POINT/COUNTERPOINT

Suggestions for topics suitable for these Point/Counterpoint debates should be addressed to Colin G. Orton, Professor Emeritus, Wayne State University, Detroit: ortonc@comcast.net. Persons participating in Point/Counterpoint discussions are selected for their knowledge and communicative skill. Their positions for or against a proposition may or may not reflect their personal opinions or the positions of their employers.

Scientific citation indices are useful in evaluating medical physicists for promotion and tenure

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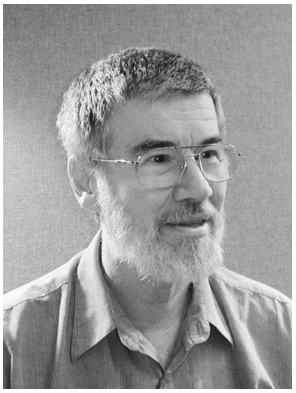
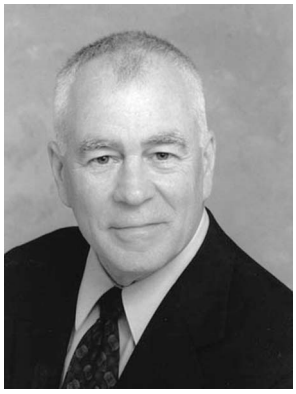
OVERVIEW

Citation indices (CIs), which can be obtained online from the Institute for Scientific Information (ISN) Web of Knowledge by subscription or through your hospital or college library, are measures of how frequently scientific publications are cited in subsequent articles by other authors. They can be viewed as an impact factor for an author's publications. In some institutions, CIs are evaluated by Rank and Tenure Committees that are considering individuals for promotion. Some well-recognized medical physicists support this practice, while others believe it puts individuals in highly-specialized disciplines (such as medical physics) at a career disadvantage. This controversy is the subject of this month's Point/Counterpoint.



Arguing for the Proposition is David W. O. Rogers, Ph.D. Dr. Rogers holds a Canada Research Chair in Medical Physics in the Physics Department of Carleton University in Ottawa. Previously he worked at the National Research Council of Canada where he headed the Ionizing Radiation Standards group from 1985. He obtained his Ph.D. in experimental nuclear structure physics under A.E. Litherland at the University of Toronto in 1972. His research centers around radiation dosimetry including clinical dosimetry protocols and the development and application of Monte Carlo techniques to medical physics problems. He currently serves as Deputy Editor of Medical Physics.



Arguing against the Proposition is William R. Hendee, Ph.D. Dr. Hendee received the Ph.D. degree in physics from the University of Texas. He joined the University of Colorado, ultimately serving as Professor and Chair of Radiology for several years. In 1985 he moved to Chicago as Vice President of Science and Technology for the American Medical Association. In 1991 he joined the Medical College of Wisconsin, where he serves as Dean of the Graduate School of Biomedical Sciences and President of the MCW Research Foundation. His faculty appointments are Professor and Vice Chair of Radiology, and Professor of Bioethics, Biophysics, and Radiation Oncology. He also is Professor of Biomedical Engineering at Marquette University and Adjunct Professor of Electrical Engineering at the University of Wisconsin-Milwaukee.

FOR THE PROPOSITION: David Rogers, Ph.D.

Opening Statement

If properly used, citation analysis can be a useful tool for a committee which is assessing a medical physicist since it gives one type of indication of the impact of the physicist's research, which we will assume is part of the physicist's job description.

Citation analysis is useful because it provides an assessment of the impact of a researcher by a broad range of his/or her international and mostly impartial peers, rather than by

committee members who most likely do not understand the research. It is a better indicator of the value of the research than a publication count since a persistent author can almost always get even a poor paper published.

