THE QUALITY OF SCIENTIFIC SCHOLARSHIP AND THE "GRAYING" OF THE ACADEMIC PROFESSION: A Skeptical View

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The results of a number of citation studies have been utilized to support the view that the "graying" of the academic profession will have no impact on the quality of work produced in various scientific disciplines. This conclusion is challenged. It is argued that citations may not indicate the most innovative and creative work, that age may be negatively related to the creation and reception of innovative work, and that the age structure of a scientific community may have an impact on the ability of innovative work to be produced and accepted.

In a recent discussion of the current period of retrenchment in American higher education, Philip G. Altbach (1979, p. 31) argued that, "While all academics are under pressure, the trauma has been greatest for younger professors, and the very future of scholarship and of academic innovation in the United States will be affected by the plight of the younger academic." Thus, new Ph.D.'s are competing for fewer positions, the ante for tenure has been greatly increased, and tenure quotas have been instituted. Altbach (1979, p. 34) quite legitimately focuses on "the human dimensions of the current crisis on younger academics." How will individuals trained as scholars react to employment outside the university? How will such individuals react to roles within the university that are primarily administrative and or teaching in nature? Trumble (1980) has examined a number of proposals for maintaining or improving the utilization of young researchers during this period of declining academic opportunities.

The proportion of young faculty, those within 7 years of the doctorate, in 450 departments decreased from 42.9 percent (1968), to 29.0 percent (1974), to 26.6 percent (1975), to an estimated 23.2 percent (1980) (Smith and Karlesky, 1977, p.

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182). This decline is due, in part, to the expansion of academic departments during the 1950s and 1960s. While there are no standards concerning the appropriate age distribution for various sciences, Trumble (1980, p. 338) reports on the basis of a survey of science and engineering department chairmen that "there may be a consensus that the proportion of young investigators should not drop below 25 to 30 percent." The actual percent of recent doctorates ranged from a high of 36 in sociology to a low of 13 in physics.

If, as is commonly believed, scientists do their most creative and innovative work and are most receptive to such work when they are young, the changing age structure may indeed have an impact on the quality of work produced within the university.

A number of researchers have recently employed citation analysis, the number of times a work is referred to in other published works, as a measure of creativity and quality. John Ziman (1968, p. 25), for instance, has pointed out, "Being a successful scientist is not just winning prizes; it is having other scientists cite your work." In a similar manner, Eugene Garfield (1978, p. 5) has argued:

> Papers which receive a large number of citations are usually found to have reported significant new knowledge or to have had a significant effect on a field.

In contrast to the assumption that there is a negative association between age and creativity in science, the results of a number of studies relating author's age to citations has led Stephen Cole (1979, p. 977) to conclude, "It is unlikely that an increase in the mean age of our scientists will in and of itself bring about a meaningful decline in our scientific capacity." The significance of this conclusion resides in the use to which it may be put in the justification of a retrenchment policy within colleges and universities. In response to a concern that a shift in the age distribution of investigators may have an impact on research, a deputy director of the Division of Policy Research and Analysis, National Science Foundation (Trumble, 1980, p. 337), states, "Studies published by Cole (1979) and Stern (1978) support the position that there is no significant correlation between research quantity and quality and age."

In this paper I shall briefly present the findings of the studies referred to by Trumble and then raise a number of issues which must be addressed before one can agree that the findings of these studies are sufficient to guarantee that the graying of academe will not "bring about a meaningful decline in our scientific capacity."

While it may be commonly assumed that scientists do their most creative work during their youth, there exists a somewhat more theoretically based position suggesting that the impact of age on scholarship may vary for different disciplines. In their comprehensive article, "Age, Aging and Age Structure in Science," Zuckerman and Merton (1972, p. 303) argue that the degree of codification of a discipline, that is, "the consolidation of empirical knowledge into succinct and interdependent theoretical formulations," should influence the relationship between age and the creation and reception of innovative and quality work. If the more precise and highly integrated theoretical knowledge found in the more codified disciplines, the physical sciences, provides an opportunity for the making of significant contributions by younger scholars, (Zuckerman and Merton, 1972, p. 303), "Experience should count more heavily in the less codified fields." It takes time to develop a command of the mass of facts and low-level theories in such fields. Under such conditions it is also difficult to define a true contribution. It is therefore in the less codified fields such as the social sciences (Zuckerman and Merton, 1972, p. 311) that:

> the personal and social attributes of scientists are more likely to influence the visibility of their ideas and the reception accorded them. As a result, work by younger scientists who, on the average, are less widely known in the field, will have less chance of being noticed. . . .

While the Zuckerman-Merton thesis is presented in comparative terms—in terms of codified versus less codified fields—Zuckerman and Merton refer to data from one field, the highly codified physics. In the study referred to, Stephen Cole (1970) examined the 1966 issue of the *Science Citation Index* for citations of articles published in the 1963 volume of the *Physical Review*. Cole's (1970, p. 293) finding that articles authored by physicists under 40 received the same number of citations as those authored by physicists over 40 led him to conclude, "Longevity in the field does not enhance one's chances of having papers immediately recognized."

