

Bibliographic Information:

Schaie, K. W.

A general model for the study of developmental problems.

Psychological Bulletin, 64:92-107.

August 1965.

Abstract:

Conventional longitudinal and cross-sectional methods are shown to be a special case of a general model for research on behavior change over time. The complete model requires consideration of the components of age, time and cohort differences. New research strategies are proposed that involve optimal combinations of the cross-sectional and longitudinal methods into sequential designs.

As an undergraduate student of R. D. Tuddenham at Berkeley, in 1951, I had become interested in changes in the adult development of psychometric intelligence. This interest led to a dissertation at the University of Washington under the direction of C. R. Strother, that involved the cross-sectional study of the Primary Mental Abilities from early adulthood into old age (cf. Schaie, 1958). I was fortunate enough to obtain access to one of the earliest Health Maintenance Organizations (Group Health Cooperative of Puget Sound), from the membership of which I obtained my dissertation sample. Some years later while preparing to teach a seminar on adult development, I became alerted to research findings suggesting that the steep linear age decrement in intelligence reported in cross-sectional studies (including my own) seemed contradicted by findings of longitudinal studies following the same individuals over time (e.g., Owens, 1953). I consequently decided to do a follow-up of my cross-sectional study to permit comparison of cross-sectional and longitudinal data in the same population, as well as drawing a new sample from the same population. This initial follow-up actually led to what is now one of the major longitudinal studies of adult psychological development, now in its 28th year (cf. Schaie, 1983).

Results of our initial follow-up replicated the steep cross-sectional age differences, while showing much less pronounced age changes within individuals, not reaching significance until the late 60s. This discrepancy led to theoretical analyses that showed the longitudinal and cross-sectional approaches to be special cases of a more general model for the study of change over time. Specifically it became clear that cross-sectional data confounded age and cohort differences, while longitudinal data confounded age and time-of-measurement (period) effects. Thus data obtained via the two methods can only agree if cohort and period effects are of trivial magnitude. A third method was then identified and named *time-lag* that compares samples of individuals of the same age at different point in times (e.g. college classes). This method, however, also confounds cohort and time-of-measurement effects.

The general model specifies the three components of age, cohort (year of birth), and time of measurement (period). It was shown that similar to the relation of temperature, volume and pressure in physics, specification of any two components would determine the third. As in physics, one might, however, be interested in any of the

three different combinations of two components. This led to the introduction of what are now called *sequential methods* of developmental data collection and analysis strategies, including the *cohort-sequential*, *time-sequential*, and *cross-sequential* paradigms (also cf. Schaie, 1977). I have recently begun to show that the remaining dependencies can be addressed by redefining the general developmental model in non-calendar terms (Schaie, 1984).

References

- Owens, W. A. Jr. (1953). Age and mental abilities: A longitudinal study. *Genetic Psychology Monographs*, 48, 3-54.
- Schaie, K. W. (1958). Rigidity-flexibility and intelligence: A cross-sectional study of the adult life span from 20 to 70. *Psychological Monographs*, 72, (462, Whole No. 9).
- Schaie, K. W. (1977). Quasi-experimental designs in the psychology of aging. In J. E. Birren & K. W. Schaie (Eds.), *Handbook of the psychology of aging* (pp. 39-58). New York: Van Nostrand Reinhold.
- Schaie, K. W. (1983). The Seattle Longitudinal Study: A twenty-one year exploration of psychometric intelligence in adulthood. In K. W. Schaie (Ed.), *Longitudinal studies of adult psychological development* (pp. 64-135). New York: Guilford Press.
- Schaie, K. W. (1984). Historical time and cohort effects. In K. A. McCloskey & H. W. Reese (Eds.), *Life-span developmental psychology: Historical and generational effects* (pp. 1-15). New York: Academic Press.

THE PENNSYLVANIA STATE UNIVERSITY

COLLEGE OF HUMAN DEVELOPMENT
UNIVERSITY PARK, PENNSYLVANIA 16802

Department of Individual and Family Studies
S-110 Henderson Human Development Building

Area Code 814
863-0241

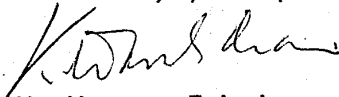
September 12, 1984

Ms. Bonnie Cohen
Editorial Features
Institute for Scientific Information
3501 Market Street
University Science Center
Philadelphia, PA 19104

Dear Ms. Cohen:

Enclosed please find the promised manuscript for your citation classics feature of *Current Contents*. I am also enclosing a copy of the original article.

Sincerely yours,



K. Warner Schaie
Professor of Human Development
and Psychology

Encl.



Institute for Scientific Information®

3501 Market Street
University City Science Center
Philadelphia, PA. 19104 U.S.A.
Tel. (215)386-0100
Cable: SCINFO
TELEX: 84-5305

August 3, 1984

Dr. K. W. Schaie
University of Southern California
Ethel Percy Andrus Gerontological Center
Los Angeles, CA 90007

Re: Psychol. Bull. 64:92, 1965

Dear Dr. Schaie:

Your above mentioned publication has been identified as one of the most cited items in its field, according to data from the Science Citation Index® (SCI®) and the Social Sciences Citation Index® (SSCI®). As a result, we would like to invite you to prepare a brief commentary and abstract on your work for publication in the Citation Classics section of Current Contents® (CC®).

The commentary may describe how the research was conceived, any obstacles you encountered, and why you think your publication is so frequently cited. The commentary will enable you to share with colleagues the personal side of your research, those experiences which rarely appear in formal scientific publications.

Current Contents is an information service which reproduces the contents pages of recent journal issues. Six weekly editions cover these disciplinary areas: (1) life sciences; (2) physical, chemical & earth sciences; (3) agriculture, biology, and environmental sciences; (4) engineering, technology, and applied sciences; (5) clinical practice; (6) social and behavioral sciences.

We hope you decide to accept our invitation. Your commentary will offer our readers valuable insight into how and why a publication becomes a Citation Classic. The enclosed "Author's Guide" explains the Citation Classics feature and describes the procedure for preparing your commentary. Please read all sections of the guide before writing your commentary. This will help us expedite your contribution through all phases of our production cycle. We would like to receive your manuscript within 30 days.

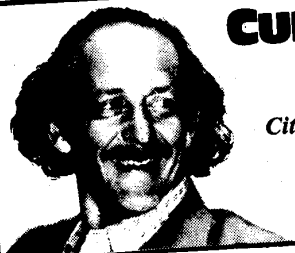
If you have any questions or comments, need more time, or decline to participate, please call me toll-free in the contiguous United States at 1-800-523-1850; in Pennsylvania, collect at 215-386-0100; or write.

Thank you in advance for your cooperation. I look forward to hearing from you.

Sincerely,

Bonnie Cohen
Editorial Features

4105A/K5
Enclosure



Current Comments®

EUGENE GARFIELD
INSTITUTE FOR SCIENTIFIC INFORMATION®

*Citation Classics—Four Years of the
Human Side of Science*

June 1, 1981

Number 22

Most readers of *Current Contents*® (*CC*®) are by now familiar with the *Citation Classics* feature which began in 1977. It seems to me that after four years of this weekly feature an evaluation is now in order.

In reviewing *Citation Classics*, one is immediately struck by the fact that our goals have changed somewhat in the past four years. Originally, we planned to draw our classics from a "group of 500 papers most-cited during the years 1961-1975."¹ By 1979, however, we realized the consequences of this narrow approach to selecting papers. Most of the 500 most-cited papers came from the life sciences. There are many reasons for this. Consequently, in 1979, in order to make our coverage more comprehensive and representative of all the fields of science, we began to publish six different classics each week—one for each edition of *CC*,² except *Arts & Humanities*. And in early 1981, to eliminate our backlog we began publishing two classics in *CC/Life Sciences* per week.

While citation frequency is a prime indication of a paper's impact, we have not rigidly adhered to any particular level of citation. A paper in one of the basic engineering sciences may be a classic even if it has been cited only 30 or 40 times. This would still be orders of magnitude greater than the number of citations received by millions of average

papers even in the life sciences. And in the social sciences, as in engineering, books often are as important as journal articles so we must apply separate criteria for them.

Apart from expanding the definition of a *Citation Classic* so that it comes closer to what scientists perceive as a classic, our basic goal in publishing *Citation Classics* has remained the same: to present the human side of science while paying tribute to diverse advances in science and scholarship. These commentaries were designed to allow scientists to talk about their major works from a personal standpoint, revealing what prompted the research, the contributions of coauthors, and obstacles that were encountered in both research and publication—in short, those details that are rarely revealed in formal scientific publication. The more than 750 classics published so far have exceeded my expectations.

