Assessing citations with the EigenfactorTM Metrics

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For more than 80 years, researchers and administrators alike have evaluated the prestige and productivity of researchers, institutions, journals, and even nations by counting citations.[1] For the past half-century, the *impact factor* [2] has been the most prominent of these citation metrics. Impact factor is essentially a measure of the average number of citations that a journal's articles receive over the two calendar years following publication. As a citation metric, impact factor has a number of virtues, not the least of which are that it is simple to describe and easy to calculate.

But there are also drawbacks to the impact factor. In particular, impact factor does not account for differences in prestige among the citing journals[3] and does not account for differences in citation patterns within and across disciplines.[4] Thus in the impact factor calculation, a citation from *Nature* is worth no more than a citation from a second-tier review journal, and a citation in the field of mathematics (where bibliographies are short and recent citations are scarce) is worth no more than a citation in the field of immunology (where bibliographies are long and recent citations are common).

To remedy these issues, we have developed the Eigenfactor™ Metrics as a complement to impact factor and other measures based on direct citation counts. The basic idea behind the Eigenfactor Metrics is that scholarly citations form a vast network of links among papers and journals (as noted by de Solla Price[5]), and we can use the full structure of the network to evaluate the importance of citations from various sources. Specifically, we rank the journals much as Google's PageRank™ algorithm ranks Web pages: we consider a journal to be important if it receives many citations from other important journals. While this might sound circular, one can iteratively calculate such journal rankings using a simple algorithm. Our methods are described in detail at http://www.eigenfactor.org/methods.htm.

We have used the Eigenfactor Metrics with a variety of bibliometric data sources. At our freely available Web site http://www.eigenfactor.org, we present Eigenfactor Metrics for scholarly journals, computed using citation data from the Thomson Reuters Journal Citation Reports (JCR). We compute two scores for each of the journals listed therein. The Eigenfactor Score™ scales with the size of a journal and thus measures the journal's total importance. All else being equal, larger journals have larger Eigenfactor Scores. *Neurology*®'s 2006 Eigenfactor Score of 0.204 means that *Neurology* receives an estimated 0.2% of all of the citation traffic in all of the JCR-listed journals. This percentage may sound small, but recall that the JCR lists over 7,000 journals in 2006. The Article Influence™ Score reflects a journal's prestige. It is a measure of the average influence, per article, of the papers in a journal and as such is comparable to the impact factor. Article Influence Scores are normalized around a mean of 1.0: *Neurology's* 2006 Article Influence Score of 2.01 means that its articles are on average 2.01 times as influential as the average article in the JCR database.

We close with a pair of caveats. First, impact factor and the Eigenfactor Metrics alike are *aggregate measures* of citation rate. They apply to the aggregate content of journals, not to the individual papers within them—and thus when valuing a single paper, the impact factor or Article Influence of the journal in which it appeared is a poor metric. At the very least, one should use a tool such as Web of Science®, Scopus™, or Google™ Scholar to tally the number of citations that the paper itself received. Better still, read the paper yourself or ask the opinions of experts who have done so.

Second, citation data are not the only way to quantitatively measure the value that a journal provides. For example, one could look at how often papers from a particular journal are downloaded instead of how many times those papers are cited. In the basic sciences, citation rate may serve as a good proxy for usage rate. In clinical fields, this is less likely to be the case. To assess more thoroughly the contribution of journals in clinical fields including

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neurology, it may be particularly important to consider not only citation data, but other direct measures of readership and usage such as those being developed by Johan Bollen at the MESUR project (http://www.mesur.org) in addition to the citation metrics such as those described here.

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