said to be essential to that activity. Two-fifths are for teaching purposes, with most considered essential to that purpose. Although non-academic scientists read less, they report that the information they get from journals is extremely important to their work. In both settings, scientists whose work has been recognized through achievement awards, read more on average than non-award winners.

These numbers are averages across all fields of science. Medical scientists read much more on the average than others. Whereas engineers are at the lower end of the spectrum. In our 2001 survey, we found that university medical faculty read on the average 322 journal articles per year. This figure is consistent with earlier studies. Meadows (1974) found that medical researchers read approximately 7.4 professional

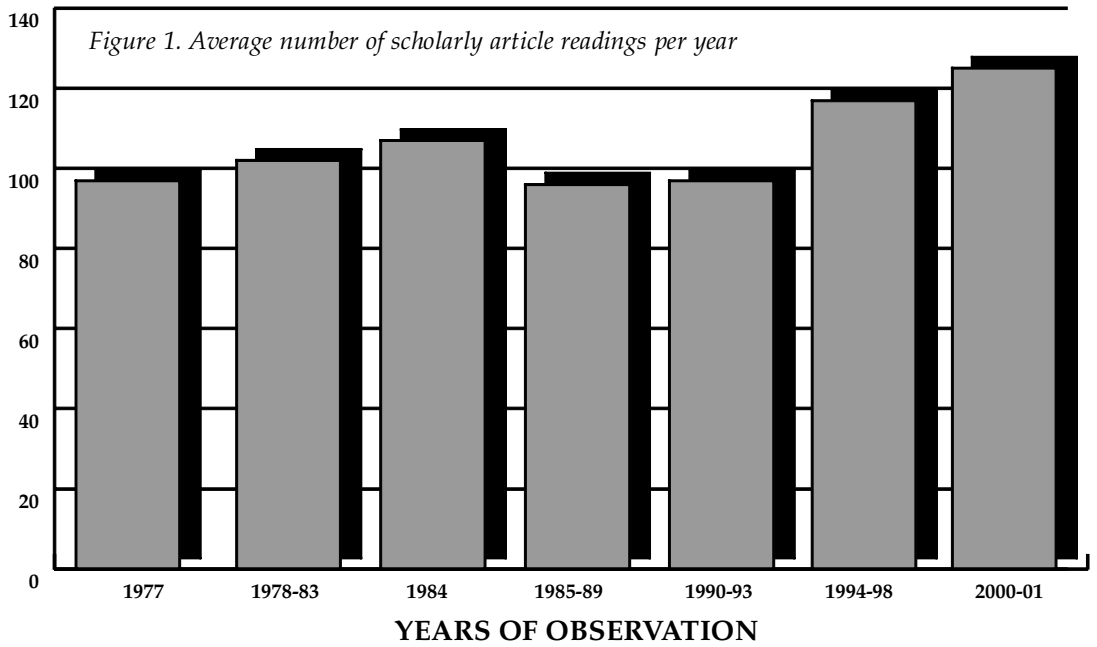
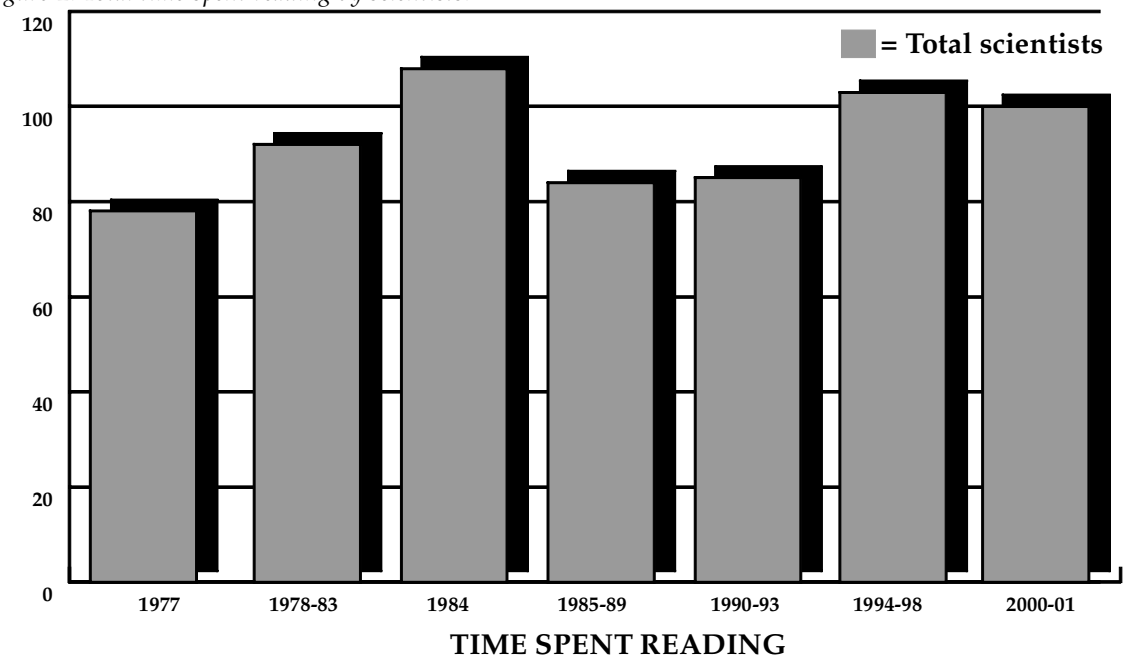


