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Electronic Journals and Changes in Scholarly Article Seeking and Reading Patterns

[Carol Tenopir](#), Chancellor's Professor
University of Tennessee
<ctenopir@utk.edu>

[Donald W. King](#), Distinguished Research Professor
University of North Carolina at Chapel Hill
<dwking@unc.edu>

Abstract

A recent article by James Evans in *Science* ([Evans 2008](#)) is being widely discussed in the science and publishing communities. Evans' in-depth research on citations in over 34 million articles and how online availability affects citing patterns, found that the more issues of a journal that are available online, the fewer numbers of articles in that journal are cited. If the journal is available for free online, it is cited even less. Evans attributes this phenomenon to more searching and less browsing (which he feels eliminates marginally relevant articles that may have been found by browsing) and the ability to follow links to see what other authors are citing. He concludes that electronic journals have resulted in a narrowing of scientific citation patterns. This brief article expands on the evidence cited by Evans ([Boyce et al. 2004](#); [Tenopir et al. 2004](#)) based on the authors' ongoing surveys of academic readers of scholarly articles. Reading patterns and citation patterns differ, as faculty read many more articles than they ultimately cite and read for many purposes in addition to research and writing. The number of articles read has steadily increased over the last three decades, so the actual numbers of articles found by browsing has not decreased much, even though the percentage of readings found by searching *has* increased. Readings from library-provided electronic journals has increased substantially, while readings of older articles have recently increased somewhat. Ironically, reading patterns have broadened with electronic journals at the same time citing patterns have narrowed.

Introduction

Over the past four decades (1977 to 2005) the authors have conducted surveys of thousands of scientists including engineers, medical researchers, and social scientists (in addition to other professionals and students). These surveys included two national surveys under National Science Foundation (NSF) contract, and surveys in universities and other settings.¹ All of these surveys applied the same questionnaire (with modest modifications to reflect technological changes) first developed under contract to the National Science Foundation in 1977 ([King et al. 1981](#)). (Examples of the questionnaires can be found at <<http://web.utk.edu/~tenopir/research>>.)

The surveys ask some questions about the scientist-respondents, such as how many articles were read in the past month and demographics, but most questions deal with a "critical incident" of the last article read. Questions about the last article read focus on factors such as the age of the article, time spent reading this article, how the reader became aware of it, where it was obtained, format of the article, purpose of reading, and so on. Trends of the information-seeking and reading patterns of university science faculty over nearly thirty years reveal where reading patterns have potentially broadened or narrowed science.

In a study published in *Science*, [Evans](#) (2008) examined a massive set of over 34 million articles and their citations to track the range of articles and journals cited in scientific articles and to compare changes in citing patterns with the growing availability of e-journals. Ironically, Evans found that there is a negative correlation between online availability of journals and how often they are cited. He attributed this narrowing of science to many things, including a decline in browsing and rise in searching or citation linking (citing [Boyce et al.](#) 2004 and [Tenopir et al.](#) 2004). Perhaps the process of citation linking and relevance ranking based on citation counts provides either a quality filter or a convenient tendency to follow what others have cited, hence resulting in a narrowing of citation patterns of scientists (for further discussion see [Tenopir](#) 2008).

For astrophysicists, this narrowing of citing patterns began even before the widespread availability of e-journals, but it continues today at the same time reading is increasing ([Kurtz et al.](#) 2000, [Kurtz et al.](#) 2005; [Henneken et al.](#) 2008). While citing patterns are clearly narrowing as these recent studies show, a more in-depth look at reading patterns adds to the picture and to the overall question of how electronic journals may be impacting the scientific endeavor. Do citing patterns follow reading patterns, or are they quite distinct? This article provides evidence that reading patterns follow a different path than citing patterns.²

