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Citation Measures Used as an Objective Estimate of Creativity

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In a previous editorial[1] I ventured to open discussion of the use of citation indexes in sociological and historical research. In the transition from 'little science' to 'big science', interest has grown in developing effective measures for evaluating scientific performance. Citation indexes and the application of citation counts or *impact factors* are providing one quantitative technique and are emerging as an important sociometric tool.

A number of studies[2-6] have underscored the potential of the *Science Citation Index*® in this field, sometimes called the 'science of science'. In 1966, the Air Force Office of Scientific Research undertook, along with ISI®, a study which made use of citation data to evaluate the impact of AFOSR-sponsored publications[7]. At a recent AAAS meeting, we presented a paper[8] on the citation characteristics of Nobel Prize winners. The paper illustrated that citation data can provide one objective measure in forecasting future Nobel awards.

Such studies mark a turning point for the *Science Citation Index*, in that they imply a recognition and acceptance of citation indexing as a valid measure in evaluating and comparing scientific merit.[9] Such studies are only a harbinger of things to come.

The following letter to the editor[10] of *Chemical and Engineering News* is reprinted here because it highlights some of these efforts.

Objective Estimate of Creativity

DEAR SIR:

The letter by Arnold E. Reif (C&EN, Aug. 29, page 7) is a further indication of the growing number of scientists and administrators who are actively seeking objective measures of scientific creativity and productivity. Dr. Myron A. Coler's article (C&EN, Aug. 15, page 72) is but one paper in a sizable literature on the science of science. Without citing the large number of papers in this field which Reif might have mentioned, your readers should know about the differences of opinion concerning publication counts, which he promotes, and citation counts or *impact* factors. Publication counts have been used for some time. [See, e.g., J. H. Westbrook, "Identifying Significant Research," *Science*, **132**, 1229 (1960).]

The Institute for Scientific Information, the Stanford Research Institute, and others have used citation counts, that is, the number of times a man's work has been cited by others. These counts and derivative impact factors are useful not only for evaluating individual papers, authors, and laboratories, but also journals. Indeed, a good method of ranking journals, as Reif proposes, is to obtain journal impact factors which we have reported on elsewhere [*Am. Doc.*,

14(8), 195 (1963)]. Your readers might also wish to examine our recent report to the Second Office of Naval Research Conference on Research Program Effectiveness ("New Tools for Improving and Evaluating the Effectiveness of Research") in which some important findings are reported on Nobel Prize winners. Reif speaks of "the genius who patiently labors for 10 years, then writes a brilliant paper that wins him a Nobel Prize." Nobel Prize winners generally publish frequently—and their cited works are more numerous and cited more frequently than those of "us mortal scientists." This conclusion, based on extensive statistical data files compiled at ISI, can be observed easily in individual cases by examining volumes of the *Science Citation Index* (see J. F. Smith, "Systematic Serendipity", C&EN, Aug. 31, 1964, page 55).

As we have repeatedly done in the past, may we respectfully caution against the serious implication by Reif that quantitative data can be used without considered (not rote) qualitative judgments. Publication indexes and impact factors are useful guides. They should never be used promiscuously and without further investigation in evaluating an individual. It is one thing to select nominees for awards from lists of frequently published or cited authors, especially as the science community grows. But statistical samples can never tell the entire story of a particular individual in the sampling.

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