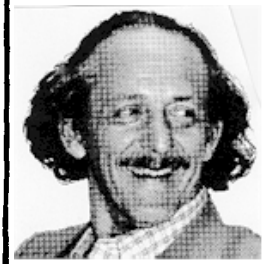
Essays of an Information Scientist, Vol:5, p.551-561, 1981-82 Current Contents, #23, p.5-15, June 7, 1982



Current Comments

Were the 1981 Nobel Prizewinners in Science, Economics, and Literature Anticipated by Citation Analysis?

Number 23 June 7, 1982

Certainly, the most prestigious and most visible award a scientist, economist, or writer can receive is the Nobel prize. Each fall, when the awards are announced, it is instructive to determine whether any of our earlier citation studies have anticipated the decisions.[1,2] These analyses often reveal interesting characteristics of the fields or literature involved.

In compiling lists of highly cited authors, we identify many people who can be considered *of Nobel class*, that is, "peers of prizewinners in every sense except that of having the (Nobel) award."[3] (p. 42) However, we cannot predict from year to year who will win the coveted award. One reason is that we have no way of knowing which fields or research fronts will be singled out.

But our co-citation studies can indicate those fields which may eventually be acknowledged by an award. We can also use citation analysis to identify those scientists whose contributions have had wide impact. Many studies indicate that these selections are confirmed by subjective peer judgments.

Nobel prizes in the sciences are often awarded for work performed nearly a generation before.[3] In 1980 the Nobel Committee departed from this tradition by selecting prizewinners from highly active areas like recombinant DNA and immunogenetics.[2] But tradition was restored in 1981. Although all of the 1981 prizewinners in the sciences are still active in their fields, their most important work was published over 15 years ago. In fact, many of their most-cited publications appeared before *Science Citation Index®* (*SCI®*) was started in 1961.

Nevertheless, six of the eight 1981 prizewinners in the sciences appeared on one or more of our published lists of highly cited authors and publications. All of these laureates have been cited over 1,000 times since 1961. The fact is that only a small percentage of the hundreds of thousands of publishing scientists are cited that often—less than one in 250.

Physics

The 1981 Nobel Prize in Physics was awarded to three scientists for their contributions to various aspects of spectroscopy. Half of the award went to Kai Siegbahn, age 63, Uppsala University, Sweden. The other half was shared equally by two Americans, Dutch-born Nicolaas Bloembergen, age 61, Harvard University, and Arthur Schawlow, age 60, Stanford University.

Spectroscopy is a basic method for studying atoms and molecules. Scientists have long known that any material heated to incandescence produces a spectrum of light so distinctive that it can be used to identify the substance. Astronomers have found that the spectra emitted by stars reveal their chemical composition, motion, temperature, and magnetic field.

But scientists now can also study earthbound substances by aiming light or other kinds of energy such as X rays at them. As the radiant energy strikes the atoms, their electrons change energy levels by moving from one orbit to another, or by breaking away completely. When such phenomena

occur, the electrons emit or absorb specific amounts of light and yield data about the identity and structure of the atoms.[4] It is largely for improving the sensitivity and resolution of spectroscopy that the Nobel Committee selected the 1981 laureates in physics.

Siegbahn was recognized for his contributions to the development of high resolution electron spectroscopy. Siegbahn first thought of applying electron spectroscopy to the study of atomic phenomena in the 1940s. J.M. Hollander, Universitywide Energy Research Group, University of California, Berkeley, and David Shirley, Lawrence Berkeley Laboratory, noted that Siegbahn "combined elements of precision X-ray spectroscopy for which his father, Manne Siegbahn, had been awarded the Nobel Prize in 1925, with those of the emerging field of nuclear spectroscopy, in which he did his own doctoral research...."[5] Only five other parent-child pairs have received the prize.[3] (p. 96-9)

Early in Siegbahn's career, measuring the spectra of emerging electrons from radiated atoms was extremely difficult. As they change energy levels, electrons collide, creating spectra that are blurred. Siegbahn resolved this dilemma by devising a highly precise instrument for tracking those electrons which leave their orbits unscathed. His "double-focusing spectrometer" allowed him to record spectra with tenfold higher accuracy than was previously possible.[6] This form of high resolution spectroscopy became known as electron spectroscopy for chemical analysis (ESCA).

Bloembergen and Schawlow shared their half of the award for their contributions to the development of laser spectroscopy. Both laid much of the theoretical groundwork and performed crucial experiments in this field. Schawlow devoted his early career to work on masers (microwave amplification by stimulated emission of radiation) in collaboration with his brother-in-law, Charles H. Townes.[6,7] Masers are devices which amplify electromagnetic energy of long wavelengths (microwaves).

In 1958, Schawlow and Townes proposed a method for shortening the wavelengths in a maser to reproduce an extremely narrow beam of light waves oscillating in phase with one another.[8] This led to the development of the laser (light amplification by stimulated emission of radiation). In fact, Townes shared the 1964 Nobel Prize in Physics with two Russian scientists, Nikolai G. Basov and Alexandr M. Prokorov, for their fundamental work on the maser and laser. Townes, however, did his prizewinning research independently of the Russians.