I think it is unfortunate that scientific journals do not have the flexibility or the sense to provide some of this background. But in the context of a scientific journal, it may not be particularly relevant to learn, for example, that Martin Seligman's paper on the laws of learning resulted from an illness he contracted after eating béarnaise sauce.³ In this particular instance, although the illness was not related to the eating experience, it so conditioned Seligman that he

still (15 years later) cannot eat béarnaise sauce. The paper grew out of his conjectures on why this is so.

Once we have determined through various citation analyses that a paper is a milestone paper in its field, how do we get the essays, or vignettes, written? First, we contact the author and ask him or her to prepare a commentary. The author also receives an author's guide which explains the feature and the kind of information we'd like included in the commentary. The author also receives samples of published *Citation Classics*. We encourage the author to stress the personal factors involved in getting the original paper published and we ask for information about coauthors, and how and where the work took place. One of the most important questions is why he or she thinks the publication has been cited so often. In order to make the essay topical for readers interested in following up on the subject, we ask the author to cite a more recent review article or publication. We also ask each author to mention any awards or honors that resulted from the research. This is further confirmation that it is indeed a classic. I take particular pleasure in noting that the authors of several classics went on to be recipients of the National Academy of Sciences award for scientific reviewing.^{4,5}

Since we began *Citation Classics* in 1977, we've extended invitations to over 2,000 authors. It is somewhat disappointing to me that only about one third have accepted. Of course if we had a better response we'd have written fewer letters, but eventually we would have covered all of them. Another 100 authors have promised to send manuscripts, but have yet to do so. We telephone most to reinvite them. Nearly half of those asked, however, have simply never acknowledged our letters. We can't even be sure they were de-

livered. This is to be expected since many have moved.

I had been concerned about the possibility that an inordinate percentage of refusals and nonresponses involved foreign authors. What if some of these authors are unable or unwilling to prepare a commentary in English? But in fact about 30 percent of nonrespondents are from outside the US, closely comparable to what one would expect from the number of classics published. It also turns out that the refusal rate of about 50 percent for authors in English-speaking countries is almost identical for the other countries. This would dispel the notion of an English-language bias.

The average age of the classics covered today is 19 years, and the vast majority of classics (454) were published in the 1960s. One hundred sixty-one were published in the 1950s, 73 in the 1970s, 35 in the 1940s, and five in the 1930s. Of course, some authors have died since writing their classic articles, but we do accept surrogates if a coauthor is not available. About 100 authors responded but refused our invitation.

I am delighted to report that 14 Nobel prizewinners, not to mention dozens of other prizewinners and academy members, have taken the time to write about their *Citation Classics*. These positive responses make the varied reasons for refusal hard to comprehend. Some authors claimed a lack of time, others a lack of interest in their original papers, and still others expressed a feeling that it just wasn't worth the effort, especially if they have left the field. I think it is unfortunate because these authors deny their colleagues and society a perspective on their work that they alone can provide. In the future, we intend to ask one of their colleagues or students if they will prepare essays. These commentaries may become a part of our

forthcoming *Encyclopedic Atlas of Science*. And we hope to publish collections of these essays for use by graduate students and others interested in the way science actually works.

From the time the first *Citation Classics* was published on January 3, 1977, until the last classic of 1980 on December 29, 1980, we covered 728 classics in *CC*. By the end of 1981 this figure will exceed 1,000! Figure 1 provides a breakdown for the 24 countries represented at the time the authors published their classic papers. Most authors came from English-speaking countries. The US accounted for 502 papers, over two thirds; the United Kingdom, 93; Canada, 29; and Australia, 19. All but three of the original publications were in English. Of the remaining three, two were published in French, and one in German. One author claimed that when he first

Figure 1: Countries which produced original *Citation Classics* articles, with the number of papers from each.

Country	Number of Papers
US	502
United Kingdom	93
England	84
Scotland	8
Wales	1
Canada	29
Australia	19
Sweden	11
Federal Republic of Germany (FRG)	6
France	5
Denmark	3
Israel	3
Japan	2
South Africa	2
Switzerland	2
Argentina	1
Belgium	1
Finland	1
German Democratic Republic (GDR)	1
India	1
Mexico	1
The Netherlands	1
New Zealand	1
Spain	1
USSR	1
Not available	41

published his results in French journals the work received little attention.⁶ While this was not necessarily true for papers published in the 1950s, it is clear that publication in any foreign language today can delay recognition of significant work.⁷ Not all scholars accept this explanation alone, however. Derek J. de Solla Price, Yale University, for example, suggests that the preponderance of papers from English-speaking countries may be due in part to what he feels is an English-speaking bias in our citation index.⁸ I would argue that our bias is towards the high impact journals, regardless of their language. And it is quite possible that a few Russian authors are overlooked because citations to their papers may be fragmented in vernacular and translation journals.

Nearly 250 different institutions are represented in Figure 2 which lists addresses for the original publications. However, since many authors have moved, they now work at over 315 different institutions which are listed in Figure 3. If overlaps are eliminated, there are over 425 institutions. To save space we have not repeated the names of institutions named in Figure 2. The fact that so many new institutions show up in Figure 3 illustrates the growth of research worldwide and the migration of classic authors to other institutions. While most worked at academic institutions, industry and government are well-represented. These figures are based on the use of the addresses for first authors only. I doubt that including second authors would change much in this case. As could be expected from the examples set by our other citation studies, a few institutions dominate the lists. The combined campuses of the University of California, for example, top both lists. Forty classics were written at California, but 55 authors are now currently at work there. The migration to the west-

Figure 2. The institutional affiliations of *Citation Classics* authors, at the time they wrote their classic papers, with the number of authors from each.