Figure 1. Average number of scholarly article readings per year

Figure 2. Total time spent reading by scientists.



papers per week (approximately 380 per year). Rogers (2001) reports that of all Ohio State University departments surveyed, the biological and medical sciences faculty and students are the greatest users of scholarly journals in both print and electronic forms. In contrast, our study of engineers in a government laboratory found they read only an average of 72 journal articles per year. Meadows reports that engineers read approximately 1.5 articles per week (ca 75 per year) and Pinelli et al (1989) observed that engineers read an average of 6.7 articles per month (approximately 80 readings per year).

The scientists in our surveys say that a high proportion of readings improve the quality of research and teaching, helps them do their work faster, and saves them time and money. The primary purposes of information obtained include primary research (34% of all readings in the national laboratory survey, 29.9% of the medical scientists), current awareness or continuing education (22% in both groups), and communications-related purposes such as writing, making presentations, or consulting (16% national laboratory scientists, 16.9% medical scientists.) Reading for background research was an important purpose for the non-university scientists (24%), though less so for the university medical scientists (6.5% medical). Additional purposes reported for the university medical scientists included clinical practice (7.8%) and teaching (16.9%).

Scientists, on average, spend well over 100 hours reading scholarly articles, an indicator that they recognize the importance and value of this activity. (See Figure 2.) Although time spent reading is going up, the number of articles read is increasing more quickly than the amount of time spent reading, showing that scientists feel the need to read more, but the time they have to do so is limited.

Our recent survey showed that medical scientists in university settings spend more time reading than the average, approximately 118 hours per year. On the average, they read more articles more quickly. They spend only 22 minutes per article as compared to engineers, who read fewer articles but spend an average of nearly an hour per reading. Previous studies of time spent reading show average times ranging from approximately 26 hours per year for engineers to approximately 288 hours per year for cancer researchers. (King, McDonald, and Roderer 1981, Tenopir and King 1997, Griffiths and King 1993).

The amount of scientific knowledge recorded in scientific journals doubles about every fifteen to seventeen years. At the time they graduate from college, scientists will have been exposed to only a fraction of knowledge they will need during their careers; in fact, five-sixths of new

knowledge in their field will be created after their graduation. They must keep current or risk not achieving their full potential in research and teaching. Clearly, they have a great incentive to do so and recognize this by the time they spend reading.

Approximately half of readings involve articles that contain information new to the reader. Although on the average two-thirds of readings are of articles within their first year, readings of older articles are reported to be very valuable to the work at hand. These may be new readings or re-readings of an article that was read previously when it was new. In our latest survey of medical faculty, over 87% of readings were from the past 14 months and 94% from the past two years.

Is too much being published? Perhaps, but from 1960 to 1995 in the U.S. the growth of journal literature was highly correlated with the number of scientists. The number of articles published per scientist has remained relatively constant over the years at about one article per ten scientists. There are just many more scientists now than in the past.

Still there are many scientists who read but never write, in particular in non-university settings such as industry, government, and national laboratories. This is especially true in the medical field. Virtually every physician – even those not involved in research or teaching – must read medical journals to keep up with advances in patient care. In the life and physical sciences about 70% of all readings are done by non-academicians, who write considerably less frequently than academic scientists. Add to that the many high school, undergraduate students, and graduate students who rely on scholarly journals but may never write an article, and there is a huge population that relies on journals to learn first about important findings. They are not part of the inner circle; they do not attend conferences, and they are not part of the invisible colleges of experts. Novice readers may not recognize prominent names or be able to judge quality for themselves, so they rely on the peer review and editorial processes as a quality filter.