Analysis of Reading

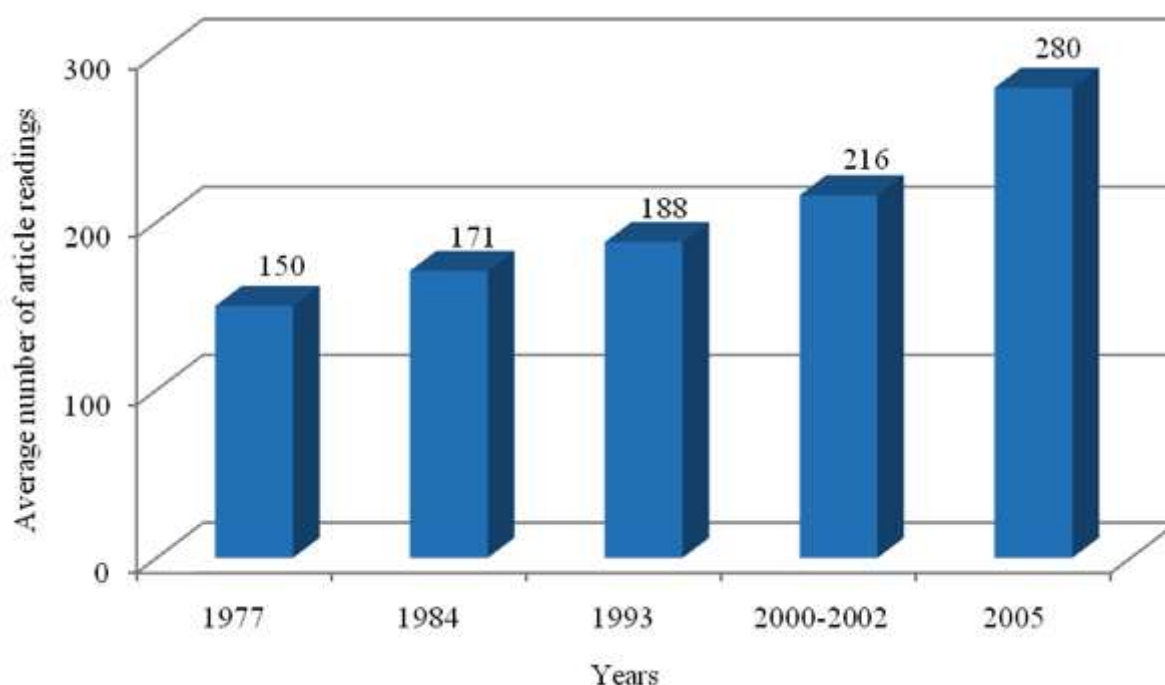
Surveys conducted from 1977 through 2005 show that university science faculty on average:

1. read more in less time per reading,
2. rely less on browsing and more on searching,
3. rely more on library provided articles than from other sources,
4. and, because they make choices based on what helps them get their work done, will readily adapt to new technologies that are convenient to their information-seeking, reading, and work patterns.

Amount of Reading

Since 1977 university science faculty have increased their number of readings in each survey time period observed. Annual average reading is calculated by multiplying the average monthly amount of reading that was reported times 12 to get an average yearly number of readings (see Figure [1](#)). University faculty in 2005 report nearly twice as many readings as they did thirty years ago. Some of this corresponds to the concomitant growth in the number of journals and journal articles, meaning that faculty must read more just to read the same percentage of the literature in their subject discipline ([Tenopir and King](#) 2000).

Figure 1. Average number of article readings per year per U.S. university science faculty member by year of survey



Time Spent Reading

While the average number of article readings per scientist is increasing, the average time spent per reading is declining. In the 2005 surveys, scientists reported spending an average of 31 minutes per reading, down from 48 minutes in 1977. Multiplying the average time spent per reading by the number of article readings shows that the total commitment to reading by U.S. science faculty increases from approximately 120 hours annually in 1977 to 144 hours annually in 2005. It appears that the amount of time available for reading scientific articles may be reaching a maximum capacity.

Information Seeking Patterns

Means of Identifying Articles Read

Science faculty members use many ways to become aware of and locate articles.

For example, they browse through the tables of contents in print or electronic journals, typically for current awareness; they search for information in online search engines, e-journal systems, aggregated full-text databases, and indices to identify new topics or for teaching, research, and writing. Following citation links in print and electronic journals is also employed, as are recommendations from a colleague or some other person. The relative importance of those various means has changed since the 1970s (see Table 1).