University of California	40	Brookhaven Natl. Labs., Upton, NY	5	State University of Iowa	1
Berkeley	17	Duke University	5	UK Atomic Res. Estab., Harwell, UK	1
Davis	3	McGill University, Montreal, Canada	5	US Air Force	2
Irvine	1	Natl. Bureau of Standards, Washington, DC	5	US Army	2
Livermore	1	Natl. Res. Council of Canada	5	US Public Health Serv.	2
Los Angeles	7	State University of New York	5	US Steel Corp., Pittsburgh, PA	2
Riverside	2	University of Colorado	5	University of Birmingham	2
San Diego	3	Washington University, St. Louis, MO	5	University of Bristol	2
San Francisco	5	Commonwealth Scientific and Industrial Res. Organization (CSIRO), Australia	4	University of Georgia	2
Santa Barbara	1	New York University	4	University of Kansas	2
Natl. Inst. Health	10	Northwestern University	4	University of Miami	2
Natl. Cancer Inst.	6	Pennsylvania State University	4	University of Montreal	2
Natl. Heart, Lung and Blood Inst.	3	University of Edinburgh	4	University of Stockholm	2
Natl. Inst. Allergy and Infectious Disease	2	University of Lund, Sweden	4	Veterans Admin. Hosp., Bronx, NY	2
Natl. Inst. Arthritis, Metabolism and Digestive Disorders	1	University of Melbourne	4	Virginia Polytechnic Inst. and State University	2
Natl. Inst. Child Health and Human Development	3	University of Oregon	4	Walter and Eliza Hall Inst. Med. Res., Melbourne, Australia	2
Natl. Inst. Dental Res.	3	University of Toronto	4	Wellcome Res. Lab., Kent, UK	2
University of Wisconsin	24	IBM Corp., Yorktown Heights, NY	3	Woods Hole Oceanographic Inst., Woods Hole, MA	2
Harvard University	22	Indiana University	3	Aarhus University, Risskov, Denmark	1
Bell Labs., Murray Hill and Holmdel, NJ	18	Iowa State University	3	Abbott Labs., Chicago, IL	1
University of London	18	Mayo Clinic and Foundation, Rochester, MN	3	Academy of Natural Sciences, Philadelphia, PA	1
Birbeck Coll.	1	Michigan State University	3	Academy of Sciences of the GDR	1
Imperial Coll. Science and Technology	3	NASA, Greenbelt, MD	3	Allied Chemical Corp., Morristown, NJ	1
Inst. Cancer Res.	2	RCA Labs., New York, NY	3	American Cyanamid Co., Stamford, CT	1
Inst. Child Health	1	Rockefeller University	3	Argonne Natl. Lab., Argonne, IL	1
Inst. Psychiatry	1	US Naval Res. Lab., Washington, DC	3	Australian Department of Science and Industrial Res.	1
Lister Inst. Preventive Med.	1	University of Adelaide	3	Australian Natl. Observatory	1
Middlesex Hosp. Med. Sch.	4	University of Pittsburgh	3	Bonville Power Admin., Portland, OR	1
Royal Holloway Coll.	3	Weizmann Inst. Science, Rehovot, Israel	3	Bowling Green State University, OH	1
Royal Postgraduate Med. Sch. University Coll.	1	Albert Einstein Coll. Med., New York, NY	2	British Museum, London, UK	1
Johns Hopkins Univ. and Hosp.	14	Avco-Everett Res. Lab., Everett, MA	2	British Postgraduate Med. Sch., London, UK	1
Stanford University	13	Baylor University, Waco, TX	2	Canadian Department of Fisheries	1
California Inst. Technology	11	Brown University, Providence, RI	2	Cardiff Royal Infirmary, UK	1
Columbia University	11	Bucknell University, Lewisburg, PA	2	Chester Beatty Res. Inst., London, UK	1
University of Cambridge	11	Canadian Department of Agriculture	2	Children's Asthma Res. Inst. and Hosp., Denver, CO	1
University of Chicago	11	Case Western Reserve University	2	Children's Hosp., Boston, MA	1
University of Illinois	11	Colonial Sugar Refining Co., Indooropilly, Australia	2	Clinical Res. Ctr., Harrow, UK	1
University of Pennsylvania	10	Dow Chemical Co., Midland, MI	2	College of Veterinary Med., Finland	1
University of Washington, Seattle, WA	9	E. I. Du Pont de Nemours and Co., Wilmington, DE	2	Crookes Labs., Ltd., London, UK	1
Cornell University	9	Haskins Labs., New Haven, CT	2	Defense Res. Board, Canada	1
University of Texas	7	Humble Oil Co., Houston, TX	2	Defense Res. Estab., Granville, OH	1
Massachusetts Inst. Technology	7	Inst. Pasteur, Paris, France	2	Dennison University, Ipswich, UK	1
University of Minnesota	7	Massachusetts General Hosp., Boston, MA	2	Distiller's Co., Epsom, UK	1
Yale University	6	Medical Res. Council, UK	2	Eastman Kodak Co., Rochester, NY	1
Carnegie-Mellon University	6	Mount Sinai Sch. Med., New York, NY	2	Essex University, Colchester, UK	1
Oxford University	6	Natl. Inst. Med. Res., Mill Hill, UK	2	Fairchild Camera and Instrument Corp., Palo Alto, CA	1
US Department of Agriculture	6	Natl. Physical Lab., Middlesex, UK	2	Fels Res. Inst., Yellow Springs, OH	1
Agriculture Res. Ctr., Beltsville, MD	3	Oregon State University	2	Free Hosp. for Women, Brookline, MA	1
Cereal Science and Foods Lab., Peoria, IL	1	Peter Bent Brigham Hosp., Boston, MA	2	Geophysical Corp. of America, Bedford, MA	1
Agricultural Marketing Serv., Beltsville, MD	1	Princeton University	2	Glynn Res. Labs., Badminton, UK	1
Regional Poultry Res. Lab., East Lansing, MI	1	Public Health Res. Inst. of the City of New York	2	Grasslands Res. Inst., Hurley, UK	1
University of Michigan	6	Rothamsted Experimental Station, Harpenden, UK	2	Hoffmann-La Roche, Nutley, NJ	1
University of Rochester	6			Hosp. Infantil de Mexico, Mexico City, Mexico	1
				Houghton Poultry Res. Station, Houghton, UK	1
				Illinois Inst. Technology, Chicago, IL	1
				Bloomington, IL	1
				Imperial Cancer Res. Fund, London, UK	1
				Imperial Chemical Indust., Welwyn Garden City, UK	1
				Indian State Institution, New Delhi, India	1
				Inst. Advanced Study, Princeton, NJ	1
				Inst. Cancer Res., Philadelphia, PA	1
				Inst. Fisheries Investigation, Spain	1
				Inst. Psychiatric Res., Indianapolis, IN	1
				Inst. Res. Cancer, Villejuif, France	1
				Inst. Investigaciones Bioquímicas, Buenos Aires, Argentina	1
				Jackson Lab., Bar Harbor, ME	1
				Jewish Hosp., St. Louis, MO	1
				Johannes Gutenberg University, Mainz	1
				Kansas State University, Manhattan, KS	1
				Karolinska Inst., Stockholm, Sweden	1
				King Gustav V. Res. Inst., Stockholm, Sweden	1
				École Normale Supérieure, Paris, France	1
				Lund Inst. Technology, Sweden	1
				M.D. Anderson Hosp. and Tumor Institution, Houston, TX	1
				Martin Marietta Corp., Baltimore, MD	1
				Massachusetts Mental Health Ctr., Boston, MA	1
				Maudsley Hosp., London, UK	1
				May Inst. Med. Res., Cincinnati, OH	1
				Mead Johnson & Co., Evansville, IN	1
				Medical Coll. Georgia, Augusta, GA	1
				Methodist Hosp., Indianapolis, IN	1
				Minnesota Mining & Manufacturing Co., St. Paul, MN	1
				Mixing Equipment Co., Rochester, NY	1
				Mobile Oil Co., Princeton, NJ	1
				Natl. Inst. Mental Health, Rockville, MD	1
				Natl. Vegetable Res. Station, Wellesbourne, UK	1
				Natl. Women's Hosp., Auckland, New Zealand	1
				New York Blood Center, NY	1
				Nobel Medical Inst., Stockholm, Sweden	1
				North Carolina State University	1
				Oak Ridge Natl. Lab., TN	1
				Ohio Agricultural Experimental Station, Columbus, OH	1
				Ontario Cancer Inst.	1
				Ontario Res. Foundation	1
				Pneumoconiosis Res. Unit, Johannesburg, South Africa	1
				Polytechnic Inst. New York, Farmingdale, NY	1
				Portsmouth & Isle of Wight Area Pathology Serv., Portsmouth, UK	1
				Quartermaster Res. and Engineering Ctr., Natick, MA	1
				Research Board of Canada	1
				Rijksuniversiteit Leiden, The Netherlands	1
				Rockwell Park Memorial Inst., Buffalo, NY	1
				Rowett Inst., Bucksburn, UK	1
				Royal Coll. Science, London, UK	1
				Royal Coll. Surgeons of England, London, UK	1