How myths get perpetuated

Why are some of these myths so widespread? There are at least two reasons. The first is that some research implies that citation counts measure all reading and researchers confuse the number of articles cited by authors with the number of articles read. This grossly underestimates reading since so many more people read than write. The same person often reads an article more than once in his or her career, and an author does not cite everything he or she uses.

Another reason for the myths is that the results of some prominent studies of the 1960s and 1970s, sponsored by the NSF and conducted by Garvey & Griffith, were misinterpreted. In these

Figure 3. Average number of personal subscriptions to scholarly journals

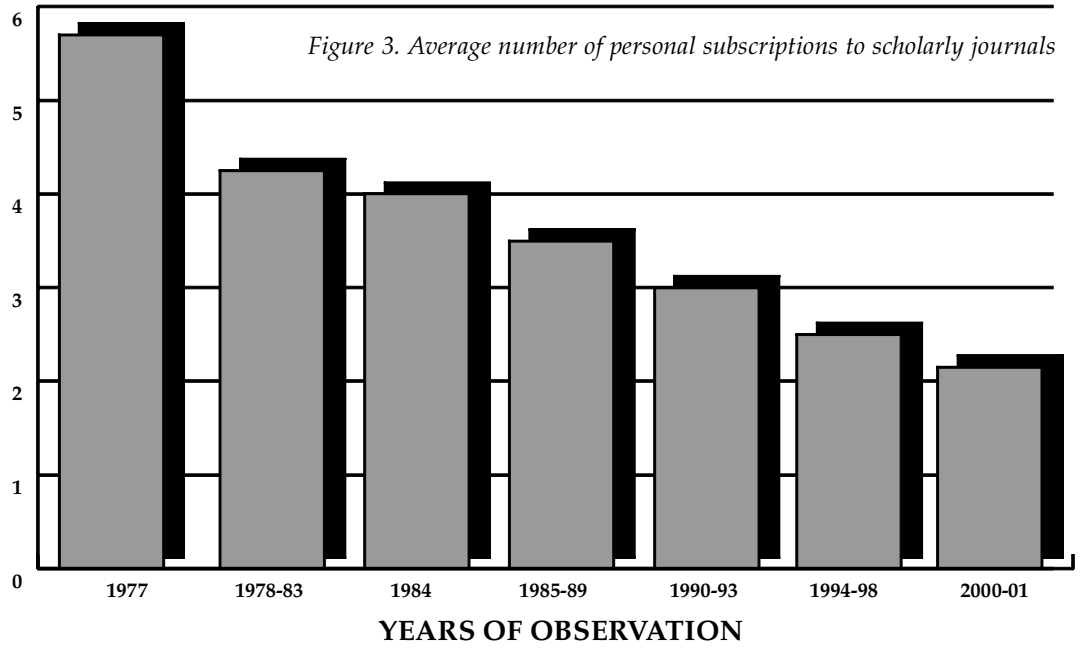
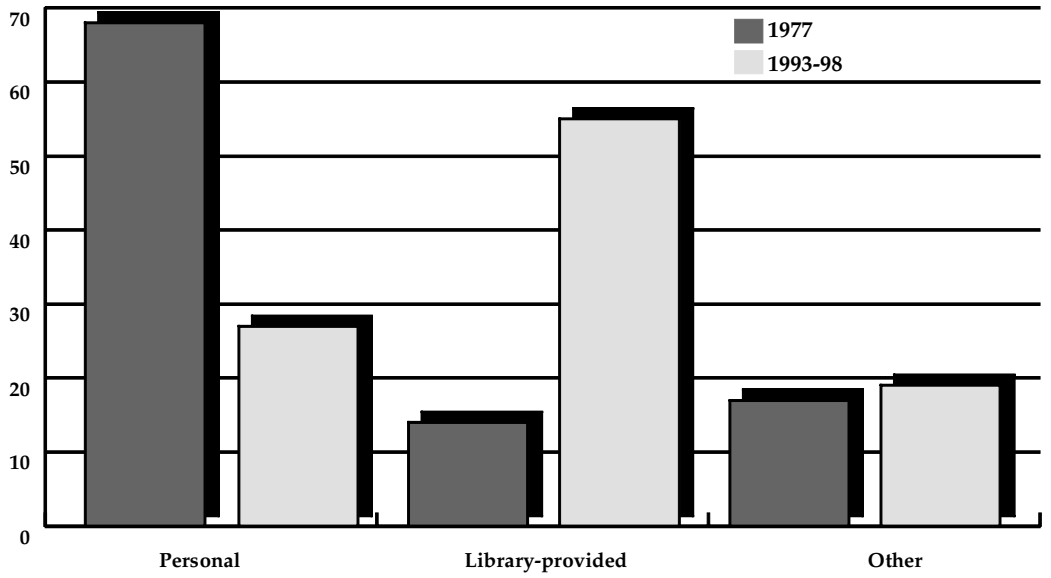


Figure 4. Proportion of readings of scholarly scientific articles



studies, the authors sent lists of recently published article titles to a sample of scientists and asked the scientists to indicate which articles they had read. They reported that a typical article in an APA journal, for example, was read only 17 times. Misinterpretation began because these results represent only the sampled responses and were not extrapolated to the entire population.

