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TEXT TO REFERENCE RATIOS IN SCIENTIFIC JOURNALS

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Abstract

In 1987, Peter Jumars, the editor of *Limnology and Oceanography*, reported that the ratio of printed pages of text to number of references had decreased during the period 1980 to 1987. In other words, authors were using an increasing number of references - an observation which was of some concern because *Limnology and Oceanography* publishes only a fixed number of pages per year. In the present study, an attempt was made to determine whether journals from other scientific disciplines (botany, physical chemistry, and geology) were undergoing a similar change in the ratio of text to references. SCISEARCH, the online version of *Science Citation Index*, was used to obtain a random sample of 900 articles from 30 journals. Contrary to Jumars' findings, no significant changes were observed between 1980 and 1987 in the ratio of text to references. However, overall article length did increase over the period studied.

It is well known that today's society is in the midst of an information explosion [1]. In 1980, it was observed that "the increase (in information) has been so exponential that we have been able to generate more printed information in the past 10 years than in mankind's complete history" [2]. In spite of this, until the early 1980's library budgets were generally able to keep pace with inflation and with the steady growth in size and number of research journals [3]. However, with the onset of the recession, budgets were cut an buying power was reduced. As a result, collections in many libraries have been reevaluated and periodicals cancelled.

In response to these trends, publishers of journals have become "much more cautious, and, wary of losing subscriptions... have often restricted page budgets to keep costs down" [3]. In fact, in many fields there is now "an economic limit on the total number of pages available to scientists" even though the number of manuscripts submitted is increasing.

At the same time that the availability of journal space is being curtailed, there may be a growing tendency for authors to include longer bibliographies in their papers. For instance, in a study of 21 psychology journals, Xhignesse and Osgood found a 69 % growth in the volume of citations over the decade 1950-1960 [4]. More recently, Cronin observed a 68 % increase in the mean number of citations per paper in the *Journal of Educational Psychology* over the years 1960-1970, and a 72.7 % increase for the period 1970-1979 [5]. These data suggest that, in at least one of the social science disciplines, an increasing amount of journal space may be taken up with citations.

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A similar observation has been made in the natural sciences. The editor of *Limnology and Oceanography* reported that, while the ratio of printed pages of text to printed pages of references was 10:1 in 1980, by 1987 it had decreased to 8:1 [6]. Because this journal has a restricted page budget, Jumars (the editor) urged authors to limit the citations in their manuscripts "to review papers and essential references written after those reviews". He claimed that if authors limited themselves to fifteen reference citations per ten pages of typescript the journal's rejection rate could be lowered from 60 % to 58 %.

It is not clear whether a similar trend is occurring in other scientific journals because, with the exception of Jumar's observations, no data have been collected. It seems reasonable to expect an increase in citations given the increasing ease with which scientists have access to information through automated indexing and abstracting services. In 1986 there were over 2000 of these services in science and technology, many of which are available online. In fact, the number of online databases has increased by more than 600 percent since 1979 [2].

To test the generalizability of Jumars' findings, journals from botany, physical chemistry and geology were examined to determine whether a similar decrease in the ratio of text to references would be observed. Comparisons of text/reference ratios were made between random samples of articles published in 1980 and 1987.

METHOD

SAMPLING

Sixty journals were randomly selected from the lists of botany, physical chemistry and geology journals printed in the *SCI Science Citation Index 1987 Annual : Guide and Lists of Source Publications*. From these, ten journals from each discipline were selected based on : (i) availability (the journals had to be available for inspection at local university libraries), (ii) coverage by SCISEARCH (each journal had be indexed by SCISEARCH in both 1980 and 1987) and (iii) size (the journals had to contain at least fifteen articles in both 1980 and 1987).

Using the Journal Name Index in SCISEARCH (the online version of *Science Citation Index*), fifteen articles were randomly selected in 1980 and in 1987 from each of the thirty selected journals for a total sample of 900 articles. Journal articles in SCISEARCH are those NOT indexed under a specific document type. In other words, bibliographies, review articles, book reviews, brief communications, and letters were excluded from the sample.

DATA COLLECTION

For each journal included in the sample a record was made of the type of publisher (commercial press, society, or government agency). In addition, for both years studied, the number of words on a full page of text was estimated for each journal. The estimated number of words per page from each year was averaged to produce a conversion factor which was used to normalize the length of each article into the number of words per article. This was necessary because of the different page formats used in the journals (they varied in size, type style, and number of columns of text per page).

For each article included in the sample the number of pages and references were recorded, as was the number of collaborating authors (single or multiple).

