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Assessing the Publication Productivity and Impact of Eminent Geoscientists

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Publication is a critical component of modern science. By publishing their findings, scientists can ensure that their results are disseminated and substantiated. This brief report analyzes the publication and citation histories of American Geophysical Union (AGU) Fellows to elucidate different styles of productivity in the geoscience community. AGU Fellows are arguably the most eminent Earth scientists, recognized by their peers for their leadership within and outside the community.

The general rule of “publish or perish” underrates the importance of impact. Citations matter. Eminent scientists from all disciplines are more likely to have a handful of highly cited publications than to have a high number of publications [Cole and Cole, 1973]. Nobel Prize winners’ groundbreaking research papers are usually highly cited and cited for far longer than the average paper [Zuckerman, 1977]. Citations are strongly correlated with other reputation-based measures of scientific quality, such as honorific awards and peer evaluations [see, e.g., Cole and Cole, 1973; Cole, 1979, 2000].

Citations can be misleading if they are interpreted as an absolute measure of quality or impact. The number of citations a publication accrues is the result of a combination of factors, such as the quality of work, the scientist’s visibility, his or her integration into scientific networks, the size of the citation community, and the journal’s standing and accessibility [e.g., Creamer, 1998; Zuckerman et al., 1991]. Papers may be referenced without being read, or they may be cited for minor technical details, ancillary to the paper’s central findings [Latour, 1987]. Self-citations can also dilute the numbers, although a study of 4816 journals found that the average self-citation rate (self-citations as a proportion of total citations) was 12.4% with a median of 9.0% [Thomson Scientific, 2004]. A paper with a controversial finding can garner a high number of citations in the form of negative references; however, research has shown that the frequency of negative citations is actually relatively low, especially in the natural sciences [Small, 1982; Hagens, 2000; White, 2000].

In an effort to evaluate criteria for success in the geosciences, we analyzed the citation and publication history of a ran-

dom sample of 115 AGU Fellows. The data were collected between May 2005 and March 2006. AGU reports a membership of 48,000 scientists from around the world. According to the AGU Web site, there are more than 900 Fellows, of which fewer than 10% are women. Our sample group was composed of 69 men and 46 women. The overrepresentation of women was a deliberate effort to compile numbers that were significant enough to evaluate gender differences. The Fellows ranged in age from 15 to 48 years post-Ph.D. We built our publication and citation data set from the Institute for Scientific Information (ISI) Science Citation Index. To avoid penalizing those members who publish in publications that are not indexed by the ISI (e.g., book chapters), we used the “cited reference search” (which captures citations to book chapters and non-ISI-indexed journals) rather than the “general search.”

The average AGU Fellow from our sample is 28 years post-Ph.D., has four cited publications per year, and receives 35 citations per publication (Table 1), although there is a great deal of variance in the sample. No statistically significant gender differences in productivity were observed. Similarly, productivity did not vary according to subfield (e.g., seismology, planetary science, ocean sciences, etc.). The total number of publications and citations increases with age, but the number of citations per publication is not dependent on the age of the Fellow.

To examine different publication patterns among the Fellows, we applied a method for classifying different types of scholars developed by Cole and Cole [1973]. Their analysis of a random sample of 499 scientists suggested that scholars can be classified into

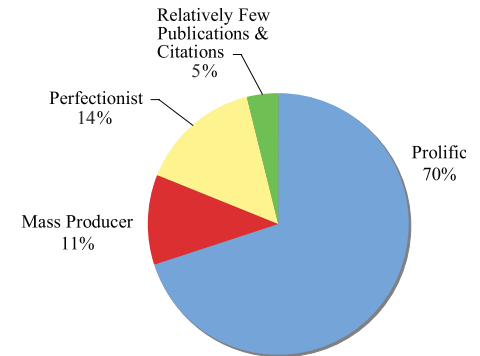


Fig. 1 AGU Fellows: different types of scholars.

four categories based on citation and publication patterns. Prolific scientists publish often and are highly cited. Mass producers publish often, but they are not cited as highly as prolific scientists. Perfectionists do not publish often, but the papers they do publish are highly cited. Silent scientists do not publish often, and when they do, their publications do not garner a significant amount of citations.