By contrast, the estimate extrapolated to the entire population of scientists likely to read an APA journal is about 520 readings per article. Even this number is an underestimate because articles are often initially read (and reread) beyond the two month period following publication and additional reading happens from separate copies of articles. The number is really closer to 860. Two studies using the same survey methods show that the total times an article is read is 1260 and 1800. Our current estimates are about 900 readings per article for all of science.

More on reading

Scientists read from an average of 18-26 journals each year, but they tend to read only a few of these journals extensively and typically read very few articles per journal. About half of them are read less than five times and only one is read from more than 25 times. Medical faculty, in contrast, read from an average of only 13 journals and they read many more articles in the journals that they find important. In our recent survey, university medical scientists reported an average of 26 readings per journal read. In addition, users are increasingly finding out about articles from a variety of sources, including online searches, and they read more separate articles.

The number of journals scientists read from is going up, even as the number of personal subscriptions is going down. (*See Figure 3.*) In the past, North American scientists subscribed to almost 6 journals. By the late 1990's this had declined to just over 2 and the downward trend is continuing on the average. In contrast to the trend, medical faculty in our recent survey still maintained an average of 6.3 subscriptions per scientist. Two thirds of all of their readings are from their personal subscriptions, both electronic and print.

Data from library consortia that are mounting hundreds of scholarly journals (such as OhioLink) tell us that when journals are easily available to university users, the number of journal titles from which they read articles goes up. Beyond their core journals, if made readily available, scientists and students read from a variety of sources. They show remarkable tenacity in changing their habits to find journal articles from places other than personal subscriptions (such as from the library) as the cost of personal subscriptions has gotten prohibitively expensive. These changes over time are shown in Figure 4.

Scholarly articles may never have the number of users or the interest level of general-interest web pages, but readership will increase

dramatically for some topics when articles are made freely available on the desktop. Free availability of a single influential source can have a huge impact. This is clearly evidenced by experiences in the late 1990s. When the medical indexing/abstracting database Medline was offered free on the web through the PubMed system, the number of users for this medical index set new records-- a month of searches in PubMed equaled a year of fee-based Medline searches (7.6 million). Now 90% of all Medline searches are done in PubMed, many by people who were never interested in scholarly medical literature before, and there are between one-half to one-million searches of PubMed per day.

In our recent survey, we found that 89.3 percent of university medical scientists were familiar with PubMed. The 66 respondents, who reported using PubMed, used it an average of 57.5 times in the last year (though the mean drops to 43 times per year if one outlier – who reported using PubMed 1000 times in the past year- is eliminated.) The 58 respondents, who read articles as a result of using PubMed, read an average of 58.6 articles from this use (again, the mean number of articles read drops to 51.8 if the outlier, who reported 500 articles read, is omitted.) PubMed is an index and users must find ways to get access to the full texts of relevant articles. This requires extra motivation. NLM's sister service, PubMed Central, is beginning to provide some free full texts and will further expand the audience for medical literature.

In our national laboratory survey, we found that 29 percent of the respondents were aware of the Los Alamos National Laboratory arXiv.org (LANL) archive service and 25 percent were aware of the DOE PrePRINT Network. About three-fourths of those aware of LANL had read an average of 7.9 preprints per person from the service in the past year. Approximately one-half of physicists were aware of the LANL services and nearly all of those aware had read preprints from it in the past 12 months. Other fields particularly acquainted with the service included engineering (31% aware) and chemistry (20% aware). Of those familiar with DOE PrePRINT, fewer of them (53%) actually read preprints mentioned by the service. Those who did so reported reading an average of six preprints per person in the last year. Most of these readers were physicists or engineers (Tenopir et al, 2001).

There is, however, an upper limit on how many users need or want access to highly specialized literature on a sustained basis. Even those who might be interested have an upper limit on their time. Also, many of these new users are quite price-sensitive and any fee will deter use. Traditional value-added services, such as peer review, indexing, and abstracting, help readers to find the most valuable articles more quickly and read more high quality articles, more quickly.