**Table 1. How U.S. science faculty learned about articles they last read:
Proportion of reading (%) by year of survey**

Method of Learning about Articles	Survey Year(s)				
	1977 (n=2,350)	1984 (n=865)	1993 (n=70)	2000-03 (n=397)	2005 (n=884)
Browsing	58.5	54.1	56.6	48.7	33.9

Automated Searching	0.7	1.1	9.4	23.7	23.1
Other Searches (e.g., A & I)	10.4	11.0	11.4	3.1	4.9
Citations	6.7	13.1	7.5	11.5	14.9
Persons (e.g., colleagues, authors, etc.)	17.7	15.3	11.3	13.0	18.5
Other	6.0	5.4	3.8	-	4.7
Total	100.0	100.0	100.0	100.0	100.0

As Evans noted, the proportion of reading by U.S. science faculty from browsing decreased in recent years, replaced by other means of learning about articles that are read. While the proportion of readings decreased over the years, however, that number of readings found by browsing remains about the same: 88 readings in 1977 and 95 in 2005. Readings from searches increased from 17 to 78 readings between these two years. In 2005, over half of browsing (58.4% of browsed readings) continue to be from print subscriptions. Searching in 1977 was primarily from A&I publications, Tables-of-Contents and other alerting tools, and by other means. Most searching in 2005 was from electronic sources (92.6% of readings from searching), although some searching continues from A&I print publications (1.9% of readings from searching).

Sources of Articles Read

The average number of personal subscriptions reported in surveys of scientists in non-university settings has decreased steadily over time, from six in 1977 to under three personal subscriptions on average per scientist by 2003. For U.S. university science faculty, the average number of personal subscriptions has remained about the same: 4.2 subscriptions per scientist in 1977 and 4.1 in 2005.

The proportion of readings by university scientists that come from personal subscriptions has steadily declined, at a much steeper rate than the decline in number of personal subscriptions. Readings from library collections in particular have made up for the decline in reading from personal subscriptions, followed by readings from other sources such as web sites and separate articles from colleagues. The changes in proportion of article readings from personal subscriptions, library provided sources, and other sources are shown in Table 2.

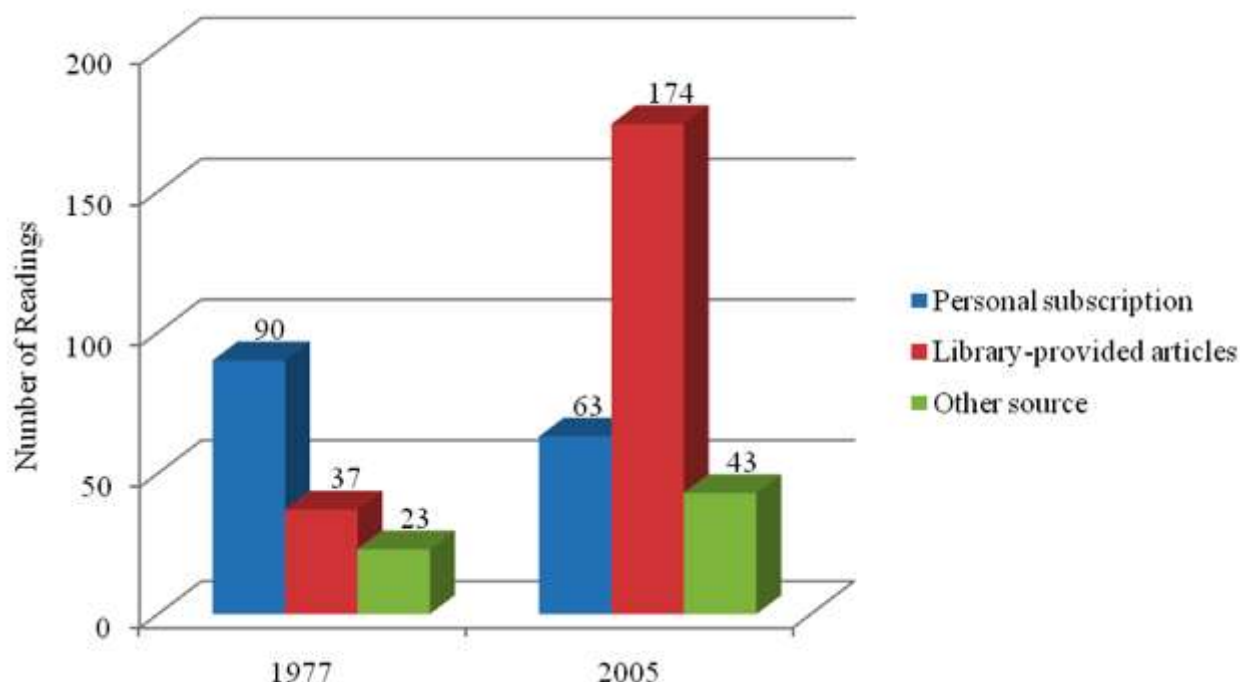
Table 2. Sources used by U.S. science faculty to obtain article they last read.
Proportion of readings (%) by years of survey

