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Measure for Measure: Altmetrics

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By Beth Juhl

Unless you are a professional bibliometrician, the proliferation of information and statistics about scholarly publications and the burgeoning set of tools to capture and analyze those data can be confounding. This "Cambrian explosion of metrics"[1] is recent—a fast-moving, visibly evolving system, but one that has already left a few fossils in its wake. The taxonomy, too, of this new era is still being developed. As a shorthand term, "altmetrics" encompasses a range of measures from the extension of traditional citation analysis (with article-level metrics or ALMs) to social media's mentions, likes, tweets, and shares. This essay offers a snapshot of the transforming landscape of new metrics:

embarking from a brief discussion of the seminal works and tools for tracing scholarly impact, and moving on to survey some of the key publications addressing the need for—and use of—an alternative set of metrics. The essay then identifies and describes the new measurement tools currently available to institutions and individuals. Cited works at the end of the essay point out those tools and web resources that are open-access and those that require a paid subscription.

"The Number That's Devouring Science"[2]

THE SEARCH FOR ALTERNATIVE METRICS CAN be traced to the growing discontent with the use and misuse of the Journal Impact Factor developed by Eugene Garfield[3]—a

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measure that was itself designed to filter the proliferating number of scientific publications for quality and content relevant to scientific researchers.[4] Garfield has reiterated in numerous interviews and articles that the Journal Impact Factor, which measures the number of articles cited in individual *journals*, should never be used to assess the relative importance of particular *articles*, the stature of specific *scholars*, or the research rankings of *organizations* (departments, labs, or other research institutions).[5] Yet to some, numbers seem so scientific, unbiased, and straightforward that many researchers and their host of assessors cannot seem to resist their allure. The Journal Impact Factor and its trademarked companion measures—the *Immediacy Index*® and the *Cited Half-Life*®—are central to the *Journal Citation Reports* (*JCR*) and *Web of Science* citation-index databases published for many years by Thomson Reuters, whose intellectual property division is now, since October 2016, a

separate company, Clarivate Analytics. The citation indexes and measures developed by the predecessor Institute for Scientific Information (ISI), founded in 1960 by Garfield, were acquired by Thomson in 1992 to become Thomson ISI.[6] This toolkit continues to form the basis for librarians' collection decisions, as it has informed the evaluation of faculty tenure and promotion dossiers and is still misguidedly consulted by many to compare journals from different disciplines, disregarding different citation and publication patterns.

New tools and methods to analyze citation data emerged throughout the 2000s. In 2004, Elsevier launched a new database, *Scopus*, poised to be a direct competitor to *Web of Science*. *Google Scholar* also appeared on the scene in 2004. All three services offered large, cross-disciplinary article search engines. At the same time, each could also be mined for citation analysis at the author, article, journal, subject area, and (in the case of *Web of Science* and *Scopus*), the institutional level. Physicist Jorge E. Hirsch (Univ. of California San Diego) proposed the *h*-index in 2005 as a measure of the total number of papers published by a scholar and the times those papers have been cited by others.[7] The *h*-index can be applied to entire journals as well as authors, but like the Journal Impact Factor, the standard *h*-index score should not be compared across incommensurable disciplines with different citation patterns. Nascent cross-disciplinary indexes *Google Scholar* and Elsevier's *Scopus* quickly adopted the *h*-index, as did *Web of Science*. Later in the decade, bioinformatics professors Carl Bergstrom and Jevin West (both, Univ. of Washington) proposed the *Eigenfactor*®, another journal-level metric based on examination of five years of *Journal Citation Reports* data. Their lab went on to produce the *Article Influence*® score to

rank individual articles by frequency of citation. Both not-for-profit and commercial publishers explored new ways to help their authors and audiences visualize citation patterns and relative influence. Open-access publisher *PLOS* (known variously as *PLOS* or the Public Library of Science) introduced its *Article-Level Metrics* (ALMs) in 2009, not only tracking views on *PLOS* but also on the *PubMed Central* full-text platform (and the larger *PubMed* database). In 2015, the National Institutes of Health introduced a beta version of a new bibliometric tool, *iCite*. Leveraging *PubMed* article metadata, *iCite* presents citation reports for individual articles, authors, departments, labs, or institutions. Users can upload up to 1,000 PubMed IDs (PMIDs) to view data about citations to those articles from other publications indexed in *PubMed.* Even as this article went to press, Elsevier announced a new journal-level metric, *CiteScore*, based on *Scopus* database metadata covering 20,000-plus journals, offered as a more encompassing, freely available alternative to the Journal Impact Factor. The *CiteScore* suite of metrics covers all articles and communications in a journal, not just the research articles analyzed by the Journal Citation Reports."Simple metrics tend to count what is easily counted, such as articles and citations in established journals, rather than what is most valuable or enduring."[8]

