Does the Jerome H. Ely *Human Factors* Article Award Predict Scientific Impact?

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DOES THE JEROME H. ELY *HUMAN FACTORS* ARTICLE AWARD PREDICT SCIENTIFIC IMPACT?

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Does the "Jerome H. Ely *Human Factors* Article Award" predict scientific impact? We answered this question by investigating whether the 13 award winning papers published in *Human Factors* between 1987 and 2000 were cited much more frequently than the 730 non-award winning papers published during the same period. The results showed the award significantly increases the citation rate of articles, but accounts for only 0.2% to 1.3% of the variance in the citation rate. Author productivity accounts for far more variance in the authors' total citation rate (65.0%) and in the citation rate of the authors' most cited article (12.0%) than does award receipt. These results have practical implications for the objective recognition of scientific impact by professional societies and for the choice of research topics, particularly by graduate students.

INTRODUCTION

The theme of this year's conference, "Bridging Fundamentals and New Opportunities," provides both a stimulus and an opportunity for the human factors engineering community to examine fundamental scientific issues while breaking new ground for the Human Factors and Ergonomics Society (HFES). This research contributes to that goal by conducting a bibliometric analysis to better understand the nature of scientific impact in human factors engineering. Bibliometric studies use the citation history of scientific articles as data to examine how scientific contributions are accumulated and used (Ikpaahindi, 1985). This method has existed for decades, and has been used in many disciplines to understand better the nature of scientific activity. However, as far as we know, no rigorous bibliometric analysis has ever been conducted in the discipline of human factors. This gap in our science is likely a symptom of a trend highlighted by Meister (1999), namely that the discipline of human factors has rarely engages in self-reflection.

The specific question we addressed was whether the "Jerome H. Ely *Human Factors* Article Award" is predictive of scientific impact. The citation rate of each article published in *Human Factors* can be used as an approximate, retrospective "gold standard" measure of its actual impact (Zuckerman, 1977). If the award is predictive of scientific impact, then award-winning articles should garner many more citations than non-award winning articles. If this turns out not to be the case, then there may be other dependent variables, such as authorship productivity, that may be used to predict scientific impact (Simonton, 1997). In either case, the results will have practical implications for the objective recognition of scientific impact by professional societies and for the choice of research topics, particularly by graduate students.

METHOD

The ISI Web of Science electronic database (www.isinet.com/isi/products/citations/wos/index.html) was used to compile the citation history of articles published in *Human Factors*. Data were collected for articles published between 1987 and 2000. A total of 743 articles were included in the resulting citation database, which recorded: the title of each article, the authors, the date of publication, the number of citations received each year (as of May 2001), and the total number of citations received. This sample has several limitations that may constrain the generality of our findings. First, the database is limited to a single journal and so does not reflect the total productivity of many of the authors. Second, it is restricted to 14 years of publications and so it does not capture the lifetime contributions of many authors.

From this basic database, two databases were developed to support the citation analysis. One database characterized the authors of the articles including a description of the publication and citation history of the 1299 authors who contributed to *Human Factors* from 1987 to 2000. The other database characterized the citation history of each article. This database included the number of citations for each year after publication, the total number of citations, and the number of citations for each calendar year.

RESULTS

Does the Award Predict Impact?

The mean annual citation rates for the 13 award-winning articles in our sample were compared with those for the 730 non-award-winning articles. This comparison showed that the former were cited 1.53 times per year (sd = 1.09), whereas the latter were cited only 0.82 times per year (sd = 0.98) ($F(1,741) = 6.67$, $p<0.01$). Figure 1 shows a small but consistent effect of the award on the citation rate for one to 13 years after publication. If we examine the frequency with which award-winning articles are in the upper half of the most-cited articles published each year, we find that more award-winning articles appear in the top 50% than in the bottom 50% ($\chi^2(1)=5.32$, $p<0.05$). On the other hand, the impact of the award accounts for less than 1% of the variance in the citation data. Furthermore, of the 20 articles with the highest citation rate in our sample, only one—the 17th most frequently cited article—received the award. Moreover, none of the 13 articles with the highest citation rates of all of the articles published in each volume of *Human Factors* in our sample received the award. Collectively, these results suggest that the award has a significant, but only modest predictor of scientific impact.

