Part 1. Current Contents (20):7-17, 14 May 1990.

The Use of Publication Studies to Affect Policies and Attitudes in Astronomy. Part 1

Back to Introduction

Helmut A. Abt
Kitt Peak National Observatory
National Optical Astronomy Observatories
Box 26732
Tucson, AZ 85726

In the series of studies summarized here and in Part 2 to be published next week, we used counts of papers, citations to them, paper lengths, numbers of authors, their affiliations, and other data obtained mostly by scanning large numbers of papers, all for the purpose of exploring commonly held ideas about science. This is applied to astronomy. These facts challenge impressions that people have about such things as a scientist's most productive years, the partiality of peer reviews, the tendency for Americans to ignore foreign papers, the effectiveness of telescopes of various sizes, and many others.

In any science or field of study, there are widely held beliefs that influence policies but that, surprisingly, have never been tested for validity. Examples in the field of astronomy are (1) an astronomer does his best work before the age of 35; (2) of course, papers by well-known astronomers receive preferred and rapid treatment in peer-reviewed journals; (3) Americans tend to ignore papers published in foreign journals while foreigners carefully reference American papers; (4) the best astronomy is done with the largest telescopes while small telescopes are used mostly to train students; and (5) the freedom in a university leads to more basic and significant research than in government-funded centers.

Are these statements true?

I have wondered upon hearing some of these statements expressed whether they are valid and how one can test their validity. This has led to a series of studies (15 to date) based on publication rates, citation counts, paper lengths, affiliations of authors, and other information obtained simply by scanning statistically large samples of papers.

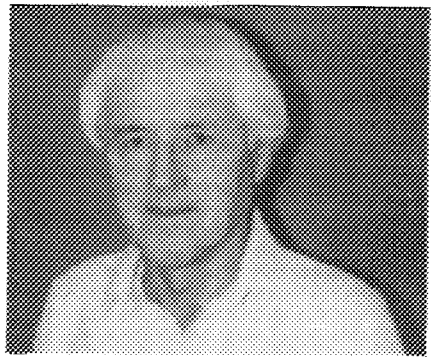
I wanted the results to be read by astronomers, even more so than by sociologists and information scientists, so they were printed (in 1980-1990) in the *Publications of the Astronomical Society of the Pacific*, a monthly journal read by many astronomers but few other people outside that field. However, some of the questions explored, and possibly the answers, are applicable to other sciences, so in this summary of these studies, I am writing to a wider audience.

Ages of Astronomers When They Did Their Most-Cited Research

Although we know of brilliant mathematicians and scientists who "burned out" at an early age, most scientists keep producing until retirement or beyond. Is their later work on a par with their earlier work? It is difficult to judge the importance of research *per se*, but we can count citations to research papers as a rough guide of significance—or at least usefulness. We will go wrong in a few cases where papers, such as compilations or summaries, are widely used but do not provide fundamental breakthroughs. But consider the reverse situation: A paper rarely cited is unlikely to be having much impact on a field.

We selected the 22 American astronomers who were the most prolific in 1920-1945 and whose careers terminated by 1970 (or not many decades earlier).[1] For each we searched five-year cumulations of the *Science Citation Index®* (*SCI®*) for 1970-1979, counting the number of citations (total 9,400) to each of their papers. The ages at which those papers were published were computed from the authors' birth dates. A histogram of their combined citations as a function of age is shown in Figure 1 (solid line). We see a broad peak in which 84 percent of citations were to papers published between the ages of 40 and 75. Less than 6 percent of the citations refer to papers published before the age of 35!

There is one weakness in this analysis, namely, that citations to papers decline with time. In an earlier study, we found a decline in 1965-1980 of 3.7 percent per year of the maximum rate after the initial peak.[2] Thus the papers written more recently (at higher ages) have an advantage. Therefore we put in such a correction factor for this decline and derived the dashed line in Figure 1. It shows that 77 percent of the citations were to papers published between the ages of 40 and 75, and 94 percent between the ages of 30 and 75.


Helmut A. Abt

These statistics imply that, as judged by productivity and citation, there should be no age bias in the awarding of grants, observing time on telescopes, promotions, salary increases, etc.

Why does an astronomer's research in his middle or late career weigh so heavily, considering that most people are unable to keep up on the developments in their and related fields? I suspect that the factors are (1) improved efficiency; (2) accumulated knowledge; (3) realization of the more important needs of the field; and (4) perhaps the development of a team structure, although that was not true of this particular sample, which was done in the time of predominantly single-author papers.