Source of Article	Survey Year				
	1977 (n=2,350)	1984 (n=865)	1993 (n=70)	2000-03 (n=397)	2005 (n=924)
Personal subscriptions	60.0	53.0	35.5	38.6	22.6
Library-provided articles	24.8	30.1	53.8	43.6	62.0
Other	15.2	16.9	10.7	17.8	15.4
Total	100.0	100.0	100.0	100.0	100.0

Library-provided articles include those obtained from library collections or school or department collections (often supported from the main library) and from interlibrary loan or document delivery. "Other sources" in 2005 include article copies obtained from a colleague, author, etc., preprints or reprints, or from an author or other website. In 1977, "other sources" were largely reprints, preprints and photocopies provided by authors or publishers.

Library-provided articles are replacing personal subscriptions as a source for articles. The picture is even clearer when comparing the number of readings in 1977 and 2005 (Figure 2).

Figure 2. Sources used by U.S. science faculty to obtain article they last read by number of readings in 1977 and 2005



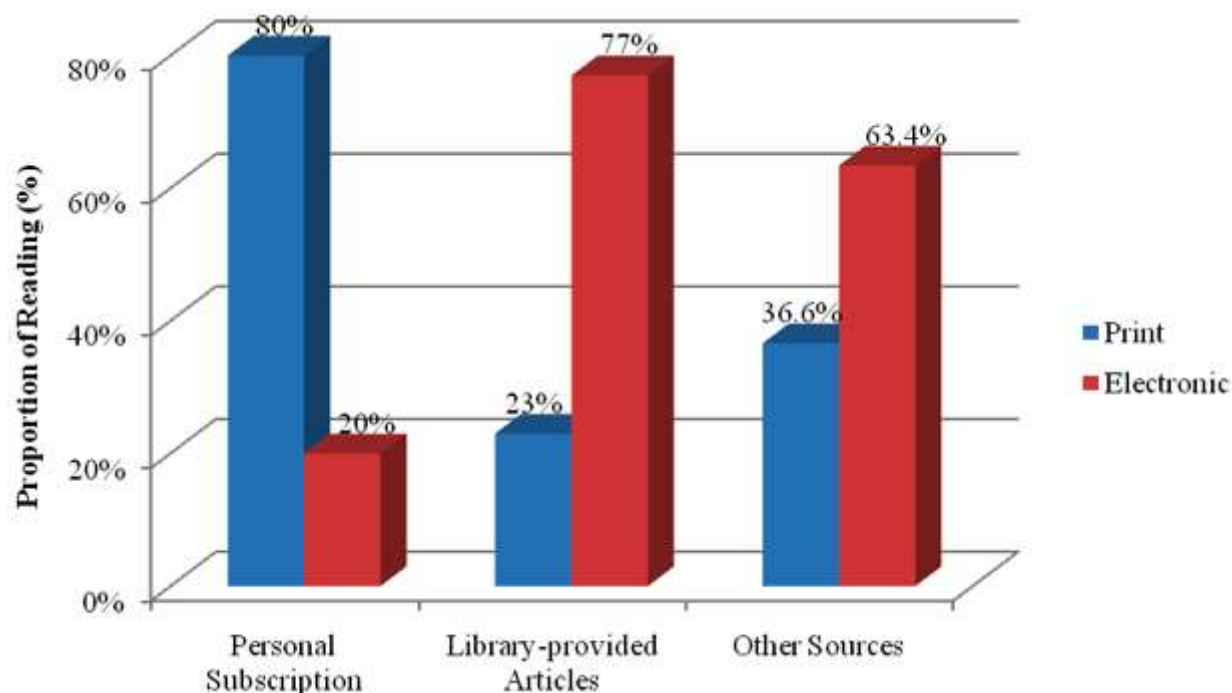
The number of readings increased by an estimated 130 readings per scientist from 1977 to 2005. The "other sources" increased by about 20 readings (from 23 to 43), which might be attributable to open access initiatives since the current 43 readings are 11 from preprints; 19 copies provided by authors, colleagues, etc.; 4 from an author website and 2 from other websites (plus 7 from an unspecified source). Reading from personal subscriptions decreased about 27 readings per faculty scientist. Some of the decrease represents a drop in personal subscriptions, but most is attributable to less reading per subscription (i.e., about 21 readings per subscription in 1977 to 15 in 2005). Most remarkable is that readings from library-provided articles increased by 137 readings, which is comparable to the net increase in readings overall (130 readings). Much of this increase is due to electronic journal or aggregation collections in libraries.