1	Royal Danish Sch. Pharmacy, Copenhagen, Denmark	1	University of Geneva	1	Children's Hosp. Med. Ctr., Cincinnati, OH	1	Portland State University
1	Royal Radar Estab., Worcester, UK	1	University of Glasgow	1	City of Hope Natl. Med. Ctr., Duarte, CA	1	Queen Elizabeth Med. Ctr., Birmingham, UK
1	Royal Signals & Radar Estab., Malvern, UK	1	University of Hawaii	1	Canton Graduate Sch., CA	1	Queen's University, Kingston, Canada
1	Rijgers University, New Brunswick, NJ	1	University of Leeds	1	College of William & Mary	1	Queen's University of Belfast, UK
1	S. Mark's Hosp., London, UK	1	University of Liverpool	1	Communication Res. Ctr., Ottawa, Canada	1	Research & Laser Technology, Inc., Rockport, MA
1	Shell Development Co., Emeryville, CA	1	University of Louvain, Belgium	1	Decision Res., Eugene, OR	1	Rheimsche-Westfälische Technische Hochschule, Aachen, FRG
1	Sclair Res. Labs., Harvey, IL	1	University of Manitoba	1	Denver General Hosp.	1	Rice University, Houston, TX
1	Stan-Kettering Inst. Cancer Res., Rye, NY	1	University of Marburg	1	Dickinson College, Carlisle, PA	1	Royal Infirmary, Glasgow, UK
1	Srbonne, Paris, France	1	University of Maryland	1	Ecole Nationale Supérieure des Mines, Paris, France	1	Royal Liverpool Hosp., Liverpool, UK
1	Suibb Inst. Med. Res., NJ	1	University of Natal, South Africa	1	Ecology and Environment, Inc., Decatur, GA	1	Rutgers Med. Sch., Piscataway, NJ
1	Standard Oil Co., Whiting, NJ	1	University of Nebraska	1	Educational Testing Serv., Princeton, NJ	1	San Diego State University
1	Stas Federal Inst. Technology, Zürich, Switzerland	1	University of Newcastle-upon-Tyne	1	Florida Medical Entomology Lab., Vero Beach, FL	1	Soroka Med. Ctr., Beer-Sheva, Israel
1	Technische Hochschule Stuttgart, FRG	1	University of North Carolina	1	Freeman Hosp., Newcastle-upon-Tyne, UK	1	Southern Illinois University
1	Tokoku Pharmaceutical Sch., Sendai, Japan	1	University of Ottawa	1	Free Seeds Internatl., Bloomington, IL	1	Strangeways Res. Lab., Cambridge, UK
1	Tory Res. Station, Aberdeen, UK	1	University of Sydney	1	Georgetown University, Washington, DC	1	Swedish Department of Occupational Health
1	Tyts University	1	University of Tennessee	1	Hampshire District Pathology Serv., Portsmouth, UK	1	Syracuse University
1	Tulane University of Louisiana	1	University of Tokyo	1	Harris Corp., Melbourne, FL	1	Tokyo Inst. Technology, Japan
1	US Department of Commerce	1	University of Uppsala	1	Hazeltine Corp., Greenlawn, NY	1	Tropical Products Institution, London, UK
1	US Department of Health, Education, and Welfare	1	University of Utah	1	Hfp. de l'Enfant Jesus, Quebec, Canada	1	US Food and Drug Admin.
1	US Department of Interior	1	University of Vermont	1	Hughes Aircraft Co., Fullerton, CA	1	USSR Academy of Science, Moscow
1	US Geological Survey	1	University of Waterloo, Canada	1	Hungarian Academy of Sciences, Budapest	1	Uniformed Services University of the Health Services, Bethesda, MD
1	University College, Swansea, UK	1	University of Western Ontario	1	Ibaraki University, Mito, Japan	1	Unilever Res. Lab., Sharnbrook, UK
1	University College of Wales, UK	1	Vanderbilt University	1	Indiana Inst. Science, Bangalore, India	1	University of Alabama
1	University of Aberdeen	1	Veterans Admin. Hosp., Little Rock, AR	1	Indiana Sch. Med.	1	University of Amsterdam
1	University of Alaska	1	White River Junction, VT	1	Inst. Animal Physiology, Cambridge, UK	1	University of Barcelona
1	University of Arkansas	1	Wake Forest University	1	Inst. Biochemistry and Technology, Munster, FRG	1	University of Basel
1	University of Bern, Switzerland	1	Winston-Salem, NC	1	Inst. Nacional de Ciencias y Tecnología, Mexico	1	University of Exeter
1	University of Bradford, UK	1	Westinghouse Electric Corp., Pittsburgh, PA	1	Intel Corp., Santa Clara, CA	1	University of Göteborg, Sweden
1	University of British Columbia	1	Westminster Hosp., London, UK	1	International Lab. Res. Animal Diseases, Nairobi, Kenya	1	University of Haifa, Israel
1	University of Cincinnati	1	Wheeler Labs., Great Neck, NY	1	Israel Inst. Technology, Haifa	1	University of Iowa
1	University of Connecticut	1	Wissat Inst., Philadelphia, PA	1	Justus-Liebig University, Gießen, FRG	1	University of Kentucky
1	University of Copenhagen	1	World Data Ctr., Moscow, USSR	1	LaTrobe University, Bundoora, Australia	1	University of Laval, Canada
1	University of Durham	1		1	Lehigh University, Bethlehem, PA	1	University of Pierre and Marie Curie, Paris
1	University of Düsseldorf	1		1	Letterman Army Inst. Res., San Francisco, CA	1	University of Rhode Island
1	University of Florida	1		1	Lewisam Hospital, London, UK	1	University of Saarland, FRG
1	University of Freiburg	1		1	Liandough Hosp., Penarth, UK	1	University of Southern Alabama
					Loma Linda University Med. Ctr., CA	1	University of Southern California
					Long Island University, Greenvale, NY	1	University of Sussex
					Louisiana State University	1	University of Vienna
					Loyola University, Maywood, IL	1	University of Virginia
					McMaster University, Hamilton, Canada	1	University of Würzburg, FRG
					Meat Res. Inst., Langford, UK	1	Upljohn Co., Kalamazoo, MI
					Michigan Technological University, Houghton, MI	1	Varian/Extrio, Gloucester, MA
					Midwest Med. Lab., St. Louis, MO	1	Veterans Admin. Ctr., Louisville, KY
					Mill Hill Labs., London, UK	1	Veterans Admin. Hosp., Miami, FL
					Mississippi State University	1	Veterans Admin. Hosp., San Diego, CA
					Monash University, Clayton, Australia	1	Washington State University
					Montiflore Hosp. and Med. Ctr., New York, NY	1	Western Michigan University
					Mt. Holyoke College, South Hadley, MA	1	West Park Hosp., Epsom, UK
					Natl. Jewish Hosp. and Res. Ctr., Denver, CO	1	Wittenberg University, Springfield, OH
					New York Med. Coll., NY	1	YMCA Tribal Development Project, Tamil Nadu, India
					Oak Ridge Associated Universities, TN	1	Retired
					Optical Sciences Co., Placentia, CA	1	
					Pace University, New York, NY	1	
					Peter MacCullum Hosp., Melbourne, Australia	1	
					Pittman-Moore, Glenorie, Australia	1	
					Polish Academy of Sciences, Warsaw, Poland	1	

Figure 3: Citation Classics authors' current institutional affiliations which were not listed in Figure 2. The number of authors from each is also shown.

3	Bigham Young University, Provo, UT	1	All India Inst. Med. Sci., New Delhi, India
3	Tel Aviv University, Israel	1	American University, Washington, DC
3	Temple University, Philadelphia, PA	1	ARCO, Harvey, IL
3	University of Arizona	1	Arizona State University
3	University of Delaware	1	Bispebjerg Hosp., Copenhagen, Denmark
2	Banet's University, Waltham, MA	1	Bolt Beranek & Newman, Inc., Cambridge, MA
2	CRN (European Organization for Nuclear Res.) Geneva, Switzerland	1	Boston University
2	City University of New York	1	Bruce Lyon Memorial Res. Lab., Oakland, CA
2	Colorado State University	1	Brunei University, Uxbridge, UK
2	Exon Corp., Houston, TX	1	Brussels University, Belgium
2	Hämeann Med. Coll. and Hosp., Philadelphia, PA	1	CNRS, Strasbourg, France
2	University of Alberta, Edmonton, Canada	1	California Department of Health
2	University of Guelph, Ontario, Canada	1	Canadian Wildlife Serv.
2	University of Oklahoma	1	Cancer Control Agency of British Columbia, Vancouver, Canada
2	University of Paris	1	Cardiovascular and Chest Surgical Associates, Boise, ID
2	University of Southampton	1	Carlsberg Foundation, Copenhagen, Denmark
2	York University, Downsview, Ontario, Canada	1	Ctr. Studies of the Person, La Jolla, CA
1	Aldenbrooke's Hosp., Cambridge, England	1	Chalmers Inst. Technology, Göteborg, Sweden
1	Aeronautical Res. Lab., Melbourne, Australia	1	

ern US is significant. Also high on both lists are National Institutes of Health, 25 classics; University of Wisconsin, 24; Harvard, 22; Bell Labs., 18; University of London, 18; Johns Hopkins, 14; and Stanford, 13. Also prominent are Cornell, Columbia, University of Cambridge, University of Chicago, University of Pennsylvania, University of Washington, University of Texas, and State University of New York.

If we eliminate those institutions which account for only one paper, only 98 account for 523 classics. Similarly, only 105 institutions are involved in current affiliations. Seventy-three of these institutions appear on both lists. In Figure 4 there is a table showing the

Figure 4: The number of institutions which accounted for one or more classic papers.

Number of Papers	Number of Institutions
40	1
25	1
24	1
22	1
18	1
14	2
14	1
13	1
11	1
10	5
10	2
9	2
7	4
6	5
5	8
4	9
3	14
2	42
1	159

number of institutions which accounted for one or more classic papers.

We also studied the number of authors per paper. It is significant that there are so many single-authored papers—302. Nevertheless, multi-authored papers dominate. Of these, however, 245 had only two authors. Papers in clinical medicine had an average of three authors, more authors than the other disciplines. We also know that high-energy physics papers

have many authors. Figure 5 shows the number of papers for each group. The average number of authors per paper in the classics is 2.06. This is significantly lower (20 percent) than the 2.56 average for papers covered by the *Science Citation Index*® (SCIT®) in 1980.

Which types of papers become *Citation Classics*? We know that superstar methodology papers, especially in biochemistry, are to be expected. Nevertheless, less than one fourth of the papers involved are methodological. Almost one third were theoretical or experimental. The remaining large category was review papers—about 100. And another large group was papers or books which provided oft-cited tables and data of one kind or another or "tests." These are only crude measures, but it should dispel the notion that methodology papers dominate citation studies. But once a well-known procedure is adopted it may be cited thousands of times. The interesting question is why a small number of such classics fail to succumb to the obsolescence phenomenon.