However innovative and revealing these emerging journal and article metrics may have been, many felt they fell frustratingly short in presenting a full picture of scholarly influence and impact. First, the scientific peer-review and publication process remained cumbersome, inefficient, and slow, and it was not adequate in keeping up with the increasing pace of research. Second, citation-analysis tools for monographs were inadequate or nonexistent, even with the introduction of *Book Citation Index* to the *Web of Science* suite of databases, largely leaving humanities scholarship out of the frame. Finally, the extant citation tools did not address the developing body of published items preserved on the web, or explain how research publications might make (and be shown to have made) an impact outside of academe. Even in journal-based disciplines, the growth of web forums changed the way scholars responded to research, offering faster,

more interactive means to engage with authors' recent publications and ideas. Traditional *bibliometrics* needed to expand to encompass *webometrics*,[9] measuring the sharing and linking of research in a networked environment. As every academic field began to adopt social media for scholarly communication, tweets and likes joined the mountain of saves, shares, links, and downloads that might be mined as indicators of influence and impact.

In October 2010, Jason Priem (then a graduate student at the Univ. of North Carolina-Chapel Hill, now head of the firm *Impactstory*, which he cofounded with Heather Piwowar) and his colleagues posted "Altmetrics: A Manifesto." They appropriated a *Twitter* hashtag for its name and claimed the domain name *altmetrics.org* (although the URL today is mostly a placeholder for the essay). The neologism coined by Priem (with Dario Taraborelli, Paul Groth, and Cameron Neylon) served as both a summary of the widespread restiveness with traditional bibliometrics and as a call to action to build better tools. Like Garfield's 1955 proposal for citation indexes (as a means to "eliminate the uncritical citation of fraudulent, incomplete, or obsolete data," with the goal "to establish the history of an idea"),[10] altmetrics is all about filters, albeit different ones. The manifestants characterized traditional filters such as citation counting, the Journal Impact Factor, and the peer-review process as dated, narrow, and threatened with becoming "swamped," and they sought new ways to "reflect and transmit scholarly impact" while sifting through the exploding volume of academic literature.[11] Rejecting journal-level measures and proprietary data sources in favor of article-based metrics drawn from relatively open data sets such as citation- and document-management platforms *Mendeley* and *Zotero*, the altmetrics proponents also sought methods to evaluate emerging formats leading up to publication, including raw research data, blogs, comments, and other informal—but more immediate— communications. Although Priem and his colleagues did not propose what form these new tools would take, the cogency of their rallying cry could be seen in the citation counts for their manifesto on *Web of Science* and *Google Scholar Citations*, each of which trace only a trickle of formal citations to the piece before 2013. Meanwhile, the

Twitter archive reflects the immediate flurry of discussion, linking, and sharing of the altmetrics manifesto. Traditional metrics were too slow to relay the story of this new idea.