In 1977 university scientists read on average at least one article from about 13 journal titles. In 2005 at least one article was read from 33 different journal titles. This increase is due in part to the availability of more journal titles in library electronic collections, but it is also because there are more access points available to obtain separate copies of articles such as author websites and preprint databases (i.e., about 43 readings in 2005 compared with 23 in 1977). Reading patterns are highly skewed; some of these specific sources are used infrequently, thus expanding the number of sources used at least once.

Over half of readings in 2005 are from electronic sources (59.5% vs. 40.5% from print sources). However, as shown in Figure 3, personal subscription readings frequently continue to be from

print issues. On the other hand, most library-provided articles and other sources are read from electronic versions.

Figure 3. Format of articles read by U.S. science faculty in 2005 by format of sources (n=923)



Purpose of Reading

The most frequent principal purpose of reading is research (48.5% of readings), followed by teaching (22.5%), writing (articles, reports, proposals, etc. – 10.8%), and current awareness/keeping up (8.0%). Those articles read for research or writing are most likely to be cited now or in the future, so over one-third of readings are not likely to be read for purposes that would involve citing. Whatever the purpose of reading, articles are important to that purpose – about 37.8% of readings are said to be "absolutely essential" in achieving the principal purpose of reading the last article.

Age of Article Readings

Evans found that the age of articles cited is shortening, that is older articles are being cited less frequently. Reading patterns appear to differ from citing patterns in respect to age of articles. Table 3 provides evidence of age of reading by university scientists working in non-university settings and scientists in surveys in which location is not established. Results do not suggest a shortening of the age of articles read for these three sets of surveys conducted over the years.³

Table 3. Age of articles read by U.S. Scientists by year(s) of observation. Proportion of reading (%) by age.

Type of scientists	Year(s) of observation	Sample Size	Age of Article (%)					
			1 st Year	2 nd Year	3 to 5 Years	6 to 10 Years	11 - 15 Years	Over 15 Years
University	1993 [2,3]	70	58.5	12.3	13.9	9.3	1.5	4.6

	2000-03 [4]	327	64.7	10.3	11.6	6.2	3.2	4.0
	2005 [5]	920	55.6	14.2	15.3	7.8	3.1	4.0
Non-University	1984-96 [6]	982	69.4	13.6	9.5	4.8	1.1	1.7
	1993-98 [3]	792	66.9	15.1	6.9	2.9	2.9	5.2
	2000 [7]	76	71.0	9.0	10.0	4.0	2.0	3.0
Both	1960 [8]	Unknown	61.5	13.3	11.0	10.2	1.7	2.3
	1977 [1]	2,350	67.2	14.3	10.8	4.0	1.6	2.0
	1993-98 [3]	862	63.2	14.5	8.3	4.2	2.6	5.1
	2002 [9]	506	63.8	9.9	13.3	3.8	2.8	4.5