In the 1960s, Schawlow left the refinement of lasers to others, and applied himself to increasing the resolution and sensitivity of laser spectroscopy. By varying the wavelength of the laser light, Schawlow was able to distinguish specific atoms and molecules from their surroundings. Like Siegbahn, Schawlow eliminated a blurring effect that made spectral emissions difficult to observe. He did this by hitting atoms with laser beams from opposite directions so that the blur from one beam canceled that from another.[5,7] One of Schawlow's most celebrated achievements was determining the energy that binds an electron to the proton of a hydrogen atom. Known as the Rydberg constant, this fundamental property of matter had eluded precise calculation before Schawlow's work.[9]

Like Schawlow, Bloembergen helped to increase the resolution of laser spectroscopy by eliminating blur in spectra. But where Schawlow has concentrated on energy states in individual atoms and molecules, Bloembergen has examined spectroscopic properties of bulk samples.[7]

Much of Bloembergen's work has been in the field of nonlinear optics. A nonlinear effect occurs when a laser beam striking the sample is of such high intensity that particles of matter no longer respond in proportion to the strength of the beam. Bloembergen's work in this field led to applications in monitoring optical communications systems, and in the spectroscopic analysis of jet engine exhausts.[9]

Bloembergen was largely responsible for extending the range of lasers beyond

visible light by mixing three beams to produce a fourth beam of very high intensity. These fourth-wave lasers have been used to study combustion inside automobile engines and element transport in biological tissues.[10]

More recently, Bloembergen has become interested in laser-induced chemistry, or laser catalysis, "in which the direction and speed of a chemical reaction may be controlled by selective excitation of specific states in the reactants, or by selective destruction of the reactant products."[9]

Like all of the 1981 prizewinners in science, those in physics are highly cited. From 1961 to 1980 Siegbahn as primary author was cited some 5,400 times by articles covered in the ISI® data base. Siegbahn has authored about 400 publications, but many citations are to his seminal books on electron spectroscopy. *ESCA: Atomic, Molecular and Solid State Structure Studied by Means of Electron Spectroscopy* has received over 850 citations since its publication in 1967.[11] Another book, *ESCA Applied to Free Molecules*, which appeared in 1969,[12] was cited over 1,200 times in only 12 years. Clearly, Siegbahn's work has had high and immediate impact on his colleagues. The two-volume work he edited in 1965, *Alpha-, Beta- and Gamma-Ray Spectroscopy*,[13] appeared on our list of the most-cited non-journal items in 1967.[14] In the 16 years spanning 1965-1980, this book was cited over 1,300 times.

Although nearly a quarter of his publications appeared before 1961, Schawlow has been cited over 1,150 times just as a primary author. He coauthored his most-cited paper, "Infrared and optical masers,"[8] with Townes in 1958. This proposal for extending maser techniques toward laser wavelengths was cited over 360 times from 1961 to 1980. Townes was the primary author of their book, *Microwave Spectroscopy*.[15] Published in 1955, this work appeared on our list of most-cited books from 1961 to 1972.[16] It is Schawlow's most-cited work, with nearly 1,800 citations in the 20 years spanning 1961-1980.

As a primary author, Bloembergen was cited over 7,300 times from 1961 to 1980. He appeared on our list of the 250 most-cited primary authors from 1961 to 1975.[17] More recently, he appeared in our study of the 1,000 most-cited authors—including coauthors—with over 2,400 citations to articles published from 1965 to 1978.[18]

Bloembergen has authored 220 publications, and two of these were treated as *Citation Classics*.[19,20] The first is his 1948 paper, "Relaxation effects in nuclear magnetic resonance absorption,"[21] cited over 1,550 times since 1961. Bloembergen attributes this to the exploitation of nuclear magnetic resonance (NMR) spectroscopy by chemists and biochemists who, he says, are more numerous and more prolific than physicists.[19] Furthermore, he suspects that new researchers in NMR spectroscopy, when confronted with the complexities of the field, like to consult the account of his early wrestling with basic problems.[19] The 1948 paper was Bloembergen's most-cited publication during the period 1961-1975,[22] and appeared on our list of most-cited papers in physics, chemistry, and mathematics from the 1940s.[23] It also appeared on our 1972 list of most-cited chemical articles,[24] and was one of the most-cited articles from 1961 to 1972.[25]

Bloembergen's other *Citation Classic* is his 1965 book, *Nonlinear Optics*,[26] which describes the general principles of this field. In 16 years this book received over 800 citations. Bloembergen believes that one of the reasons why this book is so highly cited is that the literature in nonlinear optics "has grown by at least a factor of 100 since 1964."[20] That this book continues to be frequently consulted is evident from its appearance in the core of co-cited documents for the 1980 *ISI/CompuMath*™ research front specialty entitled "Nonlinear Theory for the Interaction of Electromagnetic Waves with Nonlinear Media." Research front specialties are identified by co-citation analysis.[27,28] Bloembergen also appears as the author of a citing document in another 1980 research front entitled "Determination of Certain Nonlinear Susceptibilities

Using Nonlinear Interferometry and Spectroscopy." So not only is Bloembergen a pioneer in nonlinear optics, he is still at the forefront of this field.