The altmetrics proposition emerged at a time when the open-access movement had moved past its own manifestos and toward implementation. The two initiatives are intertwined and in many ways mutually beneficial, as open, freely accessible articles may be more widely shared and discussed, leading to more appearances in the venues measured by altmetrics.[12] New measures logically would allow various scholarly societies, publishers, and funders to show the reach, immediacy, and impact of their new publication models. Launched at the Annual Meeting of the American Society for Cell Biology in 2012, the *San Francisco Declaration on Research Assessment* (*DORA*) outlines the limitations of the Journal Impact Factor, and its authors have called for shifting away from journal-level to article-level metrics, as well as examining other plausible output measures such as research data sets released, the number and quality of students trained, and funding awarded. As documented in the *DORA News Archives*, the declaration also demanded open access to citation data for external analysis. That same year, the Public Library of Science—the open-access journal publisher of *PLOS Biology, PLOS ONE*, and other similarly titled PLOS journals— launched a specialized *PLOS Collections: Altmetrics* website with articles drawn from the site's archives and blogs. Soon after, the National Information Standards Organization (or NISO) received a grant in 2013 from the Alfred P. Sloan Foundation to study the promise of altmetrics, as described in *NISO Alternative Assessment Metrics (Altmetrics) Initiative*, and released in 2016 their recommended practices in *Outputs of the NISO Alternative Assessment Project*. The validity and scalability of altmetrics are still hotly contested, questioning what to measure, how to measure it, and how to address problems of bias toward more recent publications, and countering the perhaps inevitable claims of emphasis on narcissistic utterances or glib ephemera. But it appears for now that alternative metrics have found a place at the scholarly communications table, as evidenced by their adoption by publishers, funders, and universities.

Getting a Grip— Handbooks and Guides

Delivering on its subtitle, *Meaningful Metrics: A 21st-Century Librarian's Guide to Bibliometrics, Altmetrics, and Research Impact*, by Robin Chin Roemer (Univ. of Washington) and Rachel Borchardt (American Univ.), offers a comprehensive overview of tools and methodologies as well as practical advice for librarians hoping to raise awareness of the promise and the pitfalls of metrics on their campuses. Though aimed at academic librarians, *Meaningful Metrics* is a highly readable and thorough guide for any interested reader. The authors previously produced a freely available "Altmetrics" basic overview in *Library Technology Reports* covering much of the same territory, and they recommended websites and readings in two earlier, brief essays also published by the Association of College and Research Libraries (ACRL), "From Bibliometrics to Altmetrics" and "Keeping Up with … Altmetrics."

In the UK, several authors affiliated with the Statistical Cybermetrics Research Group at the University of Wolverhampton produced monographs touching on both traditional bibliometrics and alternative measures. Of these, Kim Holmberg's *Altmetrics for Information Professionals: Past, Present and Future* provides a slim but well-documented survey of the development and potential of the new metrics, while David Stuart's *Web Metrics for Library and Information Professionals* travels farther afield to address link analysis, full-text queries, analysis of web logs, and big data. Michael Thelwall, who leads the Wolverhampton research group, has published two works aimed at social scientists and information professionals in publisher Morgan and Claypool's "Synthesis Lectures on Information Concepts, Retrieval, and Services" ebook series: *Introduction to Webometrics: Quantitative Web Research for the Social Sciences* and *Web Indicators for Research Evaluation: A Practical Guide*. Andy Tattersall (Univ. of Sheffield) has edited *Altmetrics: A Practical Guide for Librarians, Researchers, and Academics*, with essays contributed from such leaders in the altmetrics movement as Euan Adie (founder

and CEO of Altmetric) and William Gunn (formerly at Mendeley, and now directing scholarly communications at Elsevier).

Greg Tananbaum's *Article-Level Metrics: A SPARC Primer*, posted on the SPARC (Scholarly Publishing and Academic Resources Coalition) website of the same name, compares journal and emerging article metrics, offering observations on potential applications and limitations. One can find examples of how library staff are integrating altmetrics into instruction and outreach programs, along with sample library guides, reports, and service descriptions from Association of Research Libraries (ARL) members in Ruth Lewis and coauthors' *Scholarly Output Assessment Activities*, part of ARL's long-standing "SPEC Kit" series. And some of the clearest, most straightforward introductions to altmetrics can be found in academic librarians' freely accessible library guides (e.g., from the University of Pittsburgh and Utrecht University), or ACRL's pertinent LibGuide called *Scholarly Communication Toolkit*. Vendors, too, supply practical guides for advocates planning workshops and doing outreach, or using altmetrics in collection development, for example *Altmetrics for Librarians: 100+ Tips, Tricks, and Examples*, by Stacey Konkiel and coauthors.