- [1] [\[King et al. 1981\]](#)
[2] [\[Belefant-Miller and King 2001\]](#)
[3] [\[Tenopir and King 2000\]](#)
[4] [\[King et al. 2003\]](#)
[5] [\[Tenopir et al. 2005\]](#)
[6] [\[Griffiths and King 1993\]](#)
[7] [\[Tenopir and King 2002\]](#)
[8] [\[Case Institute of Technology 1960\]](#)
[9] [\[Tenopir et al. 2005\]](#)

The university surveys show some variability in reading articles the past year after publication, but not in those over 15 years after publication. It should be noted that the survey in 1993 included only 70 respondents who were scientists, and in 2005 the proportion of readings within the first year of publication by faculty at the University of Tennessee was on average greater than those at the four universities in Ohio that are served by the OhioLink consortium.

In 2005 university faculty were asked: "Did you cite this article or do you plan to cite it in a paper or report?" The articles cited or intended to be cited tend to be older than other articles read by this group of scientists (see Table [4](#).)

Table 4. Age of articles cited or intended to be cited by university scientists compared with other articles read in 2005 (n=857)

Year Published	Article "Cited"	Other Articles
2005	45.2%	54.8%
2004	17.4%	10.6%
2001-03	22.3%	14.6%
1996-2000	7.7%	8.7%

Prior to 1996

9.1%

6.9%

Keeping in mind that the citations may be for non-article publications, these self-reported results from reading do not suggest that age patterns of citations are changing over time. Since reading of older articles is increasing slightly, perhaps the perceptions of citing reported here differ from the reality of citing observed by Evans.

In the late 1970s, under NSF contract, a large random sample of articles was examined as part of a journal tracking study of journal and article attributes ([King et al. 1981](#)). (The articles were also used to survey authors). One observation was the average age of citations varied considerably for nine fields of science designated by NSF at that time (Table 5). The half-life of articles cited also varied by the field of science. These data may serve as evidence to compare age of articles cited in the 1970s or earlier with articles cited more recently.

Table 5. Average age of articles cited by U.S. scientist in 1977 and half-life of articles cited by field of science

Average age of articles cited		Half-life of articles cited	
Field	Age	Field/Discipline	Age
Physical science	9.7	Physics	4.6
Mathematics	15.0	Chemistry	8.1
Computer sciences	5.9	Mathematics	10.5
Environmental science	8.8	Geology	11.8
Engineering	7.4	Chemical engineering	4.8
Life science	11.2	Mechanical engineering	5.2
Psychology	10.4	Metallurgy	3.9
Social sciences	11.9	Physiology	7.2
Other sciences	12.2	Botany	10.0
All sciences	10.8		

Information-seeking Patterns by Age of Articles Read

Readings of older articles are different from more current readings in several respects, including method of finding out about the reading, source of the reading, and format of reading. Age of articles has a bearing on how they are identified and where they are obtained as shown in Tables 6 and 7 below.

Table 6. How U.S. science faculty in 2005 became aware of articles by age of article read (n=835)

How Readers Became Aware of Articles (%)					
Year	Browsing	Searching	Citation	Another	Total

Published				Person	
2005	52.6	20.4	7.8	19.2	100
2004	24.6	37.3	16.9	21.2	100
2001-03	21.3	39.4	19.4	20.0	100
1996-2000	15.5	39.4	25.4	19.7	100
Prior to 1996	3.1	32.8	46.9	17.2	100

Articles published in 2005 (prior to October/November when the surveys were done) were largely identified through browsing (52.6%), but as the articles became older, readers more frequently became aware of them by other means. Articles published prior to 1996 were mostly identified through citations (46.9%) and searching (32.8%).

Articles published in 2005 were most often provided by libraries (46.7% of readings of these articles), but libraries become increasingly prominent as a source as age increases (prior to 1996 69.0% of readings are provided by libraries) while reading from personal subscriptions diminish from 33.3% in 2005 to 8.5% prior to 1996. The proportion of reading from other sources (i.e., copies from authors, colleagues, etc., free web journals, preprint copies, etc.) remains about the same regardless of age (Table 8).