Chemistry

The Royal Swedish Academy of Sciences awarded the 1981 Nobel Prize in Chemistry jointly to Kenichi Fukui, Kyoto Imperial University, and Roald Hoffmann, Cornell University, for their theories, developed independently, concerning chemical reactions. At age 63, Fukui is the first Japanese scientist to win the Nobel chemistry award. He was cited for his "frontier orbitals" theory of chemical reactivity. Hoffmann, who was born in Poland in 1937 and emigrated to the US as a child, received his share of the award for the principles of orbital symmetry conservation he developed with the late Robert B. Woodward, Harvard University. Woodward won a Nobel prize in 1965 for his work in organic synthesis. In fact, Hoffmann believes that if his colleague were still alive today, he would have won a second Nobel prize.[29]

I have special memories of Woodward. In 1959 he telephoned and asked me to read him an article from the current issue of *Angewandte Chemie*, which had not yet arrived in his library. This experience convinced me that we had to provide a library backup to *Current Contents®*, even if used only once a year by each reader. So we began our *Original Article Text Service* (*OATS®*).[30] We've also had considerable correspondence with Hoffmann over the years. He has been most supportive in following our historical and sociological studies.

In the early 1950s, Fukui published his frontier orbitals theory for predicting the site and rate of chemical reactions.[31] An orbital is an equation describing the motion and energy of individual electrons in a molecule. Simply stated, the frontier orbitals theory says that the electrons which are most loosely bound to one molecule are the ones most likely to be donated to another molecule in a reaction. Fukui's theory attracted little attention when it first appeared, primarily because Fukui's mathematics was beyond the comprehension of most practicing chemists who were then accustomed to thinking in terms of ball and stick models rather than involved equations.[29,31] Fukui's ideas also went unnoticed because those theoretical chemists who did read them doubted that reactivity could be reduced to anything so simple.[31]

Working independently of Fukui, Hoffmann and Woodward discovered in 1965 a set of rules for predicting reaction rates,[32,33] but formulated these rules in a pictorial way that made them particularly useful to laboratory chemists.[34] The "Woodward-Hoffmann rules," as they are now called, use diagrams of orbitals to estimate the barrier in energy preventing a reaction from occurring. If the energy levels in the transition state for a reaction are high, the molecules will react slowly, or not at all.[35] The almost immediate acceptance of the Woodward-Hoffmann rules led experimentalists back to Fukui's earlier work.[31]

The theories proposed by Fukui and Hoffmann bridged the gap between quantum theory and practical chemistry. Many believe they represent the most important conceptual advance in chemistry since the 1940s.[29,35] Andrew Streitwieser, University of California, Berkeley, explains: "Frontier orbitals and orbital symmetry have generated other ideas and concepts and have led to new organic and organometallic structures. The reaction classification scheme of Woodward and Hoffmann has spawned new reactions that have entered the active repertoire of the synthetic chemist. More recent work of Roald Hoffmann is showing that the same ideas can also be applied to inorganic compounds and reactions."[36]

Despite Fukui's highly mathematical approach to chemical theory, he received 3,800 citations just as a primary author from 1961 to 1980. Fukui's most-cited paper is an updated account of the frontier orbitals theory.[37] Published in 1971, this paper was cited over 200 times in only ten years.

That Fukui's work became better known thanks to the publication of the Woodward-Hoffmann rules can be shown in the citation records of two of his earliest papers.[38,39] As Fukui told us when filling out the questionnaire for our 1,000 most-cited author study,[40] the paper he considers his most important is his 1952 article, "A molecular orbital theory of reactivity in aromatic hydrocarbons."[38] It received 177 citations from 1961 to 1980. But between 1961 and 1964 we found only seven citations to this paper. (Only after we publish citation indexes for the 1950s will we know how often it was cited then.) Since the publication of the Woodward-Hoffmann rules in 1965, however, the paper has received over 170 citations—an average of ten citations per year. From 1965 to 1969 it was cited 48 times; from 1970 to 1974, 54 times; and from 1975 to 1980, 63 times.

A similar pattern in the citation record of Fukui's 1954 paper extending his molecular orbital theory[39] strongly suggests that recognition of Fukui's work was hastened by the appearance of the Woodward-Hoffmann rules. This paper was cited 15 times from 1961 to 1964, but over 165 times thereafter. As I will describe in a forthcoming study, Irv Sher, director of quality control at ISI, has developed an interesting computer procedure for identifying such "sleepers."

Hoffmann has been appearing on our lists of most-cited authors ever since we began compiling them. He was on our list for 1972.[41] His 1963 article, extending the Hückel theory (which describes orbitals in aromatic compounds) to new types of electrons,[42] appeared as his most-cited paper in our study of the 300 most-cited authors—including coauthors—from 1961 to 1976.[43] The 1963 paper received 1,511 citations in 14 years and continues to be his most-cited work as a primary author, with nearly 2,000 citations from 1961 to 1980. Hoffmann was only 26 when he wrote this paper—an extraordinarily young age to produce work of such high impact. Also on our list of the 300 most-cited authors from 1961 to 1976[43] were Hoffmann's PhD supervisor, W.N. Lipscomb, and co-worker, Woodward. Hoffmann was a coauthor on each of their most-cited papers in this study.[44,45] Hoffmann also appeared on our list of the 1,000 most-cited authors, with 7,340 citations to papers published from 1965 to 1978.[18]