A number of recent studies have provided data that shed additional light on the relationship between age and the quality of work in general, and the Zuckerman-Merton thesis in particular. In her study of age and achievement in mathematics, Nancy Stern (1978) followed Cole's design and examined citations of the works of a random sample of 435 mathematicians at Ph.D.-granting institutions. In order to ascertain the relationship between age and the publication of "important" papers, she obtained citations of work published during the 1970-1974 period. Stern's (1978, p. 135) conclusion for mathematicians parallels that of Cole for physicists, "The claim that younger mathematicians (whether for physiological or sociological reasons) are more apt to create important work is, then, unsubstantiated." Data on the role of age in the career of social science publications is provided by Oromaner's (1977) study of sociology. All articles published in 3 general core sociological journals (1960) were traced in 10 sociological journals (1961-1970). The 10 journals included the 3 core journals plus 7 specialty journals. The main finding here, once again, was that "there are no differences in the mean number of citations received by articles written by sociologists of various ages" (Oromaner, 1977, p. 383).

The most comprehensive examination of this topic is Stephen Cole's (1979) research on scientists in Ph.D.-granting departments of chemistry, geology, mathematics, physics, psychology, and sociology. In his main analysis, Cole used the 1971 volume of the *Science Citation Index* to obtain a measure of the quality of work published between 1965 and 1969. Cole's finding for all six fields combined was that there is a slight curvilinear relationship between age and quality of work. Thus, the mean number of citations for various age groups is: under 35 (7.5), 35-39 (8.8), 40-44 (9.1), 45-49 (6.4), 50-59 (5.7), and 60+ (6.3). In a second analysis he reported on a longitudinal study of articles published by mathematicians for the period 1950-1974. Cole's (1979, pp. 968-969) conclusion is that "age seems to have very little influence on the quality and quantity of work produced by contemporary academic scientists." Finally, Cole examined the codification hypothesis of Zuckerman and Merton and found little empirical support for it. He reported that young psychologists are about as likely to make important discoveries as young physicists and chemists, and that there is no significant difference in the age at which scientists in the highly codified physics and the less highly codified sociology make their first significant contribution.

While none of the studies presented indicate that younger academic scientists are more likely than their older colleagues to produce highly cited work, I suggest that it is not legitimate to conclude that a diminution in the number of younger scientists will have no impact on the quality of scientific work produced. The major points of my position are: (a) citations may not indicate the most innovative and creative work, (b) age may be negatively related to the creation and reception of innovative work, and (c) the age structure of an academic community may have an impact on the ability of innovative work to gain acceptance.

In a review of the positive uses of citation measures, Eugene Garfield (1979, p. 372), president of the Institute for Scientific Information and compiler of the *Science Citation Index*, concludes:

> Any fair appraisal of citation analysis as an aid in evaluating scientists must acknowledge that there is much about the meaning of citation rates that we do not know. We are still imprecise about the quality of scientific performance they measure.

While we do not understand the norms governing citation behavior (Kaplan, 1965; Gilbert, 1977), a number of researchers have attempted to examine the meaning of citations.

In an examination of references in theoretical high-energy physics articles published in *Physical Review*, Moravcsik and Murugesan (1975) developed a typology containing four dimensions:

1. Conceptual or operational—Is the reference made in connection with a concept or theory that is used in the referring paper, or is it made in connection with a tool or physical technique used in the referring paper?
2. Organic or perfunctory—Is the reference truly needed for the understanding of the referring paper, or is it mainly an acknowledgment that some other work in the same general area has been performed?

3. Evolutionary or juxtapositional—Is the referring paper built on the foundations provided by the reference, or is it an alternative to it?
4. Confirmative or negational—Is it claimed by the referring paper that the reference is correct, or is its correctness disputed?

Part way through the study Moravcsik and Murugesan became aware of "redundant" references, that is, situations in which a reference was made to several papers, each of which made the same point. They suggested that in such cases reference to a single paper would have been sufficient and that the multiple references were made mainly to "keep everybody happy." The most relevant findings were that about one-third of the references were redundant and that two-fifths were perfunctory. The latter is particularly significant:

> This raises serious doubts about the use of citations as a quality measure, since it is then quite possible for somebody or some group to chalk up high citation counts by simply writing barely publishable papers on fashionable subjects which will then be cited as perfunctory, "also ran" references (Moravcsik and Murugesan, 1975, p. 91).

In an application of a six-category typology to high-energy physics articles and letters, Chubin and Moitra (1975) found 20 percent of the references to be of a perfunctory nature. In such cases papers were referred to as being related to the reported paper without additional comment. The authors pointed out that, since they and Moravcsik and Murugesan employed different definitions, the results of the two studies were not strictly comparable.

Cole's (1975) content analysis of citations of Robert K. Merton's classic paper, "Social Structure and Anomie," sheds light on the meaning of citations of social science literature. Cole examined citations of this paper in 123 articles on deviance that appeared in sociological journals during the period 1950-1972. Each citation was placed in 1 of 10 categories based on the way in which "Social Structure and Anomie" was utilized in the referring paper. The two most highly populated categories were "Part of relevant literature, serves no explicit role in the analysis" (24%), and "Supports data of author, legitimates author's ideas and interpretations" (18%). Cole suggests that this 42 percent of articles citing Merton's paper cited his work in a purely "ceremonial" fashion. He concludes:

> Although I currently have no comparative figures, it is my guess that 42 percent will turn out to be a relatively low proportion of ceremonial citations when compared to the proportion of such citations received by other theoreticians (Cole, 1975, p. 208).