Stepping Back— Research and Assessment

Blaise Cronin (former editor in chief of the *Journal of the American Society for Information Science & Technology*) and his coauthors and colleagues at Indiana University and around the globe continue to contribute important research articles on developing measures of scholarly impact. Think an anthology of previously published articles on bibliometrics sounds as dry as day-old toast? Try a taste of *Scholarly Metrics under the Microscope*, ed. by Blaise Cronin and Cassidy R. Sugimoto—a hefty tome that appears completely daunting but tempts with some of the most accessible, thoughtful essays from the last few decades, including contributors' clever titles such as "Bibliometrics as Weapons of Mass Citation," "No Citation Analyses, Please,

We're British," and the forthright "Sick of Impact Factors." While *Scholarly Metrics* looks backward and only touches briefly on newer measures such as the *h*-index as applied in *Google Scholar Citations*, Cronin and Sugimoto's volume with newly contributed essays, *Beyond Bibliometrics: Harnessing Multidimensional Indicators of Scholarly Impact*, includes a section on altmetrics and developing fields such as the intriguing "academic genealogy."

National academies, funding agencies, and government oversight groups are searching for meaningful methodologies to assess the research contributions of institutions and individuals. As mentioned above, the NISO Alternative Metrics Initiative launched in the US in 2013. In the UK, a 2015 report commissioned by the Higher Education Funding Council, *The Metric Tide*, by James Wilsdon et al., surveyed the current landscape, reviewed types of metrics available, and discussed the challenges facing consumers of those new metrics. *The Metric Tide* led to the formation of an organization and website, *Responsible Metrics*, which has not been updated in some time; sadly, their proposal for a "Bad Metric" award does not seem to have been realized, although a *Twitter* hashtag, #ResMetrics, carries on the conversation. In Europe, SURF, a collaborative organization for technology in higher education, produced the provocatively titled *Users, Narcissism and Control*, by Paul Wouters and Rodrigo Costas, which presents a hopeful look at new technologies but concludes that new measures fail to normalize data across disciplines and need to be more transparent about their data sources and depth of coverage.

Keeping Up—Current Developments

As in most developing fields, published research on altmetrics can mainly be found in the journal literature. A remarkable range of discipline-specific journals have offered articles addressing the potential and pitfalls of new metrics for researchers in particular fields of study, from *Academic Emergency Medicine*,[13] to *Nature*,[14] to the *Journal of Wildlife Management*.[15] The key research articles are found in journals addressed to practitioners and information professionals

studying bibliometrics and scholarly communication. The *Journal of the American Society for Information Science and Technology* offers many timely studies of, for example, the correlation (or lack of correlation) of altmetrics scores and the Journal Impact Factor, or analysis of readership levels in various disciplines. The companion *Bulletin of the American Society for Information Science and Technology* has devoted a special issue to "Altmetrics: What, Why and Where?" Key journals *Research Evaluation* (Oxford) and *Scientometrics* (Springer) primarily address the sciences, while *Evidence Based Library and Information Practice*, an open-access journal published by the University of Alberta, offers practical advice for academic librarians, including a research-methods feature treating both bibliometrics and altmetrics.

But, as the altmetrics proselytizers themselves would observe, peer-reviewed journal literature isn't able to keep up with the rapidly developing marketplace of new measures. Following the *Twitter* hashtag #altmetrics (note—not #altmetric, which belongs to a company that will be described below) all but guarantees a deluge of news, observation, and opinion. For exposure to more nuanced ruminations, try *The Scholarly Kitchen* blog from the Society for Scholarly Publishing. Featuring contributions from an impressive salon of authors, publishers, and librarians, this resource regularly serves up perceptive insights, particularly from Rick Anderson (Univ. of Utah), Todd Carpenter (NISO), and others who have viewed academic publishing from many angles. The site also offers an archived "Metrics and Altmetrics" collection, a regular podcast series that features Jason Priem interviewed by Stewart Wills ("Altmetrics, Today and Tomorrow"), and an "Ask the Chefs" roundtable discussion led by Ann Michaels on the role of social media in publishing. A number of commercial providers also host substantial blogs that go beyond mere marketing, including an *Altmetric Blog* at https://www.altmetric.com/blog/ and the *Plum Analytics Blog* at http://plumanalytics. com/interact/blog/. Since 2014, *The Altmetrics Conference* has attracted scholars, publishers, librarians, and vendors who convene annually in various European cities—from the "1:am" first altmetrics meeting in London, "2:am" in Amsterdam,

to "3:am" in Bucharest in 2016. Through the conference site, one can access blog posts, presentations, and streaming video of selected sessions.