Why are articles cited? The answer may seem, at first glance, quite simple, yet no one really knows—least of all the cited authors themselves! A surprising number of authors, upon receiving our request to comment upon their *Citation Classic*, have themselves questioned why their papers were cited. An equally large number of authors assert in their commentaries that they don't really know why they've been cited. It's amazing how many were not really aware how often or by whom they were cited. Only a small number are interested enough to go back to the citing papers through the SCIT to find out exactly why they've been cited. In correspondence with some authors, I've pointed out that only a content analysis of the citing papers can reveal the "why" of citation.

Figure 5: The number of authors per paper.

Number of Authors	Number of Papers
1	302
2	245
3	92
4	47
5	25
6	10
7	3
8	1
9	1
10	1
11	1

I also send them copies of a few ISI® papers in which we have done content analyses^{9,10} and recommend they get students to help with the library work involved.

Of course, many authors maintain extensive reprint collections related to their discoveries or have an intense interest in the way their work has been applied. Hans Krebs, for example, in his *Citation Classic*,¹¹ quotes from an historical evaluation of his classic paper on urea formation. But most authors merely make educated guesses as to why they've been cited so often. I urge them to do these content analyses, because they can lead to important review papers.

Authors frequently assert that timeliness was the main reason their papers had so much impact. Many feel that if their work had appeared earlier or later, it might not have received much notice. Others maintain that their papers were cited simply because they developed an often-used formula or procedure. Others believe that their papers were highly cited simply because they included a comprehensive review of the literature. But in my studies I have found that the influence of the *critical review* is significant—it doesn't simply serve as a convenient way to cite the earlier literature. Equally important, some of these authors correctly believe that the new or surprising or

even the startling results published in their papers stimulated more work on the same topic. Sometimes the citing author makes this self-evident, but more often than not this is only implied in the work.

Most authors correctly assume that their papers were cited for positive reasons. Only a few authors feel that their work was also cited for negative reasons, although in at least one case, the paper was often cited for negative reasons.^{12,13}

Understanding the "why" of citation is an area of research that interests sociologists of science. In fact, Susan Cozzens of ISI has recently summarized various theories about citations,¹⁴ and in particular Mike Moravcsik, Oregon University, has examined the types of citations in physics in detail.¹⁵ Their studies may lead to a better understanding of the processes of scientific discovery. In *The Force of Knowledge*, John Ziman, our salty colleague from the University of Bristol and editor of the *Philosophical Magazine* (a physics journal), points out the importance of citations to scientific knowledge:

A typical scientific paper is full of references or citations to the experiments, calculations, observations, or theories of other people. It does not strike out on its own into the unknown, but timidly takes one little step forward from the base secured by previous research. In other words, modern research is highly collaborative, despite all the competition. Everything we do is deeply indebted to, and embedded in, the achievements of our predecessors and contemporaries in our invisible College.¹⁶ (p. 100-1)

In a 1971 article on citation indexes prepared by ISI for the *Encyclopedia of Library and Information Science*, we listed 15 reasons that authors cite other works. Among them were to pay homage, to identify methods or equipment,

to provide background reading, and to give credit for related work.¹⁷

What some authors fail to recognize is that their "simple" discoveries make it possible for others to go on to do studies that were previously impossible. In evaluating the relative impact of highly cited papers the authors themselves can take the simplistic approach and assume that a paper was cited *simply* because a certain method or theory is used. But just as often the methodology is intertwined with other complex ideas that may never have been developed had not the methodology been employed. This was certainly the case recently when we examined why the work of R.M. Campbell *et al.* was cited.¹⁸

Perhaps the most fascinating aspect of *Citation Classics* is the perception of the author in evaluating the importance of the work in question. There is often a sense of irritation that we were not wise enough to realize that his or her most-cited work was not his or her most important. While we never make that assumption, it is somewhat distressing that we are resentful because there is not a one to one correlation between citation frequency and the author's evaluation of importance. Clearly many authors feel, and correctly so, that the classic article we have selected is their most important work. But the opposite reaction of Heinz Fraenkel-Conrat and his coauthors is typical of many other classic authors. "All three authors have at least ten other papers to their credit which they would list above this one in importance. And what this paper is quoted for is not its intrinsic point (which had some importance) but for the fact that it contains a paragraph describing the method of washing and suspending commercial bentonite clay."¹⁹ What Fraenkel-Conrat and others might have added is that some of their other articles were not only important papers but also qualify as *Citation Classics*.

Harriet Zuckerman, Columbia University, in her book *Scientific Elite*²⁰ discusses the phenomenon of the scientist who doesn't feel his highly acclaimed work is his most important. A significant number of Nobel prizewinners have these feelings. She offers some possible explanations. One, she says, is the fact that often the highly acclaimed work was the result of chance or serendipity. To some scientists, this seems less important, or valid, than something that was well thought-out or planned.²⁰

Drawing on the work of Robert Meriton, Columbia University, on the behavior of scientists, which demonstrated a common scientific drive for "recognized originality,"²¹ Zuckerman further points out that since often an acclaimed work represents an accidental discovery, for many scientists this is not considered particularly original. Thus such work is not as meaningful as a work that would "deepen scientists' understanding of large problems."²⁰ (p. 211) Many Nobelists seem to feel that if it hadn't happened to someone else, we have here the idea that many discoveries are "inevitable." One wonders how much this kind of thinking pervades the halls of Congress these days.

Finally, says Zuckerman, there may often be a disparity between the personal significance of a work to its author, and the scientific significance of the same work,²² that is, the acceptance of his or her peers. It's one thing to correlate an author's personal perception of importance to that of his or her peers and another to match this with actual impact as measured by citation frequency.

Still another explanation is offered by Lewis Goldberg, University of Oregon. In writing about his classic on the human judgment process, he notes that people frequently employ a technique he calls "availability" in decision mak-

ing. "When people have to estimate the frequency of an event," he writes, "they typically rely on the ease with which instances spring to mind. Use of such a tactic is not unreasonable, but under some circumstances it can lead us astray (e.g. the frequency of more striking or memorable events gets overestimated). So it is with me: had someone asked me to estimate which of my publications was the most frequently cited, I'd certainly have selected another!"²³

Taking a slightly different tack, Price hypothesizes that a failure of communication may actually be a major part of the problem. Many authors, he feels, are simply unable to evaluate their effectiveness at communication. An author, says Price, may well have discovered "the discovery to end all discoveries," but if he or she doesn't communicate that to others, it has little value. In other words, an author may be aware of the scientific quality of his or her work, but have no idea of the quality of communication. And, Price continues, citation frequency must be a product of the inherent quality of a work and the effectiveness of its communication.⁸ He concludes that whether we like it or not, the citation record is the most accurate index of the world scientific community's opinion of a scientist we have available.²⁴

The reader is, of course, the ultimate judge of whether the space and energy devoted to *Citation Classics* is worth the effort. I continue to read each and every classic before it is published. The quality has improved enormously over the years and in many instances we have been able to call attention to important work that has otherwise not been acknowledged. That many of the papers did elicit awards confirms our choice, but I take special satisfaction in serving as a public relations catalyst for many scientists who receive inadequate recognition for their work. Indeed, a large

number of individuals turn up here who do not show up on our lists of most-cited authors. This illustrates that not only the superstars make important contributions to progress. I also hope it emphasizes the need for scientists and administrators to concentrate on publishing fewer papers of higher quality and hopefully higher impact.

Perhaps one of the most important contributions our *Citation Classics* series has made is that we now have extensive examples of significant discoveries that were entirely unplanned, and in fact, often accidental. This serendipitous theme is quite prevalent. As L. Révész of the Karolinska Institute observed: "Clearly, this is another example of how futile it is to try to foresee the path of fundamental research, to say nothing of governing it."²⁵ *Citation Classics* can serve as an excellent model of the actual discovery process. It is for this reason that we hope to publish them in a collection for use by graduate students and others.

In closing, may I urge every CC reader to inform us of any paper or book which may qualify as a *Citation Classic*. Each suggestion will be carefully evaluated and, if we agree, the authors will receive an invitation at the earliest opportunity. We are not referring here to unrecognized but important research. That is an entirely separate area of research which we are studying intensively. We will discuss these "sleepers" in the future. And when we complete the compilation of the *SCI* for 1955-1964, we will be better able to identify certain classics which very quickly after publication became a part of the common wisdom of science.

* * * * *

My thanks to Susan Fell Evans for her help in the preparation of this essay.