Citation analysis can be used well or it can be used badly. One must be vigilant to avoid using the tool badly. So what are the ground rules for effective use of citation analysis? 1) Citation analysis must not be the only indicator used. The impact of a piece of work may not be reflected by citations, such as if a new technique is recommended in a Task Group report which subsequently receives the majority of the citations. 2) The citation counts must be appropriately compared to similar counts for a body of peers. Some perspective can be gained looking at the citation counts for the most cited papers in Medical Physics and PMB which were recently reported by Patterson.[1,2] These are a baseline on the upper limits on citation counts in the field. Even these most cited papers have relatively low citation counts compared to some other fields. 3) Self-citations must be removed from the counts. 4) The researcher being evaluated should be asked to provide a list of sources to be considered, since papers or reports outside ISI's journal database are only associated with the first author. For example, under my name you will not find any citations to the EGS4 manual which I co-authored since they are only listed under the name of my co-author WR Nelson. 5) One must account for the fact that medical physics research often has a long time constant, unlike some areas of biology where researchers can sometimes react to another paper's results in a matter of months. One of my papers was cited nearly twice as often 6 to 10 years after publication as in years 1–5. 6) In common with all evaluations of co-authored publications, the role of a given author in a published work needs to be assessed—was it a small part or the driving force for the whole project?

But how useful is citation analysis as an indicator? By going to http://scholar.google.com/ and typing in a name you can get a very quick indication of the impact of someone's research, as long as you compare the results to those of peers. However, this free site is not as comprehensive as the more rigorous results found at the subscription ISI Web of Knowledge.

One myth that must be dispensed with is the argument that an incorrect result will generate more citations than a correct paper. Only errors by highly regarded authors ever get broadly cited for the errors they contain, while most errors are just ignored.

In summary, citation analysis can provide a useful insight into the impact of an individual's research output. This must not be the only criterion used by a promotion committee, but it is a useful indicator when trying to judge the impact of work which is likely to be outside the committee's immediate fields of expertise.

Rebuttal

While I agree with many points that Dr. Hendee has made, I believe that the constraints I gave on what is the appropriate use of citation analysis covers many of his objections. So, for example, when selecting a proper peer group, account must be taken of the popularity of a given area of research. So it would not be appropriate to compare someone doing research in IMRT to someone investigating fundamentals of primary standards of air kerma in x-ray beams. On the other hand, within a hot mainstream field like IMRT there are researchers whose work has more impact and this is almost universally signaled by a high citation count. At the same time, there are many IMRT papers with few citations, despite this being an area with many publications. A promotion committee would have some useful information about a candidate if they knew which group the candidate's papers belonged to.

While I agree that truly major breakthroughs often do not come from the mainstream of research, I feel that when these major breakthroughs do occur, they will get widely cited. Einstein did not work in the mainstream in 1905, but even in his day his work was widely cited as evidenced by the many people we hear about who disagreed with his work. My opponent's quotation from Smolin, who makes many valid points, is nonetheless just Smolin's opinion and I would suggest it is not correct in general. Innovative papers are cited widely if the innovation is of any use, either to our understanding or in practice. We have all seen papers which were very innovative but of no value since no-one ever used them. We work in applied physics and if something isn't used, then what is the value? One characteristic of a strong researcher is to work on problems where the solution will have some impact. Should we reward someone for an innovative solution to an unimportant problem? An innovative breakthrough, even in a field outside the mainstream, will be cited frequently. I agree that there is the rare case of something only being found to be important much later, but the exception proves the rule.

In short, citation analysis, when done properly, allows a committee to evaluate the impact of an individual's work in a reasonably unbiased way. Citation analysis must never be the sole means of evaluation, but it can be a useful tool and a valuable component of the assessment.

AGAINST THE PROPOSITION: William Hendee, Ph.D.

Opening Statement

A citation index is a measure of the frequency with which a particular scientific publication is referenced by other scientists in their own publications in peer-reviewed journals. Publications that have a high citation index are widely interpreted as having greater impact on the scientific progress in a field than those that are referenced less frequently. Within a particular discipline, publication citations suggest that one's scientific work is contributing to a major pathway of research in the discipline, and that other scientists consider it to be credible and substantive.