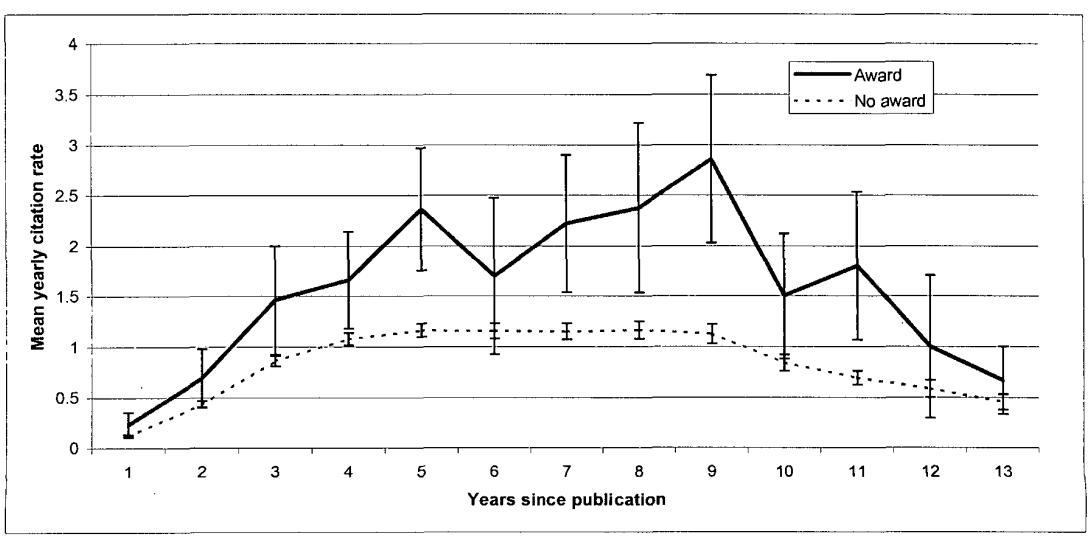

Figure 1. The citation history for Award and non-Award winning articles, 95% confidence intervals.

Perhaps other factors contribute more to scientific impact. Indeed, Simonton's (1997) theory of creative productivity suggests that the number of articles written by any given author would be a better correlate of a particular article's eventual citation rate than whether or not it receives an award. Three linear statistical models of article citation rate were constructed to compare how well receipt of the award and authorship productivity correlate with scientific influence.

Does Authorship Productivity Predict Impact?

Each of the three linear statistical models was constructed to test, first the predictive power of author productivity, and then the effect of the award. The effect of the award was evaluated by examining whether the incremental improvement in the model predictions was statistically significant, using the following equation:

$$F(1, N-2) = (R_p - R_{PA})\ ((N-2)/R_{PA})$$

R_P is the residual sum of squares of the model that includes only author productivity, R_{PA} is the residual sum of squares of the model that includes publications and award, and N is the number of articles or authors in the data set.

The first model considered whether the total number of articles written by an author is correlated with the citation rate of a particular article. A significant effect was observed ($F(1, 741) = 19.19$, $p < 0.001$). However, the number of articles written accounts for only 2.4% of the variance. While the effect of the award accounts for only an additional 0.8% of the variance, this incremental increase is also statistically significant ($F(2, 740) = 7.16$, $p < 0.01$). These results suggest that although the citation rate is not completely blind to the award or the history of author productivity, these effects are not particularly strong predictors of citation rate for an individual article.