© 1961 ISI

REFERENCES

1. **Garfield E.** Introducing *Citation Classics: the human side of scientific reports.*
Current Contents (1):5-6, 3 January 1977.*
2., Expansion of *Citation Classics*—250 unique commentaries each year.
Current Contents (1):5-12, 1 January 1979.
3. **Seligman M E P.** Citation Classic. Commentary on *Psychol. Rev.* 77:406-18, 1970.
Current Contents/Social & Behavioral Sciences (8):14, 25 February 1980.
4. **Garfield E.** The 1979 NAS James Murray Luck award for excellence in scientific reviewing:
G. Alan Robison receives the first award for his work on cyclic AMP.
Current Contents (18):5-9, 30 April 1979.
5., The 1980 NAS James Murray Luck award for excellence in scientific reviewing:
Conyers Herring receives second award for his work in solid-state physics.
Current Contents (25):5-7, 23 June 1980.
6. **Bernhard W.** Citation Classic. Commentary on *Cancer Res.* 20:712-27, 1960.
Current Contents/Life Sciences (10):14, 3 March 1979.
7. **Garfield E.** Do French scientists who publish outside of France and/or in English do better research?
Current Contents (22):5-10, 29 May 1978.*
8. **Price D J D.** Telephone communication. 20 April 1981.
9. **Small H G.** Cited documents as concept symbols. *Soc. Stud. Sci.* 8:327-40, 1978.
10. **Garfield E.** Citation measures of the influence of Robert K. Merton.
Trans. NY Acad. Sci. 39:61-74, 1980.
11. **Krebs H.** Citation Classic. Commentary on *Hoppe-Seylers Z. Physiol. Chem.* 210:33-66, 1932.
Current Contents/Life Sciences (52):12, 29 December 1980.
12. **Garfield E.** High impact science and the case of Arthur Jensen.
Current Contents (41):5-15, 9 October 1978.*
13. **Jensen A R.** Citation Classic. Commentary on *Harvard Educ. Rev.* 39:1-123, 1969.
Current Contents (41):16, 9 October 1978.
14. **Cozzens S E.** Taking the measure of science. (Restivo S P, ed.) New directions in the
sociology of science. *Int. Soc. Sociol. Knowledge Newsletter*, March, 1981.
15. **Moravcsik M J, Murugesan P & Shearer E.** An analysis of citation patterns in Indian physics.
Sci. Cult. 42:295-301, 1976.
16. **Ziman J.** *The force of knowledge.* London: Cambridge University Press, 1976. 374 p.
17. **Weinstock M.** Citation indexes. (Kent A & Lancour H, eds.) *Encyclopedia of library and
information science.* New York: Marcel Dekker, 1971. Vol. 5. p. 16-40.*
18. **Campbell R M, Cuthbertson D P, Matthews C M & McFarlane A S.**
Citation Classic. Commentary on *Int. J. Appl. Radiat. Isotop.* 1:66-84, 1956.
Current Contents/Life Sciences (41):14, 13 October 1980.
19. **Fraenkel-Conrat H.** Citation Classic. Commentary on *Virology* 14:54-8, 1961.
Current Contents/Life Sciences (23):14, 4 June 1979.
20. **Zuckerman H.** *Scientific elite.* New York: Free Press, 1977. 335 p.
21. **Merton R K.** Priorities in scientific discovery: a chapter in the sociology of science.
Amer. Soc. Rev. 22:635-59, 1957.
22. **Zuckerman H.** Telephone communication. 19 February 1981.
23. **Goldberg L R.** Citation Classic. Commentary on *Amer. Psychol.* 23:483-96, 1968.
Current Contents/Social & Behavioral Sciences (10):18, 9 March 1981.
24. **Price D J D.** Telephone communication. 28 January 1981.
25. **Révész L.** Citation Classic. Commentary on *Cancer Res.* 20:443-51, 1960.
Current Contents/Life Sciences (41):10, 8 October 1979.

*Reprinted in: **Garfield E.** *Essays of an information scientist.* Philadelphia: ISI Press, 1980. 3 vols.



Institute for Scientific Information®

3501 Market Street, University City Science Center, Philadelphia, PA 19104 U.S.A.
Telephone: (215) 386-0100, Cable: SCINFO, Telex: 84-5305

European Office

132 High Street, Uxbridge, Middlesex, UB8 1DP, U.K.
Phone: 44-895-30085, Telex: 933693 UKISI

OPC-S/83-77

AUTHOR'S GUIDE

Citation Classics is a weekly feature in *Current Contents*®(CC®). In this guide you will find a more detailed explanation of this feature, including how your publication was selected and information about how to prepare your manuscript for publication.

The Citation Classics Feature

Papers or books written in the sciences and social sciences usually contain cited references. A large number of citations to a particular publication usually indicates that the cited work has made a significant contribution to the development of scientific knowledge in its field. Also, the highly cited publication is often one that has had a lasting effect on the whole of science. Publications are identified by means of citation counts from our *Science Citation Index*® (SCI®) and *Social Sciences Citation Index*® (SSCI®) data base.

Six editions of *Current Contents* — 1) Agriculture, Biology & Environmental Sciences; 2) Clinical Practice; 3) Engineering, Technology & Applied Sciences; 4) Life Sciences; 5) Physical, Chemical & Earth Sciences; 6) Social & Behavioral Sciences — each feature a *Citation Classic* of special interest to readers of that edition. Because of the large number of highly cited life sciences publications, that edition of *Current Contents* presents two classics each week. The edition in which your commentary appears is read by individuals in your specialty as well as those in related fields, administrators, librarians, and information specialists.

Preparing Your Commentary for Publication

Content

Your commentary should be prepared from a personal standpoint. We encourage you to mention any humorous or unusual circumstances surrounding your work — those details that are rarely revealed in formal scientific publication. The commentary should contain a statement of where the research took place; what prompted your research; and contributions of coauthors. You should also discuss any obstacles you encountered in research and publication.

If you are not the senior investigator, please consult with him or her when preparing the commentary. If you wish, we can mail your manuscript to him or her after it is received here. If this is the case, could you please provide us with the name and address that we should send it to.

Please mention any award or honor that you may have received as a result of the work reported in your classic publication. If your publication has resulted in the creation of any new terminology it should be mentioned in your text.

Please include a statement about why you think the publication has been so highly cited.

Also, because it is often helpful to others and serves to bring the subject up to date, you should cite a *more recent review article or publication covering more recent work* in the field.

Style

The *Citation Classics* feature is limited to one page per week and follows a specific format; therefore, commentaries must conform to the following specifications.

- 1) **Bibliographic Information:** Please include on your manuscript this information about your highly cited publication:
 - a) the last names and initials of all authors;
 - b) full title;
 - c) full journal name (or publisher, year, and place of publication for books);
 - d) volume number;
 - e) beginning and end page number (or number of pages for books);
 - f) full date.

Please include a photocopy or a reprint of your original publication. For books, please include a photocopy of the title page.

- 2) **Abstract:** You must include a 35- to 45-word abstract of your classic publication. The abstract should briefly describe and summarize the main point of your highly cited publication. It is not necessary to detail methods or results.
- 3) **Text:** The text of your commentary should be about 450 words — no more than 500 words and no less than 400. Thus, if the margins on your typewriter are set at 50 characters apart, the proper length is 45 lines.

Severe variances from this suggested length might be cause for a request for a revised manuscript. We may edit manuscripts for grammar, clarity, consistency, and in some cases, length. Any substantial changes are subject to your approval.

References: It is essential that you include complete bibliographic information for each reference. If you mention any publication other than the one on which your *Citation Classics* commentary is based, it is important that it be properly referenced. References should be limited to six.

If you have any questions or comments about the preparation of your commentary, please call me, Bonnie Cohen, in the contiguous United States at 1-800-523-1850 or 1-800-523-1851; in Pennsylvania call collect at 215-386-0100; or write.

When your commentary is published you will be sent an issue of *Current Contents*.

Thank you for your cooperation.

This Week's Citation Classic

Warren J. R. Birth order and social behavior. *Psychol. Bull.* 65:38-49, 1966.
[College Student Personnel Institute, Claremont, CA]

Eminence, college attendance, intellectual achievement, and social responsiveness are more common among firstborn than later children. Schizophrenia, alcoholism, and delinquency are more common among the later born. Yet the evidence for those assertions is confused, and their implications are more cloudy still. [The Science Citation Index® (SCI®) and the Social Sciences Citation Index® (SSCI®) indicate that this paper has been cited over 190 times since 1966.]

Jonathan R. Warren
Educational Testing Service
Berkeley, CA 94704

December 3, 1981

"While at the University of Nebraska in the early-1960s I was struck with the seriousness of the eldest sons coming from the farm to the College of Agriculture. Schachter's book¹ had recently appeared and sharpened my interest in the psychological effects of birth order and in the mechanisms that produced them. At a College of Agriculture seminar, I learned that rotifers, microscopic water animals, became less robust with increasing age of the mother. Since then, biochemical changes in human mothers have been found to be associated with age and number of pregnancies. Physiological origins of birth order effects cannot be dismissed, although current explanations tend to focus on family structure and intrafamilial relationships. This interplay of influences represented by a deceptively simple and easily observed concept may account for the appeal of birth order as a topic of study. Further, like sex, age, and birth date, everyone has it, and like birth date can attribute mystical powers to it, such as those of the seventh son of a seventh son. Benjamin Franklin took great satisfaction in being the youngest son of a youngest son for five generations. Daughters in those days had no apparent importance.