Within limits, citation indices are a measure of the importance of one's scientific effort as viewed by peers, and often they are interpreted in this manner. However, a high citation index may reveal primarily that one is working in the main-

stream of research in a discipline, and that there are many other scientists working in the mainstream and citing each other's publications. An individual conducting research in an area where many others are working will have a higher citation index for publications than will a person in a discipline where fewer scientists are publishing. This difference in citation index is more a reflection of the number of researchers in the field than a measure of the relative importance of the publications. Further, a high citation index may indicate simply that one is in the mainstream of research rather than at the margin or on an independent pathway that few researchers are following. That is, the citation index is as much a measure of conformity as it is a measure of importance of one's work—and in many cases conformity overrides importance.

Major breakthroughs in science typically do not come from scientists working in the mainstream of research. Usually, they come from individuals of extraordinary creativity and independence who ask new questions, recognize unexamined assumptions, or extrapolate ideas from one field to another. As Smolin has described,[3] "Many of Einstein's contemporaries testified that he was not unusually talented mathematically. Instead, what enabled him to make such tremendous advances was a driving need to understand the logic of nature, tied to a breathtaking creativity and a fierce intellectual independence. But Einstein does not stand alone. One can cite many examples showing that big advances in physics come when unusually creative and intellectually independent individuals ask new questions and forge new directions." Smolin goes on to say:[3] "People who develop their own ideas have to work harder for each result, because they are simultaneously developing new ideas and the techniques to explore them. Hence they often publish fewer papers and their papers are cited less frequently than those that contribute to something hundreds of people are doing."

The risk in giving substantial weight to citation indices in evaluating scientists for promotion and tenure is that decisions may favor those working in the mainstream of well-populated fields of research, and reflect conformity of the research effort rather than original and independent thinking. The unusually creative and free-thinking scientist would frequently be penalized by the citation-index criterion, whereas the mediocre scientist pursuing inquiry along a common pathway with many others would be rewarded. This distinction is in exactly the wrong direction if truly creative scientists are to be nurtured, and fields such as medical physics are to thrive in the academic setting.

Rebuttal

In research institutions, several criteria are used to determine an individual's suitability for promotion and tenure. They include the level of peer-reviewed research support, the individual's publication record (number of publications and prestige of the journals in which they appear), and the stature of the individual as a researcher as attested to by highly-regarded peers. In some institutions, citation indices also are used.

Medical physicists often do not fare well in these analyses of productivity. Unlike other basic scientists, many medical physicists have heavy clinical workloads that interfere with their research efforts. Often they are engaged in teaching graduate students, residents and technologists, which also takes time from research. Medical physics research is frequently technology-focused rather than disease-focused, which presents challenges when seeking research support from the National Institutes of Health. And, finally, medical physics is a niche specialty within biomedicine, so that citation indices are smaller than those for scientists working in more-populated disciplines without the constraints facing medical physicists.

Even with these handicaps, many medical physicists are highly-productive researchers, educators and clinical physicists who deserve to be recognized and honored by the promotion and tenure process. This recognition requires insight by the rank and tenure committee into the profession of medical physics, and a willingness to judge physicists as individuals and not as cases to be evaluated against pre-established measures such as citation indices. Further, the committee must understand that scientific advances usually are made by individuals working at the margins of a discipline rather than in the mainstream, where the citation indices are invariably greater.

Intelligent decisions about rank and tenure require extraordinary knowledge and judgment about the worthiness of individuals. They should not be prejudiced by dependence on criteria that more often reflect conformity within a discipline rather than a presence at the frontiers of knowledge.

[1]M. S. Patterson, "Medical physics top ten," Med. Phys. **31**, 682 (2004).
[2]M. S. Patterson, "The physics in medicine and biology top ten," Phys. Med. Biol. **49**, L1–L4 (2004).
[3]L. Smolin, "Why no 'New Einstein'?," Phys. Today 56–57 (2005).