In her book, *Scientific Elite*, Harriet Zuckerman notes that Nobel laureates often do not consider their prizewinning research to be their best work.[3] (p. 210) Many authors have similar feelings about their most-cited publication. Hoffmann, however, believes that his most-cited paper[45,46] is in fact his most important contribution to theoretical chemistry.[47] Coauthored by Woodward, "The conservation of orbital symmetry"[45,46] has been reprinted in book form,[48] and has received more than 3,300 citations since its publication in 1969. This landmark paper elaborating the Woodward-Hoffmann rules was one of three papers by Hoffmann on our list of the 100 most-cited chemical articles in 1972.[24] It was Woodward's most-cited article in our primary author study for the years 1961-1975,[22] and in our "all-author" study for the years 1961-1976.[43] It also appeared on our list of highly cited organic chemistry papers for the 1960s.[49] Woodward and Hoffmann were coauthors on one other article on this list as well, entitled "Stereochemistry of electrocyclic reactions."[50] This paper provided the groundwork for the Woodward-Hoffmann rules.

Physiology or Medicine

One half of the 1981 Nobel Prize in Physiology or Medicine was given to psychobiologist Roger W. Sperry, age 68, California Institute of Technology, for his research exploring the functions of the right and left hemispheres of the brain. Two professors of neurobiology at Harvard University shared the other half of the award. Canadian-born David H. Hubel, age 55, and Torsten N. Wiesel, a 57-year-old Swede, were cited by the Nobel Committee for discovering how visual information is transferred from the eye's retina to the brain.

For 40 years, Sperry has performed major research in the functional design of the brain. The split-brain studies for which he won the Nobel prize represent only the most recent phase in his distinguished career. Many of his colleagues feel he could just as easily have been cited for his earlier work analyzing the brain functions of fish, cats, and monkeys.[51,52]

In his experiments with animals, Sperry surgically severed the nerve bundles connecting the two hemispheres of the brain. He discovered that these animals could still perform learned tasks when stimulated on one hemisphere. More importantly, Sperry showed that the information learned by one half-brain did not transfer to the other.[51]

In the 1960s, Sperry studied epileptic humans whose nerve bundles connecting the two hemispheres had been severed to control seizures for which all other treatment had proved ineffective. His experiments with these patients showed that each cerebral hemisphere had its own separate world of thoughts, emotions, sense impressions, and memories. Moreover, Sperry discovered that the right hemisphere was actually superior to the left in comprehending some kinds of spatial relationships.[51,52]

Sperry's work has far-reaching implications for many fields of human inquiry. Philosophers and psychologists are now studying the importance that split-brain studies have for theories of consciousness, cognition, and behavior.[51,52] Cerebral anatomists are now looking for inborn differences in the organization of cortical tissue in the two hemispheres.[51] The announcement of the Nobel Committee states that Sperry "has provided us with an insight into the inner world of the brain which hitherto had been almost completely hidden from us."

Hubel and Wiesel have collaborated for 20 years on research into how the brain processes information from the eyes. Working on anesthetized cats and monkeys, they tested the specific functions of individual cells in the visual cortex at the rear of the brain. With the animals' eyes open and aimed at a screen illuminated with variously oriented lines and patterns of light, the scientists used extremely thin electrodes to measure the electrical impulses given off by neurons in the visual cortex.[53]

Their first major discovery was that each nerve cell has an "orientation preference" to particular elements of light hitting the retina.[54] Some cells are most responsive to contrast, others to linear patterns, others to movements of the light, and so forth. Hubel and Wiesel also learned that the cells are arranged in a hierarchy of increasingly complex functions, and that this hierarchy translates the patterns of light into a coherent picture for the brain to interpret.[53]

Aside from advancing basic knowledge about how the brain works, the research of Hubel and Wiesel has had important applications in pediatric ophthalmology. Hubel and Wiesel showed that normal sight is established at birth, and that neurons in the visual cortex are adaptable only for a short period.[55] If an infant's vision is impaired, some neurons of the ill-seeing eye change functionally, and the brain refuses to accept their signals. Once the period of adaptability has passed, the impairment in the brain becomes permanent. At this point even if the child's eye problems are corrected, the child will not be able to see normally because the brain cannot process the information it receives. Hubel and Wiesel's work thus showed the importance of early medical intervention in such cases.[55]

As a primary author, Sperry was cited nearly 3,000 times in *SCI* from 1961 to 1980. His most-cited paper is entitled "Chemoaffinity in the orderly growth of nerve fiber patterns and connections."[56] Cited over 250 times since publication, this paper reviews Sperry's earlier work in which nerve fibers of various animals were surgically cut and teased apart. Sperry found that the scrambled fibers reorganized and connected only with fibers for which they had a preprogrammed chemical affinity. Sperry's work in this area explained how neural networks for behavior could be inherited, and dispelled objections to the concept of instinct.[57] The

paper on chemoaffinity in nerve growth continues to exert a strong influence on neurological research. It appears in a cluster of core papers for the 1980 *ISI/BIOMED* ™ research front entitled "Ontogeny of Retinal and Tectal Specificity in Frogs."

That Sperry has had a profound influence on psychology and other social sciences is evident from the 1,400 citations to his work in *Social Sciences Citation Index*® (*SSCI*®) during the period 1966-1980. While some of the journals in *SSCI* are also covered in *SCI*, many of these citations are from publications in philosophy and the behavioral sciences.