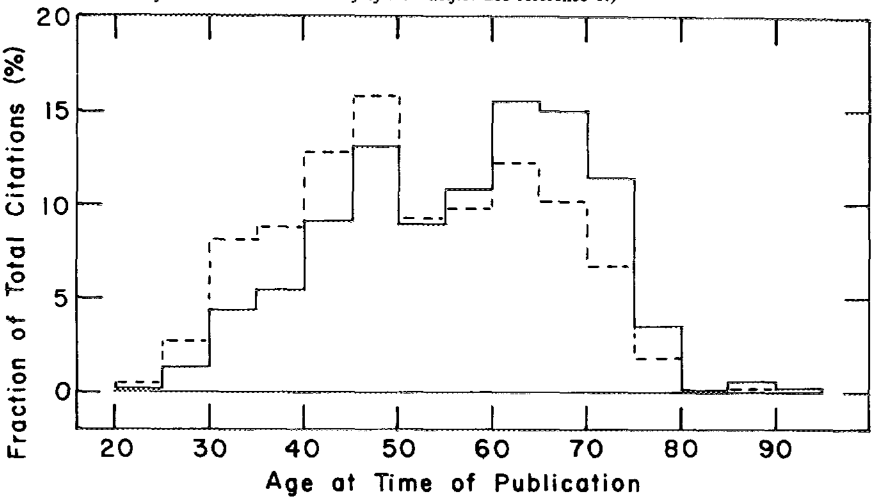
Are Prolific Astronomers Different From the Less Prolific Ones in Any Fundamental Way?

We were curious about what happens to people who obtained PhDs in astronomy and how their productivity changes with time.

We collected information on about 115 people who obtained PhDs in astronomy from 10 major universities during 1945-1960 (which, in retrospect, was an opportune time to enter the field).[3] We counted their papers published in 1945-1980 in the three major American journals but counted papers with n authors as 1/n of a paper for each author.

The attrition rate was steady after an initial burst. That is, for 9 percent of the astronomers, their last published paper in astronomy was during the year they received

Figure 1: For 22 outstanding twentieth-century American astronomers, we counted citations in 1970-1979 to papers published throughout their lifetimes. The fraction of citations that are to papers published at various ages (in five-year intervals) is shown by the solid line for the mean of the group. After we allow for an exponential decay in citations with time and again normalize to 100 percent area, we obtain the dashed line. (Courtesy of the *Publications of the Astronomical Society of the Pacific*. See reference 1.)



their PhDs, but thereafter a statistically steady 1.5 percent of the astronomers wrote their last paper each year. After 22 years, 40 percent of the initial group had stopped publishing. We could identify 7 percent who died or became seriously ill and 4 percent who went abroad and published there.

For the group as a whole, their productivity showed peaks at the time of receiving a PhD and six years after (the tenure challenge?); thereafter it was a steady five 1,000-word pages per person per year.

But the whole group could naturally be divided into two subgroups: those 13 who produced more than 10 1,000-word pages per year and those 102 who produced less. We will call these the "more-prolific" and the "less-prolific" astronomers.

The two subgroups have the following different characteristics. The productivity of the more-prolific astronomers increased steadily from an average of 15 1,000-word pages per year at the time of the PhD to about 25 such pages per year after 20 years. In contrast, the less-prolific astronomers settled down to a steady or slightly decreasing three 1,000-word pages per year. Interestingly, the more-prolific astronomers showed no peaks at the time of receiving the PhDs or six years later.

We interpret these data to say that the more-prolific astronomers are self-motivated and do not depend, as do the others, on external pressures to produce. And the more-prolific astronomers became more prolific with time, perhaps due to increased efficiency or the accumulation of publishable data and results for summaries or increased assistance (although I know that this particular set of 13 tended to work without much assistance in their research). Finally, the more-prolific astronomers contributed 30 percent of the published pages of the whole group at the time of the PhD and 65 percent of the total after 23 years.

Do Papers by Well-Known Astronomers Receive Special Treatment in Peer Reviews?

To answer this question, we made use of the records in the *Astrophysical Journal* editorial office.[4] As a sample of "well-known" astronomers, we selected all those living people who had received the major awards in American astronomy plus the presidents of the major society, the American Astronomical Society. We counted 49 such people who published 242 papers in the *Astrophysical Journal* in 1977-1986. As a control sample, we used the papers that were received by the journal just following each of the 242 papers, providing that they were not also by one of these well-known astronomers.

In the reviewing process, the referees are usually anonymous but they know the identities of the authors. Papers rarely (about 5 percent of the time) are accepted after one review. Most papers require a revision and some then need a second review. In some cases the review and revision cycle can occur several times. But we found that papers by well-known astronomers required 1.34 reviews per paper and papers by the control group, 1.37 reviews. The difference is 0.5 sigma and shows no preferred treatment for the papers by the well-known astronomers.

The average reviewing time for the papers by the well-known astronomers was 42.7 days, while for the control group it was 40.8 days. Therefore the former did not receive more prompt reviewing. The longer average time may be due to the fact that the papers by the well-known astronomers tended to be longer (15.5 1,000-word pages) than those by the control group (9.0 1,000-word pages).

The final acceptance rate of 95 percent was higher for the papers by the well-known astronomers than the 90 percent for all astronomers[5] or the 83 percent for the control group. But then we would expect experienced astronomers to be able to produce an acceptable paper more often than a less-experienced astronomer.

Thus we found no evidence that, in predominantly anonymous reviewing, well-known astronomers received more prompt or more favorable reviewing than other astronomers.