The second model was developed at an aggregate level of analysis, and tested whether the total number of articles written by an author is the single best predictor of the total number of citations they will receive. Again, a significant effect was observed ($F(1, 1299) = 2411.14$, $p < 0.001$), this time accounting for 65.0% of the variance in the total citation rate of each author. Including the effect of the award accounts for a marginally greater proportion of the variance, for a total of 65.2%. Although quite small, the incremental increase is also statistically significant ($F(1, 1297) = 8.81$, $p < 0.01$). These results suggest that scientific impact is better explained at a higher level of analysis examining, not an individual article as in the first model, but rather the aggregate of an authors' articles.

The total number of articles written by an author can only be determined a posteriori, so the analyses reported so far suggest that scientific impact can only be measured retrospectively. If this result holds, then the citation rate of the authors' most-cited work should be sensitive to the total number of papers written. This prediction was confirmed by our third model, with the total number of articles written accounting for 12.0% of the variance in citation rate of the authors' most cited article ($F(1, 1298) = 179.07$, $p < 0.001$). Including the award accounts for a slightly greater proportion of the variance, for a total of 13.3% ($F(1, 1297) = 20.14$, $p < 0.001$). Table 1 summarizes the variance accounted for by the three statistical models we tested to predict citation rates.

Table 1. Summary of analysis to evaluate the effect of author productivity and Award receipt on citation rate, with the proportion of variance accounted by each factor shown in parentheses.

Predicted citation rate	Productivity	Award
Citation rate of an article	Total articles written by contributing authors (2.4%)	(0.8%)
Citation rate of an author	Articles written by author (65.0%)	(0.2%)
Citation rate of an author's most cited work	Articles written by author (12.0%)	(1.3%)

CONCLUSIONS

The results from our research suggest that the ability of the "Jerome H. Ely *Human Factors* Article Award" to predict scientific impact is, at best, weak and inconsistent, accounting for only 0.2% to 1.3% of the variance in the citation rate of articles. Instead, author productivity seems to provide a much stronger correlate of scientific impact, accounting for 65% of the variance in the authors' total citation rate and 12.0% of the variance in the citation rate of the authors' most-cited article. These results suggest that the award process may not be able to select articles that will be the most highly cited, but that it can differentiate them from those that are unlikely to ever be cited.

These findings are limited to a database that includes articles from a single journal. Most authors of *Human Factors* articles publish in several different journals and so a database that is limited to a single journal could introduce important biases. For example, an author may be very prolific, but may publish in *Human Factors* only occasionally. This bias would tend to inflate the variance accounted for by the award. To the extent that author reputation within the human factors community affects the award, the focus on author's publications in only *Human Factors* would tend to inflate the role of the non-award factors.

Even with these caveats, these findings have practical implications, both for HFES and for human factors researchers. First, our research suggests that professional recognition of scientific impact in the form of awards should consider aggregate objective measures, such as citation rates and authorship productivity, rather than subjective measures, such as review by a panel of experts. This evidence-based observation is a reflection of how science works, and thus is not a critique of HFES or of the members of the Ely award selection committee. As Simonton (1997) pointed out, scientific creativity "is to some significant degree blind or haphazard. This means that at some crucial level the individual has no a priori way of foreseeing which ideational combinations will prove most fruitful" (p. 67). Consequently, scientific impact can only be reliably identified retrospectively rather than prospectively, although there is no reason why awards could not be given after scientific impact has been firmly established. For example, ISI typically rewards the most influential articles in particular fields with the status of "Citation Classics" based on the citation rate.

Second, our research suggests that the most reliable way to contribute to science is by continually generating new ideas rather than by trying to hone in on scientific impact a priori. The evidence we have presented shows that the latter approach is statistically unlikely to bear fruit (see also Simonton, 1997). This lesson is relevant, not just to seasoned human factors researchers, but especially to graduate students who are selecting topics for their theses and who are considering a career as researchers. Better understanding how science really works can encourage our students to enjoy the repeated fun of scientific discovery rather than live with the worrisome and unrealistic burden of deliberately selecting a singular thesis topic that will lead to a Nobel prize.

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