Hubel is the primary author of most of the high impact papers he published with Wiesel. Hubel was cited over 8,200 times from 1961 to 1980. As a primary author, Wiesel received over 2,000 citations during the same period. Both researchers appeared on our list of the 1,000 most-cited authors.[18] Hubel received over 3,750 citations, and Wiesel received over 3,600, to articles published from 1965 to 1978.

Hubel and Wiesel's most frequently cited work is "Receptive fields, binocular interaction and functional architecture in the cat's visual cortex," which appeared in *Journal of Physiology* (London) in 1962.[58] Since then, it has been cited over 1,580 times according to *SCI*. Another paper on the receptive fields and functional design of the cat's visual cortex[59] received 825 citations from 1965, when it was published, to 1980. Wiesel's most-cited article as a primary author is a 1963 study showing that light deprivation causes cells in key areas of the brain to atrophy.[60] It was cited 375 times in 18 years.

Hubel appeared on our list of the 250 most-cited primary authors from 1961 to 1975.[17] Both Hubel and Wiesel were among the 300 most-cited authors from 1961 to 1976.[43] In both of these studies, the 1962 article on the visual cortex in the cat[58] was their most-cited work.

The influence of their work on the behavioral and social sciences is shown by the appearance of two of their papers on our list of the 100 most-cited articles in the social sciences.[61] These were the 1962 study of the visual cortex in the cat,[58] and a 1968 paper on the visual cortex in the monkey.[62]

The continuing impact of Hubel and Wiesel's work is confirmed by our 1980 cluster data. Between them, Hubel and Wiesel have authored six of the documents co-cited by articles in the 1980 *ISI/BIOMED* research front entitled "Development and Physiology of the Visual System." Hubel also has a paper in the core of co-cited documents for the research front entitled "Retinal Projection Structure in Albinism."

Economics

James Tobin's winning of the 1981 Nobel Prize in Economics was, in the words of 1970 economics laureate Paul Samuelson, "never a question of whether, only of when."[63] Tobin, age 63, Yale University, is the tenth American to win the award since its inception in 1969. Tobin was cited by the selection committee for providing a basis for understanding how people behave in acquiring various assets and debts, and developing the implications of their behavior for the performance of financial markets and the whole economy. The Nobel Committee noted that Tobin had "unquestionably inspired substantial research during the 1970s on the effects of monetary policy, the implications of budget deficits, and stabilization policy in general."[64]

In his prizewinning work, Tobin applied the "portfolio theory," which states that investors tend to balance the risks in one investment against those in another, thereby protecting themselves from catastrophic losses. Harry Markowitz was the originator of this approach to the decisions of individual investors.[65,66] Although Tobin contributed to the theory itself, his main interest was in developing its implications for macroeconomic analysis. An influential paper published in 1958 showed why people would hold money and liquid assets even though they were sacrificing interest.[67] As Tobin later explained, "It's just the principle of not putting all your eggs in one basket."[68] The

1958 article, "Liquidity preference as behavior towards risk," is Tobin's most-cited work. From 1966 to 1980 it was cited 175 times. When we compile citation indexes for the previous decade we'll know more about its immediate impact at publication.

Tobin has published 218 works, and has received more than 2,100 citations since 1966, the first year for which *SSCI* is now available. Tobin was one of 11 economists in our study of the 100 most-cited *SSCI* authors, with 1,570 citations from 1969 to 1977.[69] He is the fifth of eight living economists on this list to receive the Nobel prize. Our success in identifying probable Nobelists by citation data has here proved extraordinary. However, none of Tobin's publications appeared in our 1969-1977 studies of the 100 most-cited articles and 100 most-cited books by social scientists.[61,70] This suggests that the citations to Tobin's work are distributed fairly evenly over many publications, and not concentrated on a few high impact papers.

Literature

In reviewing nominees for the Nobel Prize in Literature, the Swedish Academy considers writers whose works "by virtue of their contents and form, possess literary value."[71] (p. 9) This sweeping definition of literature has allowed the Academy to choose philosophers and historians as well as novelists, poets, and playwrights. This practice is a happy one because many authors do not limit themselves to a single kind of writing. The 1981 prizewinner, Elias Canetti, is a case in point. He has written a novel,[72] literary and political essays,[73,74] a study of the psychology of groups,[75] and a first volume of his autobiography.[76]

Canetti was cited for "writings marked by a broad outlook, a wealth of ideas, and artistic power."[77] Few writers could be influenced by more cultures than Canetti. A 77-year-old recluse, Canetti is a Sephardic Jew who was born in Bulgaria and whose father was Turkish. Canetti has lived in Vienna, Lausanne, and Zurich, but has spent over half his life in England. He writes exclusively in German.

Canetti's work has been well known in Germany and Austria for some time. In 1972 Canetti was awarded the Büchner prize, perhaps the most prestigious literary prize in the Federal Republic of Germany, by the Deutsche Akademie für Sprache und Dichtung. But Canetti deliberately shuns public attention, and is not as well known as he might be outside German-speaking countries. Perhaps because *Arts & Humanities Citation Index*™ (*A&HCI*™) has a distinctly Anglo-American bias, Canetti did not appear on our list of the 100 most-cited authors of twentieth-century literature.[78] This study compiled citation data from *A&HCI* for the years 1977-1978. We found that 50 authors of twentieth-century literature had been cited 55 or more times during those two years. Canetti was cited over 100 times in the five years spanning 1976-1980, but most of these citations were in the years 1979 and 1980. This sudden burst of attention may be due to the English translations of many of Canetti's works which appeared in the late-1970s. However, we did increase the number of journals covered in *A&HCI* in 1979 and again in 1980. This in itself may have caused the increase in citations to Canetti's work. *A&HCI* now covers over 1,100 journals, and it is quite possible that Canetti would appear on an updated list of the most-cited authors of twentieth-century literature.