DATA ANALYSIS

Analysis of variance (ANOVA) tests were used to determine if there were differences in text/reference ratios between : (i) years (1980 and 1987), (ii) disciplines (botany, physical chemistry, and geology), (iii) journals, and (iv) publishers (commercial, society and government). When significant F values were obtained, post hoc comparisons of cell means were made using the Tukey HSD test, $p < .05$. Where Hartley F Max tests revealed that the variances in the samples were large, that is, when the assumption of homogeneity of variance was violated, the non-parametric Kruskal-Wallis H test was used to verify ANOVA results.

RESULTS

YEAR OF PUBLICATION

The mean number of references cited per article increased significantly (by 18 %) between 1980 ($\bar{x}$ = 26, s.d. = 17) and 1987 ($\bar{x}$ = 31, s.d. = 21), F (1.898) = 12.76, $p < .001$. At the same time, the length of articles also increased significantly (by 12 %) between 1980 ($\bar{x}$ = 6928 words per article, s.d. = 4687) and 1987 ($\bar{x}$ = 7761, s.d. = 4846), F (1.898) = 6.87, p = .009.

Contrary to what might have been expected given Jumars' observations [4], the text/reference ratio, that is, the ratio of words per article to number of references, did not change significantly between 1980 ($\bar{x}$ = 393, s.d. = 858) and 1987 ($\bar{x}$ = 385, s.d. = 884), F (1.898) = .02, p = .89. In other words, the authors in this sample made proportionately the same number of citations to pages of text in 1987 as they did in 1980.

SCIENTIFIC DISCIPLINE

A significant difference was observed in the text/reference ratio accross disciplines, F (2.897) = 11.01, $p < .001$; H = 15.57, $p < .05$. Although caution should be used in interpreting these results given the uneven variances in the samples, Tukey's HSD test suggests that the mean text/reference ratio was significantly higher in geology ($\bar{x}$ = 579, s.d. = 1462) (indicating that fewer references were used) than in botany ($\bar{x}$ = 285, s.d. = 171) and physical chemistry ($\bar{x}$ = 302, s.d. = 241). That is, the geologists used fewer references per page of text than did the scientists from other disciplines.

JOURNALS

As can be seen in Table 1, the mean number of references cited per article ranged greatly accross the journals. The lowest number cited was in the physical chemistry journal, *Applications of Surface Science* (the overall mean over the two years studied was 19 references per article), while the highest was in the geology journal, the *Journal of Petrology* ($\bar{x}$ = 59).

The analysis of variance and the Kruskal-Wallis H tests indicated significant differences in the journals' mean text/reference ratios, F (29.870) = 11.92, $p < .001$, H = 175.0, $p < .05$. The HSD test revealed that the mean text/reference ratio in the geology journal, *AAPG Bulletin*, was significantly higher than in any other journal (the *Bulletin* contained several articles in which the authors cited no references at all). Otherwise, as can be seen in Figure 1, there was a great deal of consistency in the mean text/reference ratios accross the journals, most of which ranged between 200 and 300.

Table 1 : The mean number of references per article per journal in three disciplines

	Discipline	Mean
	Botany	
1.	Australian Journal of Botany	24
2.	Israel Journal of Botany	26
3.	Review of Palaeobotany & Palynology	40
4.	Soviet Plant Physiology	25
5.	Physiologia Plantarum	23
6.	Environmental and Experimental Botany	22
7.	Journal of Experimental Botany	23
8.	Zeitschrift für Pflanzenphysiologie continued by Journal of Plant Physiology	24
9.	Annals of Botany	21
10.	Planta	27
	Physical Chemistry	
11.	Journal of Colloid and Interface Science	23
12.	Journal of Photochemistry continued by Journal of Photochemistry & Photobiology A - Chemistry	20
13.	Journal of Physical Chemistry	28
14.	Theoretica Chimica Acta	29
15.	Surface Science	29
16.	Applications of Surface Science	19
17.	Biophysical Chemistry	26
18.	Journal of the Chemical Society - Faraday Transactions I + II	21
19.	Journal of Molecular Structure	23
20.	International Journal of Quantum Chemistry	23
	Geology	
21.	Economic Geology	41
22.	Geological Society of America Bulletin	45
23.	Chemistry Geology	30
24.	Sedimentary Geology	40
25.	Journal of Petrology	59
26.	Lithos	42
27.	American Mineralogist	22
28.	New Zealand Journal of Geology	20
29.	AAPG Bulletin - American Association of Petroleum Geologists	25
30.	Scottish Journal of Geology	27