Per Dollar, Does One Get More Research and More Citations to That Research with Large Telescopes or Small Ones?

My first venture into publication studies occurred when an observatory director, faced with a reduced budget, decided to close down all of the small telescopes on grounds that the large ones produce the most important research.[6] In an absolute sense, that is undoubtedly true, but per dollar of initial cost and current maintenance, do we get more papers and more citations to those papers produced with large or small telescopes?

We found that the number of papers based on observations from six telescopes of various apertures, A, at the Kitt Peak National Observatory varied as $A^{1.1}$, the citations to those papers as $A^{1.5}$, and the initial telescope costs as $A^{2.4}$. These indicate, for instance, that a telescope three times the size of another one costs 14.0 times as much to build but produces only 3.3 times as many papers that yield 5.2 times as many citations. Clearly one gets more results per dollar with the small telescopes. If one also includes maintenance as well as initial construction costs, the small telescopes still do several times better in citations per dollar than the large ones.

The reason this happens is that competition for observing time with large telescopes is so severe that allotments of time are small and people find it difficult to carry out large projects. Many people, therefore, choose to accept several weeks of time with a small telescope, rather than two or three nights with a large one if they can do their project that way.

This conclusion should not be carried to an extreme. For instance, some research (on very faint objects) cannot be done with a small telescope. Also, when time resolution is important, the long integration times with a small telescope may not reveal as much information as short integration times with a large telescope.

In any case, this study showed the relative superior economic efficiency of small telescopes and stopped their closure on Kitt Peak.

Does the Freedom Available to University Researchers Lead to More or Better Research Than at Government-Funded Centers?

Some government-funded organizations (e.g., Goddard and Marshall Space Flight

Centers) are largely mission oriented and most of their scientists have related responsibilities. Others (e.g., National Radio Astronomy Observatory, Charlottesville, Virginia, and Kitt Peak National Observatory) also have "missions" in that their staffs are expected to spend various fractions of their time developing and maintaining equipment and reduction facilities. Universities too have "missions": to teach students, to guide their research, and to aid in the operation of the universities. But relative to the others, universities tend to be less concerned with equipment and more concerned with thought and learning. Do university scientists, then, produce more research or more basic (important) research?

To answer such a question again brings us back to the problem of judging what results are basic or important. Our only quantitative measure of importance is counting citations, which is sometimes a measure of usefulness, rather than importance. But with that disclaimer, let us proceed.

In the last two decades, there have been four large (3 to 5 meter apertures) optical telescopes in operation by the US. Two of those are owned by universities (the University of California's Lick Observatory on Mount Hamilton and the California Institute of Technology Observatory at Palomar Mountain) and are used mostly by their faculties and students. The other two, Kitt Peak National Observatory and Cerro Tololo Inter-American Observatory, La Serena, Chile, are National Science Foundation (NSF)-funded and are available to all qualified astronomers in the country, both from NSF centers and universities. We counted the papers based on observations with these four telescopes that were published in 1980-1981 in the two major American astronomical journals.[7] We also counted the *SCI* citations in 1982-1984 to those papers. In several cases papers were based on the use of two of those telescopes, so the credit was shared.

The university telescopes produced 110.5 papers while the center telescopes produced 149.5 papers. Of course not all papers are equivalent, so we counted pages: 1,060.4 pages for the university telescopes and 1,418.9 pages for the center telescopes. These papers yielded 1,477 citations for the university telescopes and 1,924 citations for the center telescopes. When we listed the 13 papers cited the most, 6.5 came from the university telescopes and 6.5 from the center telescopes (but generally the latter were higher on that list).

These numbers imply that the center telescopes produce more and longer papers that are cited more often than the university telescopes. The reason this is so is probably because of the ways in which observing time is awarded. The center telescopes, being available to a larger group of astronomers, ensure that through competition the average proposal is better.

Next Week

Abt will continue the summary of his studies on paper rejection and citation rates in astronomy and other specialties, awareness of international literature, increase in multinational collaborations, and the growth of the literature.

REFERENCES

1. **Abt H A.** At what ages did outstanding American astronomers publish their most-cited papers? *Publ. Astron. Soc. Pac.* 95:113-6, 1983.
2. ————. Long-term citation histories of astronomical papers. *Publ. Astron. Soc. Pac.* 93:207-10, 1981.
3. ————. Statistical publication histories of American astronomers. *Publ. Astron. Soc. Pac.* 94:213-20, 1982.
4. ————. Are papers by well-known astronomers accepted for publication more readily than other papers? *Publ. Astron. Soc. Pac.* 99:439-41, 1987.
5. ————. What happens to rejected astronomical papers? *Publ. Astron. Soc. Pac.* 100:506-8, 1988.
6. ————. The cost-effectiveness in terms of publications and citations of various optical telescopes at the Kitt Peak National Observatory. *Publ. Astron. Soc. Pac.* 92:249-54, 1980.
7. ————. An assessment of research done at the National Optical Observatories. *Publ. Astron. Soc. Pac.* 97:1050-2, 1985.