It is important to remember that the citation patterns for writers in *A&HCI* often differ from those of scientists. As their work becomes incorporated into the body of scientific knowledge, many scientists are eventually obliterated from the citation record.[79,80] By contrast, literary figures become increasingly cited as their work is studied and appreciated by scholars. As with many Nobel laureates in the past, Canetti is sure to receive far more attention now that he has won the prize.

Authors in *A&HCI* also can have very different publication records from those in the sciences. Nobel prizewinners in sci-

ence are generally known for their steady production of important articles throughout their careers. Artists may be more erratic, as Canetti's case shows. *Auto-da-Fé*,[72] Canetti's novel and first book, was published in 1935, but between 1938 and 1960 the author published almost nothing at all.[81] During the last two decades, however, Canetti has frequently appeared in print. In 1960, he published his study of mass psychology, *Crowds and Power*,[75] which received 26 citations from 1966 to 1980 in *SSCI*. Since 1960, however, Canetti has published six books, including his impressions of a trip to Morocco,[82] and sketches of 50 monomaniacal characters.[83]

Although the Nobel prize is the most esteemed award in the world, it has been criticized in the past because of the narrow range of fields covered.[3] Since its inception in 1901, the Nobel prize has seen very few changes, despite a huge growth in scientific research. An additional prize in economics was instituted in 1969 by the Bank of Sweden to celebrate its 300th anniversary.

However, in late-1980, Swedish industrialist Holger Crafoord endowed a new series of scientific prizes in neglected fields. These include geosciences, biosciences (especially ecology), mathematics with astronomy, and arthritis research. The Royal Swedish Academy of Sciences did not give awards in these fields in 1981, but there will probably be one prize in a single subject each year, rotating on a four-year cycle.[84] The new prizes should generate lively interest in these other areas of research, and honor additional authors *of Nobel class*. I will, however, in the future have more to say about the numerous other "Un-Nobel" prizes which are not only highly prestigious but emphasize the limitations of any single award to recognize the wide diversity of talent and genius in the world. That is one of the reasons why I persist in these studies. The evidence for a strong correlation between peer judgment and citation impact is increasing. So is the evidence that this correlation is being recognized. But as I said nearly 20 years ago,[85] we must never assume blindly that the most-cited authors deserve the Nobel prize.

* * * * *

My thanks to Joseph Pickett and Bella Teperov for their help in the preparation of this essay.

REFERENCES

1. **Garfield E.** Are the 1979 prizewinners *of Nobel class? Essays of an information scientist*. Philadelphia: ISI Press, 1981. Vol. 4. p. 609-17.
2. ----------. The 1980 Nobel prizewinners. *Current Contents* (31):5-17, 3 August 1981.
3. **Zuckerman H.** *Scientific elite*. New York: Macmillan, 1977. 335 p.
4. **Schlit A A.** Spectroscopy. *McGraw-Hill encyclopedia of science and technology*. New York: McGraw-Hill, 1977. Vol. 12. p. 717C-22C.
5. **Hollander J M & Shirley D A.** The 1981 Nobel prize in physics. *Science* 214:629-31, 1981.
6. **Lubkin G B.** Nobel physics prize to Bloembergen, Schawlow and Siegbahn. *Phys. Today* 34(12):17-20, 1981.
7. **Stoicheff B P.** Laser spectroscopy shares prize. *Science* 214:631-3, 1981.
8. **Schawlow A L & Townes C H.** Infrared and optical masers. *Phys. Rev.* 112:1940-9, 1958.
9. **Burgess D D.** A spectrum of achievements. *Nature* 294:111-2, 1981.
10. **Sullivan W.** Physics: to the heart of matter. *NY Times* 20 October 1981, p. C2.
11. **Siegbahn K, Nordling C, Fahlman A, Nordberg R, Hamrin K, Hedman J, Johansson G, Bergmark T, Karlsson S E, Lindgren I & Lindberg B.** *ESCA: atomic, molecular and solid state structure studied by means of electron spectroscopy*. Uppsala: Almqvist & Wiksells, 1967. 283 p.
12. **Siegbahn K, Nordling C, Johansson G, Hedman J, Hedén P F, Hamrin K, Gellius U, Bergmark T, Werme L O, Manne R & Baer Y.** *ESCA applied to free molecules*. New York: Elsevier, 1969. 200 p.