Altmetrics Websites and Tools

Librarians live to classify and it is helpful to organize the new metrics into categories—a sort of who-to-whom matrix of interacting variables—defining *measurables* (saves, tweets, posts, shares, likes, views, downloads, etc.) and the sources of *who or what* is being assessed (single articles or other publications, individual authors, journals, or publishing platforms, or organizations such as labs, academic departments, universities, etc.). Additionally, it is useful to know which websites and tools individuals can access freely themselves, and which are available only to institutional subscribers. Unfortunately, the artificially neat lines of any organizing matrix soon begin to blur and dissolve, as some tools, such as peer networks like *Mendeley* or *Academia*, act as both source data and the measure itself, while other tools, such as *Altmetric*, offer limited free access to individuals and a more fully functioning product for purchase by institutions, funding agencies, or publishers. What follows is a list of the main resources organized by basic function, with occasional hopscotching across categories.

Identities

Just as the disaggregating power of the web drove the need for the Digital Object Identifier or DOI as a means to locate specific versions of articles, chapters, books, journals, or other publications on distinct platforms,[16] various unique identifiers for individual authors help to pull together a unified portrait of an author's publications and affiliations and allow automated systems, databases, and websites to link related items to the correct "Joan Smith." For many years, the *Researcher ID*®, Thomson-Reuters' proprietary identifier used by the *Web of Science* database, was the leading tool for author disambiguation. Users can sign up for a Researcher ID in

Web of Science (or may have one already created for them), and add or correct associated citations, research interests, or biographical information. Authors can register for or claim a Researcher ID even if their institution does not have a subscription to the *Web of Science*. Elsevier's *Scopus* also offers a unique researcher ID, although users cannot manage their own identities and can only request corrections.

Google Scholar Citations, introduced in 2012, allows scholars to create a personal profile that can be shared publicly and displayed in search results, or kept private. Authors can add or edit their list of publications, either by retrieving them from *Google Scholar* or by adding them manually. The citations profile page provides a metric snapshot for all the publications associated with the author, including total number of citations to these works from across *Google Scholar*, for total citations, the *h*-index for that author (a formula for the number of papers published and the number of times cited), and the *i10 index*, a derivative of the *h*-index that examines papers cited more than ten times within the *Google Scholar* database. Though one can link to a public profile page, it is difficult to reuse the profile identifier on other websites or platforms.

ORCID—the Open Researcher and Contributor ID—launched in 2012, provided the interoperability that *Google Scholar* lacked and is a nonproprietary alternative to the Researcher ID. One's ORCID provides each registered scholar with a unique alphanumeric code and is now commonly used on curricula vitae, in scholarly publishing workflows, and as a registration service that can link various accounts together across the web. As an open-source tool, ORCID can be integrated into a variety of web services, including altmetrics tools such as *Altmetric*, *Impactstory*, and *Plum Analytics*. In a nod to the ubiquity of ORCID, Thomson Reuters' Researcher ID and the *Scopus* Author Identifier can now pull citations from or push citations to linked ORCID accounts, so that publication and personal details do not have to be entered in multiple places. Individuals can register for an ORCID identifier for free; institutions may join at

several different levels of membership in order to be able to curate faculty accounts and to integrate ORCID information into campus reporting systems.

Approaching identities from a different angle, the *Crossref* organization (previously styled CrossRef) launched an open registry of funder identities in 2013 to essentially normalize funders' names for better cross-platform reporting; its *Funder Data—Crossref Meta-Data Search* (known also as *FundRef*) of more than 14,000 registered entities is now accessible via the site's metasearch engine. *DataCite*, a membership organization supported by an alphabet soup of public and private institutions from more than twenty countries—and coordinated with the *International DOI Foundation* and other metadata initiatives—serves as a registry and DOI clearinghouse for research data sets, an important function complementary to publication and personal IDs.