We applied this framework to the AGU Fellow sample to assess how standardized measures of productivity and quality characterize individuals considered eminent by the geoscience community (Table 2). We used a threshold of three or more cited publications per year as the benchmark of a high publication rate and a threshold of 21 citations per publication as the benchmark of a high citation rate.

These thresholds are consistent with other indicators and accepted standards. National averages of scientific publication output range from two to three publications per year per scholar [Xie and Shauman, 2003]. The citation threshold reflects a publication analysis produced by the University of Texas Institute for Geophysics that found an average of 16–25 citations per publication for all publications authored by scientists at the Institute [Frohlich and Resler, 2001].

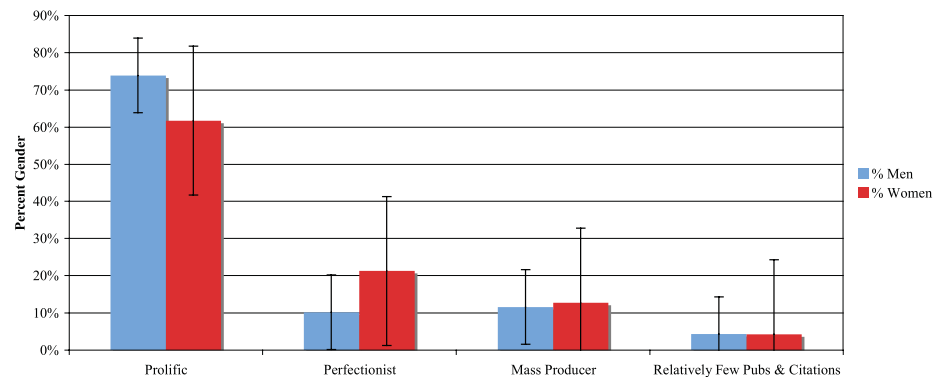


Fig. 2. AGU Fellows: gender differences among different types of scholars ($N = 115$).

Using these thresholds, the AGU Fellows can be seen to reflect all four types of scholarship identified by *Cole and Cole* [1973] (Figure 1).

The distribution of scholarship types is clear. More than two thirds of the sample has followed the “prolific” path to success with a high number of both publications and citations. This is not the only path to success, however. Nearly one third of the sample has pursued alternative paths by either “mass producing” without receiving a high number of citations or “perfecting” by publishing a small number of high-impact papers. Only 5% of the sample had relatively few publications and citations; many of these scholars have made significant contributions outside of publishing, for example, in institutional administration, national and international committee leadership, and private-sector consulting.

None of the gender differences in publication and citation rates was statistically significant, due to considerable intragender variation (Figure 2). However, the trends in the distribution are consistent with findings from other studies of research productivity, with more men tending to be “prolific” publishers and more women tending to be “perfectionists.” On the basis of the interviews with more than 200 scientists, *Sonnert* [1995, p. 152] found that women are “more cautious and careful in their methods and pay more attention to detail.” He added that numerous women in his interview sample “acknowledged a tendency to be perfectionists in their scientific work.” *Valian* [1998, p. 275] also suggested that women demonstrate perfectionist tendencies to avoid rejection.

Publishing three or more papers per year that accrue, on average, more than 20 citations per paper can be considered a general indicator that a geoscientist is on a path to eminence. In terms of promotion, tenure, and selection for honors, though, it is important to recognize that while publications and citations are important, there are diverse approaches to advancing research and these approaches may vary by gender.

Table 1. AGU Fellows: Publication and Citation Indicators

	Mean	Median	Standard Deviation
Years since Ph.D.	28.1	28.0	7.7
Citations per publication	34.9	30.4	16.3
Publications (cited) per year	4.0	3.4	2.0

Table 2. Classifying Different Types of Scholars in the Geosciences

Number of Publications (Productivity)	Number of Citations (“Quality” or “Impact”)	
	High (21 or More Citations per Publication)	Low (20 or Fewer Citations per Publication)
High (three or more publications per year)	type I: prolific	type II: mass producers
Low (two or fewer publications per year)	type III: perfectionists	type IV: other contributions

Modified from *Cole and Cole* [1973].

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