13. **Siegbahn K,** ed. *Alpha-, beta- and gamma-ray spectroscopy.* Amsterdam: North-Holland, 1965. 2 vols.
14. **Garfield E.** Play the new game of twenty citations! Wherein ISI reveals the fifty most frequently cited "non-journal" items. *Essays of an information scientist.* Philadelphia: ISI Press, 1977. Vol. 1. p. 224-8.
15. **Townes C H & Schawlow A L.** *Microwave spectroscopy.* New York: McGraw-Hill, 1955. 698 p.
16. **Garfield E.** A core research library for developing graduate schools—the 100 books most-cited by researchers. *Essays of an information scientist.* Philadelphia: ISI Press, 1977. Vol. 2. p. 1-5.
17. ----------. The 250 most-cited primary authors, 1961-1975. Part I. How the names were selected. *Essays of an information scientist.* Philadelphia: ISI Press, 1980. Vol. 3. p. 326-36.
18. ----------. The 1,000 contemporary scientists most-cited 1965-1978. Part 1. The basic list and introduction. *Current Contents* (41):5-14, 12 October 1981.
19. **Bloembergen N.** Citation Classic. Commentary on *Phys. Rev.* 73:679-712, 1948. *Current Contents* (18):7, 2 May 1977.
20. ----------. Citation Classic. Commentary on *Nonlinear optics.* New York: Benjamin, 1965. 222 p. *Current Contents/Engineering, Technology & Applied Sciences* 10(39):12, 24 September 1979.
21. **Bloembergen N, Purcell E M & Pound R V.** Relaxation effects in nuclear magnetic resonance absorption. *Phys. Rev.* 73:679-712, 1948.
22. **Garfield E.** The 250 most-cited primary authors, 1961-1975. Part III. Each author's most-cited publication. *Essays of an information scientist.* Philadelphia: ISI Press, 1980. Vol. 3. p. 348-63.
23. ----------. Highly cited articles. 36. Physics, chemistry and mathematics papers published in the 1940s. *Essays of an information scientist.* Philadelphia: ISI Press, 1980. Vol. 3. p. 54-60.
24. ----------. A list of 100 most cited 'chemical' articles. *Essays of an information scientist.* Philadelphia: ISI Press, 1977. Vol. 2. p. 37-44.
25. ----------. The second fifty papers most cited from 1961-1972. *Essays of an information scientist.* Philadelphia: ISI Press, 1977. Vol. 2. p. 21-5.
26. **Bloembergen N.** *Nonlinear optics.* New York: Benjamin, 1965. 222 p.
27. **Garfield E.** ABCs of cluster mapping. Part 1. Most active fields in the life sciences in 1978. *Essays of an information scientist.* Philadelphia: ISI Press, 1981. Vol. 4. p. 634-41.
28. ----------. ABCs of cluster mapping. Part 2. Most active fields in the physical sciences in 1978. *Essays of an information scientist.* Philadelphia: ISI Press, 1981. Vol. 4. p. 642-9.
29. **Boffey P M.** 2 share Nobel in chemistry; 3 win in physics. *NY Times* 20 October 1981, p. A1; C2.
30. **Garfield E.** The mysteries of ISI's international *OATS* library service revealed (again)! *Essays of an information scientist.* Philadelphia: ISI Press, 1977. Vol. 2. p. 55-7.
31. Five win Nobels for chemistry, physics. *Chem. Eng. News* 59(43):6-7, 1981.
32. **Hoffmann R & Woodward R B.** Letter to editor. (Selection rules for concerted cycloaddition reactions.) *J. Amer. Chem. Soc.* 87:2046-8, 1965.
33. **Woodward R B & Hoffmann R.** Letter to editor. (Selection rules for sigmatropic reactions.) *J. Amer. Chem. Soc.* 87:2511-3, 1965.
34. **Schwarzschild B M.** Chemistry prize to Fukui and Hoffmann. *Phys. Today* 34(12):20-2, 1981.
35. **Richards G.** Rules for chemical reactions. *Nature* 294:114, 1981.
36. **Streitwieser A.** The 1981 Nobel prize in chemistry. *Science* 214:627-9, 1981.
37. **Fukui K.** Recognition of stereochemical paths by orbital interaction. *Account. Chem. Res.* 4:57-64, 1971.
38. **Fukui K, Yonezawa T & Shingu H.** A molecular orbital theory of reactivity in aromatic hydrocarbons. *J. Chem. Phys.* 20:722-5, 1952.
39. **Fukui K, Yonezawa T, Nagata C & Shingu H.** Molecular orbital theory of orientation in aromatic, heteroaromatic, and other conjugated molecules. *J. Chem. Phys.* 22:1433-42, 1954.
40. **Fukui K.** Personal communication. 1 September 1980.
41. **Garfield E.** More on forecasting Nobel prizes and the most cited scientists of 1972! *Essays of an information scientist.* Philadelphia: ISI Press, 1977. Vol. 1. p. 487-8.
42. **Hoffmann R.** An extended Hückel theory. I. Hydrocarbons. *J. Chem. Phys.* 39:1397-412, 1963.
43. **Garfield E.** The 300 most-cited authors, 1961-1976, including co-authors. 3C. Their most-cited papers and affiliation data. *Essays of an information scientist.* Philadelphia: ISI Press, 1980. Vol. 3. p. 711-22.
44. **Hoffmann R & Lipscomb W N.** Theory of polyhedral molecules. I. Physical factorizations of the secular equation. *J. Chem. Phys.* 36:2179-89, 1962.
45. **Woodward R B & Hoffmann R.** The conservation of orbital symmetry. *Angew. Chem. Int. Ed.* 8:781-853, 1969.
46. ----------. Die Erhaltung der Orbitalsymmetrie. *Angew. Chem.* 21:797-869, 1969.