Studies of electronic journal use

Several recent studies have observed the use of electronic journals among university scientists. Use of electronic journals varies with field of science, but averages are consistent in these studies, which found that approximately half to nearly 100% of university faculty in the sciences use electronic journals at least some of the time, although a much smaller percent say they prefer electronic over print.

In 2000 Grajek found that about three-quarters (77%) of all library users at Yale University Medical Center used their computer to access electronic journals. Significantly more faculty (96%) than other users reported accessing electronic journals. Grajek's data from previous years' surveys show a steadily rising increase in electronic journal use, from 50% in her 1997 survey to 58% in 1998 and 66% in 1999. Lenares (1999) indicates that 48% of faculty from a sample of ARL institutions used electronic journals in 1998 but 61% said they did so in 1999, with the largest increase in physical sciences (from 60 to 90%). Brown in 1998 found that less than 50% of science faculty at the University of Oklahoma used electronic subscriptions to obtain journal articles and only 23-31% preferred electronic journals over print journals. A nationwide survey of university faculty, researchers and students in the Netherlands established that over one-half used electronic journals and, of those who use the Internet for this purpose, an average of 1.2 journals are consulted regularly (Voorbij). Rogers (2001) observes that over half of the faculty and graduate student respondents to her survey use electronic journals and that acceptance is growing. Nearly two thirds of faculty and students responded that it is "very important" or

"important" for the university library to replace print journal subscriptions with electronic subscriptions, with the primary advantages being availability and ease of use. University librarians report that students much prefer electronic journals and the availability in digital form is one of their most important selection criteria when choosing articles for their schoolwork (Tenopir, 1999 and Tenopir & Read, 2000).

In our recent survey of university medical scientists, 19.5% of all article readings were from electronic sources. In our survey of national laboratory scientists, about 35% of readings were from electronic journals and digital databases. The amount of time spent reading electronic/digital articles was similar to that of paper-based articles (for the national laboratory: 52.2 minutes per article versus 51.4 minutes; for medical: 24.1 for electronic versus 21.9 for print.) Surprisingly, our recent surveys show that identifying and locating electronic resources takes more time than print. In the national laboratory survey, the reported time spent browsing electronic/digital articles was estimated to be 13.3 minutes per reading, compared to 6.5 minutes spent browsing print copies. The time spent obtaining, locating, displaying, and downloading or printing totaled 17.7 minutes per electronic reading versus 8.2 minutes browsing print copies (including locating and photocopying the reading.) In the medical scientists survey, the reported time spent browsing electronic articles was 10.4 minutes per reading, compared to 6.7 spent browsing print copies. The time spent locating, obtaining, downloading, and photocopying/printing was 20.9 minutes versus 10.0 for print.

These studies together provide some emerging patterns of university faculty use of electronic journals:

- Use of electronic journals saw a big jump in the last half of the 1990s and is continuing to escalate. On average, one-half to nearly 100% of scientists in a field use electronic journals at least part of the time.
- Students prefer electronic and will choose an electronic version over print, even if the article is less relevant.
- Preferences and use varies quite a bit with field of science (and past behavior seems to be a good predictor of preferences, such as the historical use of eprints in physics)
- Medical scientists read much more than average. In contrast, engineers read fewer journal articles than average, but spend much more time on each reading.
- Free systems like PubMed can have a big impact on adoption of electronic journals, as they provide awareness of refereed journal articles.
- Peer review is important to many readers as a quality filter and time saver, though probably less so for the most knowledgeable at the top of their careers who recognize important names and quality work.
- For new journals and those journals outside readers' core sources and for current articles, there is more e-reading (so habits are changing).
- Any overall increase in use is bounded by the willingness of users to pay (in actual costs as well as their time) and readers journals that they consider outside their core, are especially price sensitive.

Summary

To summarize our three decades of studies and observations, we have consistently found that the information in journals serves many purposes (research, teaching, current awareness, background reading, etc.) for scientists in both university and non-university settings. These scientists report that journal articles are highly important to their work, more so than any other information resource. Medical scientists rely on journals much more on the average than other scientists, engineers less.

Scientists are willing to pay a high price in their time as they spend many hours reading scientific literature. Many more scientists read than write, although university scientists tend to both read and write more journal articles than do scientists outside the university setting. The convenience of desktop access to journal articles allows all scientists to read more, from a wider variety of sources, although there is an upper limit on the time they can devote to reading. This limit is reached whether the articles carry a fee or are freely available. Finally, the information that scientists get from refereed journals results in improved performance, as evidenced by the awards and accomplishments of scientists who read more.

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