Table 7. Source of articles by the age of article read by U.S. science faculty in 2005 (n=913)

Year Published	Source of Last Read Article (%)			Total
	Personal Subscription	Library-Provided	Other	
2005	33.3	46.7	20.0	100
2004	13.4	68.5	18.1	100
2001-03	13.3	64.5	22.3	100
1996-2000	6.8	73.0	20.3	100
Prior to 1996	8.5	69.0	22.5	100

An important issue is how much impact retrospective conversion to electronic format has had on information seeking. The format of the source for the last article reading also varies by age, with the most recent and the oldest articles more likely to be from print journals than other readings (Table 8.)

Table 8. Format of articles read by U.S. science faculty in 2005 by the age of articles (n=911)

Year Published	Format of Last Read Article (%)		Total
	Print	Electronic	

2005	46.3	53.7	100
2004	29.1	70.9	100
2001-03	33.3	66.7	100
1996-2000	31.5	68.5	100
Prior to 1996	49.3	50.7	100

While reading of print and electronic versions are roughly equal for articles published in 2005, over the next nine years (1996 to 2004) electronic versions are much more often read. Prior to 1996 reading tends to revert somewhat to print, probably reflecting lower availability of electronic versions beyond that time. This likely will change as more backfiles of articles are digitized.

Conclusions

The advent of digital technologies on searching and publishing over the past three decades has had a dramatic impact on information seeking and reading patterns in science. Evidence from surveys conducted with U.S. science faculty show that:

- Scientists have substantially increased their number of readings.⁴
- Most additional readings are from:
 - Searching (as opposed to browsing) and citations
 - Library-provided articles.
- Scientists read from a much broader range of sources of articles due to:
 - access to enlarged library electronic collections
 - online searching capabilities
 - access to other new sources such as author websites.
- Age of articles read appears to be fairly stable over the years, with a recent increase in reading of older articles.
- Electronic technologies have enhanced access to older articles, demonstrated as follows:
 - nearly 80% of articles over ten years old are found by online searching or from citation (linkages)
 - nearly 70% of articles over ten years old are provided by libraries (mostly electronic collections)
 - articles over ten years old are obtained about equally from print and electronic articles, although the trend in age appears to increase in electronic format and then decrease around ten years old.

Scientists clearly have vastly improved capabilities and resources available to them for identifying and obtaining the articles they read. Such capabilities and resources should result in finding and obtaining articles that better meet scientists' information needs.

While citing patterns may be narrowing, reading patterns are not. This is due to several differences between why scientists read and why they cite articles.

- Reading is done for many purposes: current awareness, teaching, and administrative in addition to research and writing. Only those readings for research and writing are cited.
- Scientists read many articles for every one that they cite. Choosing the best article to cite may be subject to peer pressure in the form of choosing more often to cite those that are cited by others. Following citation links in electronic journal articles may have proportionately more influence on citation behavior than reading behavior.

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Notes

1. Universities specifically surveyed prior to 2005 include University of Tennessee, University of Pittsburgh, and Drexel University. Universities surveyed in October/November 2005 include University of Tennessee and Case-Western Reserve, University of Akron, Ashland University, and Malone University (all located in Ohio). Surveys in other settings include companies such as AT&T Bell Laboratories, Air Products and Chemicals, Inc., Baxter Healthcare, Bristol-Myers Squibb, Colgate-Palmolive Co., Dupont, Eastman Chemicals Co., Eastman Kodak Co., and Johnson & Johnson (2 divisions); three energy companies, seven government agencies (e.g., National Institutes of Health, National Oceanographic and Atmospheric Administration, Department of Labor) and three Federal labs (Oak Ridge National Labs, Rockwell International and Rocky Flats).

2. More details on reading patterns and changes over time are forthcoming in "Electronic Journals And Changes in Scholarly Article Seeking and Reading Patterns" , [Carol Tenopir, Donald W. King, Sheri Edwards, and Lei Wu](#). *Aslib Proceedings*, 2009. Some of the figures also appear in this article.

3. The "year published" in 2005 represents an age of up to 10 to 11 months, since the survey was conducted in October and November 2005. The ages given in Table 3 were established by interpolating age on a log-normal scale, since each survey was done at different times in a year.

4. Number of readings do not equate to number of articles read, because an article may be read many times with each time being counted as a reading.

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