Scholarly Networks

"We see only what we know," as Johann Wolfgang von Goethe observed.[17] To many librarians, new web-based reference-management tools such as *CiteULike*, *Zotero*, *Papers*, or *Mendeley* looked like services they already knew, offering a way to collect, organize, and format the cited references in one's bibliographies. At first, these appeared to be only web-based alternatives to traditional, commercially produced citation-manager tools like *EndNote*, *ProCite*, *Reference Manager*, or *RefWorks*. But the new open-source platforms soon evolved beyond simply managing bibliographic references into collaborative systems for sharing, discussion, and peer review. While not primarily designed to convey the stature of authors or the reach of their publications, each tool preserves source data that can be measured in terms of saves, shares, and downloads.

CiteULike and *Mendeley* were developed by UK academics, and both launched in 2008. *CiteULike* is a browser-based bookmark tool whose design has remained fairly stable since its original release, allowing users to cite and save references to their personal libraries, share those libraries, and connect with others who save the same items. *Mendeley*, on the other hand, continues to add new features

and modules such as a recently launched datasets repository, thanks in part to the development support of its new owner, Elsevier. *Mendeley* not only offers fully featured reference-management software complete with word-processor integrations and shared collections, but also supports a robust collaboration environment that links like-minded groups, claiming more than five million users worldwide. A personal Stats dashboard displays the number of citations to one's work (and the *h*-index measure, from *Scopus*), plus views or readers of one's articles (from *ScienceDirect* and *Mendeley* databases). The major altmetrics services, including *Impactstory*, *Altmetric*, and *Plum Analytics*, all harvest and report user activity on the *Mendeley* platform.

Like *Mendeley*, *Academia* and *ResearchGate* were also founded in 2008 but they marked a distinct break from the world of bibliographic reference managers. Instead, each serves more as a paper repository and hub for making scholarly connections. Boasting more than 45 million users worldwide, *Academia* (previously named *Academia.edu*) offers user profiles and subject tags based on article uploads and manually created cited references. By assigning tags to one's collected articles and choosing to follow particular scholars, one builds a personal landing page that supplies related articles of potential interest. Users have access to real-time analytics showing profile and document views; alerts emails notify users of new visits or mentions in recently uploaded papers.

Academia has no particular subject affiliation, whereas *ResearchGate*, which claims more than 12 million users, focuses on the sciences. Like the other tools, the free profile setup on *ResearchGate* walks users through a list of possible name variations and suggests colleagues that one may wish to follow based on common research interests or co-citations. An interesting organizing feature is the ability to group articles or other publications into projects and to post information about current projects underway. Personal statistics present profile views, reads or article views, and citations; statistics are driven by the full-text availability of papers uploaded to the system. *ResearchGate* offers researchers their *h*-index value as well as an

RG Score, which is based on interactions of other *ResearchGate* users with one's own contributions, discussions, and answers to research questions; institutions or academic departments can also be assigned an RG Score. As with so many other new metrics, the score is intriguing but, being based on a self-selected community of varying depth by discipline, it is difficult to know exactly what such numbers mean outside of their own network.

SSRN, the Social Science Research Network (with more than 2 million users when it was acquired in May 2016 by Elsevier), was established in 1994—long before either *Academia* or *ResearchGate*—and it offers a rigorously organized repository for social sciences preprints, conference papers, and other publications. Participation in *SSRN* is free though the site also sells subscriptions to subject portals and offers pass-throughs to some publishers for full-text article access. Posted rankings offer top downloads by subject area, author, and organization. *SSRN* had a particularly high participation rate in some areas, such as business and law, but its acquisition by Elsevier caused a storm of concern among open-access advocates. While *SSRN* is still freely available, new initiatives such as *SocArXiv Preprints* offer a fully noncommercial alternative for social scientists to archive their published works in earlier stages, from working papers presented at conferences to final preprints. *SocArXiv* has been developed in partnership with the Center for Open Science's *Open Science Framework*, an initiative that promises to help manage the workflow of scholarship from the inception of a research project to publication, with an analytics section documenting usage.

Beyond bibliographic products, *figshare*, a part of the Digital Science family (owned by Macmillan, along with *ReadCube* and *Altmetric*), similarly offers repository space for research data. Individuals may join for free and upload both public and private research materials and see real-time information on views and downloads. Institutional subscriptions allow universities to host all their research data in one place, to promote their research outputs by making them publically available with stable DOIs, and to view insights from usage analytics at the item, researcher, department, or institution level.

