# FREE RADICALS


by Dale Hall

Papers from our **Journal** have been cited almost 60,000 times in the 1990s, and the **Journal** is routinely among the top two cited in electrochemistry. These are statistics of which we should be proud. Our **Journal** is full of interesting and useful information. But what makes papers interesting and useful, anyway? What factors influence which papers are read and used?

A recent article in *Psychological Science* (**7** (23), 69-75, 1996) by Robert Sternberg and Tamara Gordeeva provides some clues. They examined what makes an article influential in their field, psychology research, but their main points likely apply to other fields, including our own. What Sternberg and Gordeeva learned may be useful to you as both a producer and consumer of scientific publications. Sternberg and Gordeeva made a detailed survey of researchers in the field, asking them what factors make an article influential, and then analyzed the results with formal statistical methods. Their method was quite rigorous; as a result, it was also highly labor-intensive, so it doesn't and wasn't intended to supplant citation analysis and related methods. Citation analysis attempts to determine whether a paper is influential; the study by Sternberg and Gordeeva attempts to understand why.

Before examining Sternberg and Gordeeva's findings, we need to understand what "influential" means. My dictionary says, among other definitions, that to influence is to "have an effect on the condition or development of," in this case, science. Influence has components of both breadth and depth. In other words, a publication's influence increases with a broader audience and also with how profoundly it affects the thought and actions of that audience.

Sternberg and Gordeeva distilled a long list of specific publication attributes into six factors. Of the six, *theoretical significance* ranked highest in importance. Theoretical work of major significance often leads to a fundamental shift in thinking or a substantial and widely applicable increase in understanding. It's also often near the beginning of the research and development chain. If it's true, and it probably is, that work at any place in that chain can influence the thinking and work that occurs further down the chain, then the pool of researchers who may cite it or be influenced by it increases the more fundamental it is.

In contrast, *practical significance* ranked dead last and was preceded by *methodological interest*. If you're working on new chlor-alkali electrode materials or semiconductor wafer processing methods, your work is unlikely to become a citation classic. This doesn't necessarily mean that practically oriented work is either unimportant or inferior. It's just intended to be used in different ways. If the whole sequence from fundamental discovery to new products and processes wasn't producing economic and social value, there would be precious little money available for theoretical or any other work. Which was more important, the theory of relativity or the transistor? It depends on your point of view.

One of the principal reasons for communicating research discoveries is so that others can build on them. The whole structure of scientific publication and communication rests on the underlying belief that science as a whole advances much faster when ideas and results flow efficiently through the scientific community. Indeed, the *value for future research* ranked second as an indicator of impact in the Sternberg-Gordeeva study. Despite the ever-present desire to capture full value of discoveries by keeping them proprietary, science has been able to walk the fine line between secrecy and open sharing of information with considerable success.

If you've ever put down a poorly written paper or sneaked out of a terrible lecture, you won't be surprised to learn that *quality of presentation* ranked third as an impact indicator. To be fully appreciated, good work has to be well packaged and explained. Correspondingly, *substantive interest in terms of content and timeliness* ranked fourth, right behind presentation quality as an impact indicator. Work that captures the audience's interest and is timely is more likely to be influential. Sometimes, this takes curious forms. In our laboratory, for example, a researcher recently spent a fairly small amount of time studying the metallurgical properties of bolts from the Titanic's hull. Because of continuing public fascination with the subject and the fortuitous timing with a blockbuster movie, that small study caused hordes of reporters to descend on the laboratory, and front page stories appeared in major newspapers across the country. In terms of sheer general publicity, it will probably dwarf anything else our laboratory does this year.

Aside from such unusual cases, the circle of direct influence of scientific research is often quite small. The number of citations for even the most influential papers in many fields is quite low: not thousands, nor even hundreds, but tens of citations over the life of a paper may make it a standout in its field. This says something about the enormous diversity of science as an enterprise. Assuming that researchers in a given field recognize, read, and respond to leading-edge work, it also says something about the relatively small size of clusters of researchers in specific areas. There isn't as much depth of coverage in science as one might think. This, of course, is an important message to the public and to those who determine funding for science.

It's reassuring when a rigorous and analytical study produces results that correspond with common sense. As Sternberg and Gordeeva point out, "the factors seem to capture reasonable intuitions as to what psychologists should strive for when they seek to do work that will have an impact on the field." It's no accident that certain papers become highly influential. In every field of endeavor, and science is no exception, impact is the result of value delivered. ■