47. **Hoffmann R.** Personal communication. 27 January 1980.
48. **Woodward R B & Hoffmann R.** *The conservation of orbital symmetry.* New York: Academic Press, 1970. 178 p.
49. **Garfield E.** Most-cited articles of the 1960s. 1. Physical sciences. *Essays of an information scientist.* Philadelphia: ISI Press, 1981. Vol. 4. p. 156-66.
50. **Woodward R B & Hoffmann R.** Letter to editor. (Stereochemistry of electrocyclic reactions.) *J. Amer. Chem. Soc.* 87:395-7, 1965.
51. **Trevarthen C.** Hemispheric modes of consciousness in the human brain. *Nature* 294:112-3, 1981.
52. **Gazzaniga M S.** 1981 Nobel prize for physiology or medicine. *Science* 214:517-8, 1981.
53. **Schmeck H M.** Scientists share Nobel prize for research on human brain. *NY Times* 10 October 1981, p. 1; 51.
54. **Whitteridge D.** Visual machinery of the brain. *Nature* 294:113-4, 1981.
55. **Lettvin J Y.** The 1981 Nobel prize for physiology or medicine. "Filling out the forms". An appreciation of Hubel and Wiesel. *Science* 214:518-20, 1981.
56. **Sperry R W.** Chemoaffinity in the orderly growth of nerve fiber patterns and connections. *Proc. Nat. Acad. Sci. US* 50:703-10, 1963.
57. *McGraw-Hill modern scientists and engineers.* New York: McGraw-Hill, 1980. Vol. 3. p. 142-3.
58. **Hubel D H & Wiesel T N.** Receptive fields, binocular interaction and functional architecture in the cat's visual cortex. *J. Physiol.—London* 160:106-54, 1962.
59. ----------. Receptive fields and functional architecture in two nonstriate visual areas (18 and 19) of the cat. *J. Neurophysiol.* 28:229-89, 1965.
60. **Wiesel T N & Hubel D H.** Single-cell responses in striate cortex of kittens deprived of vision in one eye. *J. Neurophysiol.* 26:1003-17, 1963.
61. **Garfield E.** The 100 articles most cited by social scientists, 1969-1977. *Essays of an information scientist.* Philadelphia: ISI Press, 1980. Vol. 3. p. 563-72.
62. **Hubel D H & Wiesel T N.** Receptive fields and functional architecture of monkey striate cortex. *J. Physiol.—London* 195:215-43, 1968.
63. **Samuelson P A.** 1981 Nobel prize in economics. *Science* 214:520-2, 1981.
64. **Vinocur J.** Tobin of Yale wins Nobel in economics. *NY Times* 14 October 1981, p. A1; D22.
65. **Markowitz H.** Portfolio selection. *J. Finan.* 7:77-91, 1952.
66. ----------. *Portfolio selection.* New Haven: Yale University Press, 1959. 351 p.
67. **Tobin J.** Liquidity preference as behavior towards risk. *Rev. Econ. Stud.* 25:65-86, 1958.
68. **Marbach W D & Gibney F.** Laurels for an old Roman. *Newsweek* 98(17):62, 1981.
69. **Garfield E.** The 100 most-cited *SSCI* authors, 1969-1977. 1. How the names were selected. *Essays of an information scientist.* Philadelphia: ISI Press, 1980. Vol. 3. p. 633-9.
70. ----------. The 100 books most cited by social scientists, 1969-1977. *Essays of an information scientist.* Philadelphia: ISI Press, 1980. Vol. 3. p. 621-32.
71. **Sinha S M.** *Nobel laureates of literature 1901-1973.* New Delhi: Chand, 1975. 397 p.
72. **Canetti E.** *Auto-da-Fé.* New York: Stein & Day, 1946. 464 p.
73. ----------. *The conscience of words.* New York: Seabury Press, 1979. 246 p.
74. ----------. *The human province.* New York: Seabury Press, 1978. 281 p.
75. ----------. *Crowds and power.* New York: Viking Press, 1963. 482 p.
76. ----------. *The tongue set free.* New York: Seabury Press, 1979. 268 p.
77. **Vinocur J.** Writer of Central Europe wins Nobel prize. *NY Times* 16 October 1981, p. A1; C20.
78. **Garfield E.** The 100 most-cited authors of 20th century literature. Can citation data forecast the Nobel prize in literature? *Essays of an information scientist.* Philadelphia: ISI Press, 1981. Vol. 4. p. 363-9.
79. **Merton R K.** *Social theory and social structure.* New York: Free Press, 1968. p. 27-9; 35-8.
80. **Garfield E.** The 'obliteration phenomenon' in science—and the advantage of being obliterated! *Essays of an information scientist.* Philadelphia: ISI Press, 1977. Vol. 2. p. 396-8.
81. **Sontag S.** Mind as passion. *NY Rev. Books* 25 September 1980, p. 47-52.
82. **Canetti E.** *The voices of Marrakesh.* New York: Seabury Press, 1978. 103 p.
83. ----------. *Earwitness.* New York: Seabury Press, 1979. 101 p.
84. **Walgate R.** Plugging Nobel gap. *Nature* 288:7, 1980.
85. **Garfield E.** Citation indexes in sociological and historical research. *Amer. Doc.* 14:289-91, 1963.