Open Peer Review

Some measures of impact are difficult to express numerically but nonetheless carry weight within research communities. Open peer-review initiatives—both pre- and post-publication—have varying goals: to accelerate the path to publication, allow more voices to contribute to assessment, and acknowledge the contributions of reviewers themselves. Several of the services mentioned above offer some form of nontraditional peer review, from informal discussions (such as various *Mendeley* forums) to explicit post-publication review (as offered by the new *Open Review* tool from *ResearchGate*).

PLOS ONE, through its comments functionality, has since inception allowed registered users to discuss articles published in their journals. The National Institutes of Health's *PubMed Commons* is more rigorous in that it only allows comments from authors who have articles in the *PubMed* database. *PubMed Commons* also offers membership to journal-club discussion groups based on specialty research areas. *PubPeer* is another independent journal-club site that allows anonymous review, but it has been embroiled in scrapes related to suspect research data and article retractions. *Peerage of Science* aims to transform pre-publication review by providing a free platform where authors can submit their work and solicit comment from peers (volunteer scientist-reviewers who are vetted by virtue of their publication records in ranking international outlets—ironically, the journals indexed in *Web of Science*). Conceived in 2010 by a group of Finnish scientists, *Peerage of Science* has developed productive partnerships with both for-profit and open-access publishers, including Springer, BioMedCentral, and Brill, who benefit from timely reviews from self-selected (and thus, presumably, motivated) reviewers. Those reviewers themselves benefit by being able to choose what they review and then gain recognition for their contributions.

Publons goes even farther to put peer reviewers into the spotlight. Named as a joking reference to the "smallest publishable unit" and boasting more than 100,000 registered reviewers who have uploaded more than 500,000 reviews, the New Zealand and UK-based *Publons* peer review site offers "a measurable indicator of a researcher's expertise and contributions" and provides a means for editors and publishers to identify expert reviewers. The site allows reviewers to rate one another and presents ranked lists of reviewers by field, by reviewer institution, or country. *Altmetric* incorporates *Publons* metrics into its *Attention Score*, described below. Another site, *F1000: Faculty of 1000* and its *F1000Prime* component, goes beyond expert peer review to provide article recommendations from researchers in the fields of biology and medicine. While the core product (launched in 2002) is a subscription service, its *F1000 Research: F1000 Faculty Reviews* site commissions review articles on the life sciences as part of a new open-access publishing initiative. The subscriber portion provides article rankings that are updated daily, including a "Top 10 Hidden Jewels" list for less high-profile specialty journals.

Getting It Together— Reporting Tools

With the multitude of venues documenting research impact to choose from, one could easily devote so much time and energy to monitoring one's scholarly reputation that there is no time left to actually publish research. Fortunately, several startups have stepped into the marketplace with services that aggregate different measures and provide reporting tools at the article, individual scholar, department, or organizational level. Publishers and content providers have licensed altmetrics reports as means to enrich their journal sites or database platforms. At institutions whose libraries license the Summon discovery service from Ex Libris or Elsevier's *Scopus*, for example, users can observe the signature *Altmetric* donut. Those who have used EBSCO's version of the nursing database *CINAHL* can witness *Plum Analytics* in action. These new ventures have quickly moved from nascent startups to valuable properties, with *Altmetric* becoming part of Macmillan's Digital Science family in 2012, and as this essay goes to press in early 2017, Elsevier has acquired *Plum Analytics* from EBSCO after its three-year ownership. "Rather than portending something amiss in the altmetrics space," Todd Carpenter wrote in *The Scholarly Kitchen*, "this deal appears to signal a developing understanding of where altmetrics sit in academia and who is most interested in them and why." Carpenter suggests that the deal situates *Plum Analytics* more successfully in the suite of assessment tools and publishing integrations already offered by Elsevier, though he also voices concerns that this acquisition might lead to walling off altmetrics source data as publishers align with specific providers.