1. Schachter S. *The psychology of affiliation: experimental studies of the sources of gregariousness*. Stanford, CA: Stanford University Press, 1959, 141 p.
2. Zolotor B. B. Family configuration and intelligence. *Science* 193:227-36, 1976.

This Week's Citation Classic

Deed E. L. Effects of externally mediated rewards on intrinsic motivation. *J. Persanal. Soc. Psychol.* 18:105-15, 1971.
[University of Rochester, Rochester, NY]

Monetary rewards were found to decrease intrinsic motivation for the rewarded activity — puzzle solving in a laboratory experiment and headline writing in a field experiment. By contrast, positive performance feedback enhanced intrinsic motivation for the target activity in a laboratory experiment. [The Social Sciences Citation Index® (SSCI®) indicates that this paper has been cited over 170 times since 1971.]

Edward L. Deci
Department of Psychology
University of Rochester
Rochester, NY 14627

November 6, 1981

"In a graduate seminar at Carnegie-Mellon University, Vic Vroom was discussing 'insufficient justification' research¹ when I realized how interesting it might be to consider the effects of different levels of justification on tasks of varying levels of intrinsic interest. I remember being terribly excited by the question, though I did nothing with it for a year. Somewhat later Vic and I were writing the introduction for a book of readings that we were preparing for Penguin.² In it we were considering the motivational assumptions that underlie different theories of management. Scientific management, for example, is very extrinsic, whereas participative management is primarily intrinsic, and we raised the possibility of combining the better elements of each approach. That led to the question of whether the two types of motivation are additive; the question interested me very much.

"A few weeks later I was startled by the realization that the two questions were real-

1. Festinger L. & Carlsmith J. M. Cognitive consequences of forced compliance. *J. Abnormal Soc. Psychol.* 58:203-10, 1959.

2. Vroom V. H. & Deci E. L., eds. *Management and motivation*. Baltimore, MD: Preagle, 1970, 399 p.

3. Deci E. L. & Ryan R. M., eds. *Intrinsic motivation and human behavior*. New York: Plenum, To be published.

4. (Berletoz L., ed.) *Advances in experimental social psychology*. New York: Academic Press, 1980, Vol. 13, p. 39-80.

This Week's Citation Classic

Deed E. L. Effects of externally mediated rewards on intrinsic motivation. *J. Persanal. Soc. Psychol.* 18:105-15, 1971.
[University of Rochester, Rochester, NY]

ly the same question. With that realization came a rush of excitement and a flood of ideas. I was nearing the end of my second year of graduate school and was ready to start my dissertation. I knew then that I had found the idea and the basic structure for studying it. I did three studies that explored the question, and they were published together as the article cited above.

"I think there are several reasons why the paper has been widely cited. For one thing, it explored an idea whose time had come. Quite independently, two other groups of researchers headed by Arie Kruglanski at Tel Aviv University and Mark Lepper at Stanford University were exploring the same question. The fact that we were all working on the same question at that time was an important factor in helping to generate interest in the area. I also think the concept of intrinsic motivation is a very compelling one that has a lot of relevance to people's lives. Rich Ryan and I are finishing a book³ in which we discuss the relevance of this area of research for education, psychotherapy, child rearing, and management. In addition, the findings from the research appeared to be contradictory to some basic tenets of the conditioning theories that were so central to psychology at that time, so a considerable controversy began. Finally, I think psychology is ready for a new field of human motivation, and the concept of intrinsic motivation holds promise. The area of research which arose following the publication of this article can be related to expectancy theory and attribution theory, which are of wide interest, but it also provides the basis for going beyond cognition to a level of analysis that is deeper in the individual and encompasses a wider range of human functions.

"Three years ago Ryan and I reviewed 50 studies on intrinsic motivation⁴ that had been done since this article was published. The book we are now finishing reviews twice that number."

1. Festinger L. & Carlsmith J. M. Cognitive consequences of forced compliance. *J. Abnormal Soc. Psychol.* 58:203-10, 1959.

2. Vroom V. H. & Deci E. L., eds. *Management and motivation*. Baltimore, MD: Preagle, 1970, 399 p.

3. Deci E. L. & Ryan R. M., eds. *Intrinsic motivation and human behavior*. New York: Plenum, To be published.

4. (Berletoz L., ed.) *Advances in experimental social psychology*. New York: Academic Press, 1980, Vol. 13, p. 39-80.

This Week's Citation Classic

Morton J. Interaction of information in word recognition. *Psychol. Rev.* 76:165-78, 1969. [Applied Psychology Research Unit, Cambridge, England]

Quantitative predictions are made from a model of word recognition on the effects of word frequency on recognition, the interaction of stimulus and context information, and the effects of repeated presentation of stimuli. The relevance of the model for studies of memory is discussed. [The Social Sciences Citation Index® (SSCI®) indicates that this paper has been cited over 285 times since 1969.]

John Morton
Applied Psychology Unit
Medical Research Council
Cambridge CB2 2EF
England

December 4, 1981

"As a graduate student I looked at the effect of a Reading Efficiency Course. It became clear that slow readers often had skills that were not being used, such as knowledge of the structure of language which could be used to 'predict' what was being read. So I studied the role of context on word recognition and showed that less stimuli information was required for a word to be identified if the word fit into a context. From this, I conceived the idea of a 'unit' corresponding to each word, at which stimulus and contextual information could interact and I described its properties. This unit was later called a 'logogen', following a suggestion at a conference by the physiologist Hallowell Davis (probably the most useful comment I have ever had at a conference!).

"My thesis was finished in 1961 and the material reached the journals in 1964. There wasn't much interest in the model I had developed and I did other things for a few years until I got interested in signal detection. I then realised that I could treat the model mathematically, which I did, and went on to write the cited paper which was a

1. Crowder R G & Morton J. Psycholinguistic acoustic storage (PAS). *Percept. Psychophys.* 5:365-73, 1969. [Citation Classic: *Current Contents/Social & Behavioral Sciences* 11(47):10, 19 November 1979.]
2. Morton J. Facilitation in word recognition: experiments causing change in the Logogen Model. [Colsons P A, Warrat M E & Berman H, eds.] *Processing in variable language*. New York: Praeger, 1979. Vol. 1, p. 259-68.
3. Morton J & Patterson K. A new attempt at an interpretation. [Culbert M, Patterson K E & Marshall J C, eds.] *Deep dyslexia*. London: Routledge and Kegan Paul, 1980. p. 91-118.
4. Basso M F, Donchin R & Sillman B. Synonyms neuropsychologiques et psychologiques cognitives. Trois exemples: splanin tacite, splanin phonologique et splanin orthographique. *Can. Psychol.* 23:211-46, 1980.

This Week's Citation Classic

Farm D E & Glauber R R. Multicollinearity in regression analysis: the problem revisited. *Rev. Econ. Statist.* 49:92-107, 1967. [Sloan School of Management, Massachusetts Institute of Technology, and Harvard Business School, Cambridge, MA]

This paper reviews the nature of multicollinearity among independent or predictor variables in regression analysis. It develops certain statistical measures which may be used to determine the presence of multicollinearity in a set of independent variables and, if present, the variables most seriously affected, and the pattern of interdependence among them. [The Social Sciences Citation Index® (SSCI®) indicates that this paper has been cited over 215 times since 1967.]

Donald E. Farrar
Benham Management Corporation
755 Page Mill Road
Palo Alto, CA 94304

December 3, 1981

"This paper was the first scholarly project I undertook on completing my doctoral dissertation. It grew out of my exposure to regression analysis and to standard multiple regression computer programs as a young economist in the early-1960s, together with my interest at the time in factor analysis as a technique for analyzing sets of highly interdependent variables in other empirical studies.

"Certain statistics which I did not understand, such as the determinant of the correlation matrix of independent variables and diagonal elements of the inverse correlation matrix, were produced routinely by standard multiple regression computer programs at the time. I was told they helped to diagnose multicollinearity among independent variables, but did not understand how or why. In an effort to understand this witchcraft, Robert Glauber and I immersed ourselves in the literature on distributional properties of closely related multivariate statistics, until finally we were able to develop transformations of the variables of interest (determinant and diagonal elements of inverse correlation matrix) which we

1. Belsey D A, Kuh E & Welsch R E. *Regression diagnostics: identifying influential data and sources of collinearity*. New York: Wiley, 1980. 292 p.

could interpret and whose distributional properties were known. We then added additional statistics through which one could identify patterns of interdependence among multicollinear variables.