These three papers are significant in that they provide some empirical evidence to support a skeptical position concerning the equating of highly cited papers with innovative or creative work. It is certainly premature at this stage of our knowledge of the meaning of citations to employ the results of citation studies as a basis for policy decisions which, if proven wrong, may have a deleterious impact on the quality of scientific work produced.

In the same article in which Stephen Cole argued that the increase in the mean age of scientists should not bring about a decline in our scientific capacity, he (Cole, 1979, pp. 976-977) pointed out that we must study the types of contributions made by scientists of various ages in different disciplines. If it is true, as Altbach (1979, p. 32) argues, that the productivity requirements associated with the granting of tenure have been increased, then it is possible that there will be a deflection from theory building and a simultaneous attraction to research. The return from the latter, in terms of number of publications per year, is likely to be greater than that from the former. This phenomenon is also likely to be reinforced by the fact that research-oriented work is more likely than theory development to bring outside funding to the university. In their analysis of federal grants for sociological research in 1967, Smelser and Davis (1969, p. 149) concluded:

> Although many of the projects may have had theoretical aspects, we found virtually no awards that could be judged to support theoretical analysis as such.

I suggest that, while the puzzle-solving activity associated with normal science may not be affected by a change in the age structure of various disciplines, and may even be encouraged, the paradigm-building and creative work associated with revolutionary science (Kuhn, 1970) may be discouraged.

Kuhn (1970, p. 90) not only argues that scientific thought changes with the development and acceptance of new paradigms but also observes that, "Almost always the men who achieve these fundamental inventions of a new paradigm have been either very young or very new to the field whose paradigm they change." Alvin W. Gouldner (1970, p. 377) has applied the age and generational analysis to recent changes in the dominance of structural-functional theory in American sociology and reports that the major division concerning support or opposition to this approach is between "those who were professionally trained before or during World War II and those who were trained after it." Hagstrom (1965, p. 283) also suggests that, since the commitments of younger scientists to the accepted views are more superficial than those of older scientists, "young scientists may find it easier to accept new views." Older scientists are more likely to be victims of "trained incapacity," in the sense that the very wealth of knowledge and skills they possess makes it hard for them to accept innovations. Hagstrom (1965, p. 283) quotes Darwin's observation that, although convinced of the truth of his views, "I by no means expect to convince experienced naturalists whose minds are stocked with a multitude of facts all viewed, during the long course of years, from a point of view directly opposite to mine." He continues on to quote Darwin's expressed confidence in the future and in the "young and rising naturalists, who will be able to view both sides of the question with impartiality." Barber (1962) has studied resistance to change by older scientists. It is not that physical aging in itself is the source of such resistance, but rather that the mere fact of having lived for a longer time provides the scientist with an opportunity to acquire the cultural and social factors associated with resistance. Barber (1962, p. 555) has summarized such factors:

> As a scientist gets older he is more likely to be restricted in his response to innovation by his substantive and methodological preconceptions and by his other cultural accumulations; he is more likely to have high professional standing, to have specialized interests, to be a member or official of an established organization, and to be associated with a "school."

Finally, Barber (1962, p. 543) quotes what is probably the most famous statement on this issue, Max Planck's observation that "a new scientific truth does not triumph by convincing its opponents and making them see the light, but rather because its opponents eventually die, and a new generation grows up that is familiar with it."

By definition, the graying process results in the young accounting for a smaller percentage of the total membership of the community in question. In order for groups of younger cohorts to present a challenge to the adherents of the reigning paradigm, they must contain enough members to create a network for the provision of social, emotional, professional, and intellectual support. Mullins (1973, p. 23) has recently documented the significant role played by clusters of professionals "who reinforce one another's interests" in the development of theory groups in American sociology. What are the absolute and relative numbers necessary to sustain the new generation until "its opponents eventually die" or retire? That is, what numbers are necessary in order to guarantee survival in the face of the power exercised within academia and the scientific communication system by older colleagues?

Sociologists of science have stressed the importance of social and cultural factors in the development and change of scientific ideas (Mulkay, 1979). In the present discussion I have suggested that an understanding of the impact of the graying of the academic profession on scientific scholarship requires an examination at the structural level of analysis (Blau, 1976) and of revolutionary change. The papers reviewed focus on an individual level of analysis and on normal periods of scientific activity. Future research in this area must relate context, meaning, and utilization of citations (Gilbert, 1976; Small and Greenlee, 1980), as well as context in which revolutionary changes develop, to both age and age structures within scientific and academic communities.

Finally, it must be remembered that this discussion has been limited to the role of academic scientists. Thus, while the graying of the academic profession may not limit overall scientific capacity, it may have serious consequences on the role of academic science in the development of innovative and revolutionary scientific thought.

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