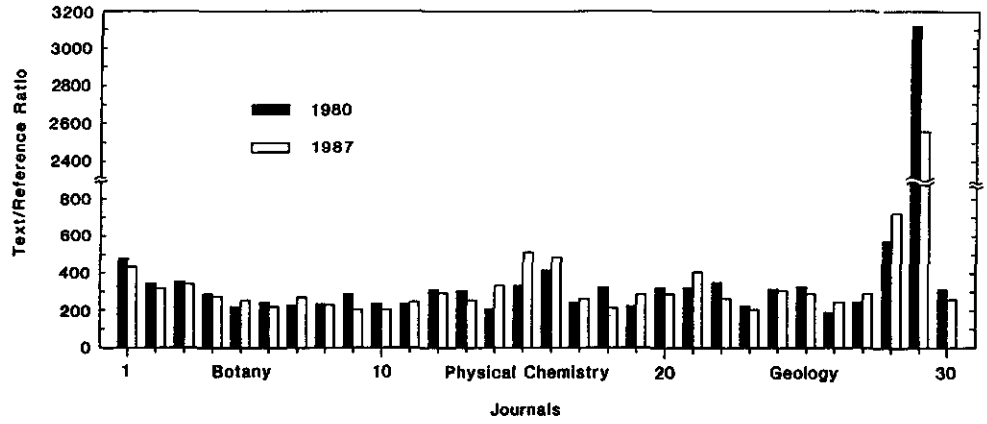

Fig.1 : The mean text (words per article)/reference ratio in three disciplines (10 journals/discipline) for 1980 and 1987.

TYPE OF PUBLISHER

Sixty-three percent of the articles sampled were in journals published by commercial presses, 30 % by societies, and 7 % by government agencies. The mean text/reference ratio differed significantly by type of publisher, F (2,897) = 10.51, $p < .001$; $H = 52.55$, $p < .05$. The commercial publishers ($\bar{x} = 289$) had a significantly smaller mean text/reference ratio than either the societies ($\bar{x} = 564$) or government agencies ($\bar{x} = 553$). These results indicate that there were more references per words of text in articles produced in commercially published journals than in those produced by societies or government publishers.

SINGLE VERSUS MULTIPLE AUTHORSHIP

The majority of the articles sampled (74 %) were written by more than one author. These papers were significantly shorter ($\bar{x} = 7115$ words per article) than those written by single authors ($\bar{x} = 8000$ words per article), t (374) = 2.33, $p < .05$. However, although they wrote longer papers, the single authors made the same number of citations (on a words per article basis) as those who co-authored articles. That is, there was no significant difference between the mean text/reference ratios of single and multiple-authored papers.

DISCUSSION

The results of this study revealed that the number of references per article increased in scientific journals between 1980 and 1987. However, while the number of citations increased, the total number of words per article also increased with the result that the ratio of text to references did not change significantly between 1980 and 1987. Thus, Jumars' observations about the journal of *Limnology and Oceanography* are not generalizable to journals in the fields of botany, geology, and physical chemistry.

The overall increase in the length of articles indicates changes in the writing patterns of scientists more complex than Jumars' suggestion that authors are simply using word processing technology to dump "peripherally relevant references into manuscripts" [6]. This increase is surprising given the limited page budgets of many journals and the various strategies used by

publishers to restrict article length. It is also curious that articles from commercial publishers had a lower text to reference ratio than articles published by societies of government agencies. Are the societies and government publishers more aware of this phenomenon than the commercial publishers and t:erefore restricting references or are the commercial publishers simply more concerned than others with the need to support arguments in scientific articles with references?

In the "Instructions to Authors" sections of many of the journals examined in this study, article length limits were suggested. For example, in the *Journal of Experimental Botany* authors are requested to submit manuscripts that do not exceed 5000 words, including figures. In some cases, such as in the journal *Physiologia Plantarum*, authors are billed for the printing costs of articles that exceed six printed pages. 'Voluntary' page charges are common in geology journals (as high as $125.00 per page in the *Geological Society of America Bulletin*). Despite these attempts to restrain verbose authors, in none of the journals examined did editors mention limits as to the numbers or types of references (such as review articles) that should be cited.

It is clear from the results of this study that the problem of inadequate scientific journal space (if it really is a problem) has not resulted in a decrease in the length of published articles (at least in the discipline of geology, botany and physical chemistry). Furthermore, it seems that curtailing article length is not simply a matter of curbing the tendency to use very-increasing lists of references, but may involve persuading authors, as well as editors and reviewers, that shorter papers are desirable.

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