"The paper has become something of a classic over the years for a number of reasons. First, multicollinearity is an important and ubiquitous problem faced by any economist in applying the most fundamental of econometric tools, multiple regression analysis. Our paper was the first which attempted to help practitioners understand and deal with the problem. Second, the statistics we proposed for diagnostic purposes were easily available by-products of standard calculations performed routinely by computers during the course of regression computations. Hence, they were easily and economically obtained and were incorporated in a number of standard computational routines. And third, the paper was reasonably well written. It is capable of being understood by most of the persons who would have an interest in the subject.

"I am not sure which of the above reasons is most important. I believe that being first in an important field helps. I'd also guess that most persons read the paper after encountering the statistics it suggests in realms of computer output rather than the other way around. And, perhaps, the exposition also helped.

"As a matter of passing interest, I recall that the paper was turned down by at least one journal and was accepted only grudgingly by the *Review of Economics and Statistics*, where it was the last rather than the lead article in the issue which carried it. I also recall that a senior colleague of my co-author did not like the paper, as it was not sufficiently Bayesian to satisfy his tastes. As a result, Glauber gave serious consideration at the last minute to withdrawing his name from the paper. Publication was not particularly important at the time for junior faculty at the Harvard Business School, but disapproval of one's work by a senior professor could be.

"I always liked the paper, however, and am pleased that it has left its mark in the literature and in the computing centers where work in our profession is done. A more recent review in this field has been written by Belsley, Kuh, and Welsch.¹

This Week's Citation Classic

CC/NUMBER 23
JUNE 7, 1982

McFall R M & Lillesand D B. Behavior rehearsal with modeling and coaching in assertive training. *J. Abnormal Psychol.* 77:313-23, 1971.
[University of Wisconsin, Madison, WI]

Nonassertive college students were taught to be more assertive about refusing unreasonable requests. Training was provided through two sessions of role playing, with the treatment program administered via prerecorded audiotape. Variations in treatments across subjects assessed the contributions of specific components. [The *Social Sciences Citation Index*® (SSCI)® indicates that this paper has been cited over 190 times since 1971.]

Richard M. McFall
Psychological Clinic
Indiana University
Bloomington, IN 47405

March 16, 1982

"As a graduate student of George A. Kelly,¹ I was interested in exploring the potential psychotherapeutic benefits of role playing techniques. After joining the faculty of the University of Wisconsin, I began looking for a psychological problem for which role playing might be a sensible treatment method. Joseph Wolpe and Arnold Lazarus² had reported successfully using 'behavior rehearsal,' a form of role playing, to teach socially anxious clients to behave more assertively; therefore, I decided to evaluate experimentally the value of role playing methods for 'assertive training.'

"My first experiment³ (with Albert R. Marston) convinced me that the prevailing conception of assertiveness was too ambiguous to be measured satisfactorily. Since my primary interest at the time was in assessing the treatment

effects of role playing, I decided to finesse the definitional problem by focusing on an extremely narrow but reliably measurable subtype of assertive behavior—namely, the refusal of unreasonable requests. At times I have regretted choosing such a narrow and negative referent for assertive behavior, as it has contributed to the tendency for people to equate assertion with abrasive, aggressive, and self-centered behavior. Nevertheless, from a research perspective, it proved to be a good decision.

"The next experiment (with Diane Bridges Lillesand) became this *Citation Classic*. Generally, I think the study was influential because it provided other investigators in the area with a fresh experimental paradigm and a set of novel measures that resolved several assessment and behavioral measures were prerecorded on audiotape, which enabled other laboratories to replicate our work. The study also happened to be one of the first controlled experiments on 'assertive training,' which was destined to become a popular topic in the 1970s.

"Although the study initially received mixed reviews, the editor (Donald Peterson) fortunately decided to publish it. He suggested a change in terms—from 'assertive training' (Wolpe and Lazarus's term) to 'assertion training'—for grammatical reasons. Subsequently, this change provided an unintended gauge of the study's impact; one could monitor the spreading use of the revised term.

"In recent years my research focus has evolved from the original narrow interests in role playing and assertion to a broader and more basic interest in the relationships among social competence, social skills, and psychopathology."⁴

1. Kelly G A. *The psychology of personal constructs*. New York: Norton, 1955. 2 vol.
2. Wolpe J & Lazarus A A. *Behavior therapy techniques*. Oxford: Pergamon Press, 1966. 106 p.
3. McFall R M & Marston A R. An experimental investigation of behavior rehearsal in assertive training. *J. Abnormal Psychol.* 76:295-303, 1970.
4. McFall R M. A review and reformulation of the concept of social skills. *Behav. Assess.* 4:1-33, 1982.

This Week's Citation Classic

CC/NUMBER 19
MAY 16, 1982

Meichenbaum D H & Goodman J. Training impulsive children to talk to themselves: a means of developing self-control. *J. Abnormal Psychol.* 77:115-26, 1971.
[University of Waterloo, Waterloo, Ontario, Canada]

The efficacy of a self-instructional (SI) training program was examined in two studies. The training program taught the impulsive child to talk to himself, initially overtly and then covertly. Relative to placebo and assessment control groups, the SI training group demonstrated improvement across tasks and over time. [The *Social Sciences Citation Index*® (SSCI)® indicates that this paper has been cited over 270 times since 1971.]

Donald H. Meichenbaum
Department of Psychology
University of Waterloo
Waterloo, Ontario N2L 3G1
Canada

March 1, 1982

"Several lines of investigation gave impetus to the design of this study. On the one hand a number of studies suggested that children who had problems with self-control were evidencing a 'meditational' deficit or an inability to use their own language to guide and control their nonverbal behavior. The impulsive and hyperactive child was described as someone who did not 'stop, look, and listen.'¹ Although a number of treatment approaches ranging from behavior modification to pharmacological intervention were being employed with children who had self-control problems, there was increasing concern about the limitation of these approaches in terms of generalization and durability of treatment effectiveness.

"It was within this context that a cognitive-behavioral self-instructional (SI) training program was developed. A training program designed to teach impulsive children a set of problem-solving skills or 'how to think' when confronted by academic and

social situations was developed with Joseph Goodman, a graduate student at the University of Waterloo.

"The format of the training was influenced by the developmental theory and research of the Soviet psychologists L. Vygotsky² and his student, A.R. Luria.³ They suggested that children become socialized by first responding to the instructions of an adult or older sibling and then internalizing those instructions in an abbreviated fashion as a form of inner speech. With age and task proficiency those self-verbalizations drop out of the child's repertoire.

"An analogy could be drawn to the following adult example. Consider for a moment how you learn a motor skill such as driving a stick-shift car or skiing. At the outset you likely talk to yourself in an intentional manner, but with proficiency these verbalizations drop out of your repertoire until your plan or the automaticity of your act is interrupted. At that point you likely talk to yourself once again. The SI training program was designed along these lines. Impulsive children were encouraged to talk to themselves, initially aloud and then covertly. They were then assessed on a variety of measures of self-control.

"Although the results of this initial study were at best encouraging, the study provided a powerful paradigm for interventions. In the last ten years we have learned a great deal about how to teach impulsive children, as well as a variety of other populations, how to talk to themselves.⁴ These procedures have now been applied to a host of populations ranging from adult psychotic patients to athletes, from retarded children to uncreative college students. We have learned how an SI training program can supplement other forms of interventions, and what are the limitations of the procedures.⁵ Our study has been cited so often because it pointed the direction for future cognitive-behavioral interventions. The study contributed to a shifting zeitgeist whereby psychological interventions were becoming more cognitive. Behavior modification was going cognitive as was psychology in general. This study fit the new mold."

1. Douglas V. Stop, look and listen: the problem of sustained attention and impulse control in hyperactive and normal children. *Can. J. Behav. Sci.* 4:259-76, 1972.
2. Vygotsky L. *Thought and language*. Cambridge: MIT Press, 1962. 168 p.
3. Luria A R. *The role of speech in the regulation of normal and abnormal behavior*. New York: Liveright, 1961. 148 p.
4. Meichenbaum D. *Cognitive-behavior modification: an integrative approach*. New York: Plenum Press, 1977. 305 p.
5. Meichenbaum D & Assouline I. Cognitive-behavioral modification and metacognitive development: implications for the classroom. (Kendall P & Hollis S, eds.) *Cognitive-behavioral interventions: theory, research and procedures*. New York: Academic Press, 1979. p. 11-36.