For Institutions

Founded by medical genetics researcher Euan Adie in 2011, the London-based company *Altmetric* (and its website suite of tools) provides services to institutions, publishers, and funders as well as individuals. *Altmetric* generates an *Attention Score* for a publication by factoring a growing collection of sources, including mainstream news reports, blogs, *Wikipedia* mentions, saves to online reference managers (e.g., *Mendeley*), reviews and recommendations on post-publication peer-review sites such as *Publons* and *F1000*, blog posts, social media mentions, and posts to *YouTube* or discussion sites such as *Reddit*. The *Altmetric Support* portal (and Knowledge Base, in its Solutions section) provides a chronology and complete list of sources. The Attention Score is computed from number of mentions, the type of source where the mentions occur (for example, standard news outlets rank more highly than blogs), and the author of the mention (with prominent persons in the field ranking more highly). The Attention Score is then presented graphically as the *Altmetric* donut, a colorful representation of the categories where impact could be measured. Through its *Altmetric Explorer* web apps and various Badge products, the company provides real-time metrics to institutions, publishers, and funders. *Altmetric* provides the Badge service free of charge to universities for use in institutional repositories, and makes research output data available on request to academic librarians. *Altmetric Badges for Books* were introduced in 2016 to track book mentions and cites based on ISBNs or book- and chapter-level DOIs.

PlumX metrics from *Plum Analytics* do not compute a numeric score, but instead report on more than sixty different types of research output—so-called "artifacts," and the activities related to those artifacts—in five categories: usage (e.g., downloads, plays, or *WorldCat* holdings), captures (exports and saves, bookmarks, subscribers), mentions (blog posts, reviews, links), social media (likes, tweets, shares), and citations (from *Crossref*, *PubMed*, *Scopus*, *SSRN*, etc.). *Plum Analytics* methods match on these artifacts and aggregate activity as dashboards, documenting trends and reach at the artifact, researcher, departmental, or organization level. The company sells its *PlumX Dashboards* product to institutions where staff can curate researcher and departmental profiles and manage publications associated with those individuals and groups. Its PlumX metrics allow institutions to embed reports directly into institutional repositories or web pages. It also offers a reporting object not unlike the *Altmetric* donut—a sunburst-shaped graphical representation of the categories and venues in which the research makes the most impact. Other tools in the *Plum Analytics* suite report on grant activities, present benchmark comparisons, or offer funding opportunities matching an organization's research profile.

Not content to simply purchase off-the-shelf solutions, leading research universities, originally in the UK and now worldwide, are working with Elsevier to develop a framework of research metrics that can be shared and compared across institutions. The pilot *Snowball Metrics* project has produced two *Snowball Metrics Recipe Books*, the latest with two dozen scholarly communication measures such as research output and citations, public engagement, and altmetrics based on *Web of Science*, *Scopus*, *Google Scholar*, and other sources.

For Individuals

Unlike the high-stakes commercial enterprises *Altmetric* and *Plum Analytics*, the nonprofit *Impactstory* is funded by the National Science Foundation and the Alfred P. Sloan Foundation. Led by altmetrics leading lights Heather Piwowar and Jason Priem, with an advisory board that includes representation from SPARC, *Impactstory* takes a third path to reporting, preferring to help individuals "tell stories" about their research rather than offering numerical scores or graphs. *Impactstory* provides simple badges, such as one's "greatest hit" publication (based on saves or shares) or the percentage of one's publications that are open access. Such achievements are based on *Impactstory* categories of buzz (the volume of discussion surrounding one's research), engagement (who is accessing research outputs, and where they're located), openness (the availability of the research to a worldwide audience), and fun (whimsical measures, such as one's popularity in Japan). Users may register for free by linking a *Twitter* account and then import publication information from an ORCID profile. *Impactstory* is committed to open data and open source, and rewards authors with high rankings for publishing in open venues. Reporting depends on publication identifiers like DOIs, and without them is somewhat inaccurate.

Several browser plugins allow scholars to quickly look up their article metrics on the fly. *Altmetric*'s free *Bookmarklet for Researchers* lives in one's bookmarks bar, and when viewing a research article of interest, a user can click an "Altmetric it!" button to view the article's Attention Score donut. The service currently works on pages containing a DOI, publisher sites where the embedded article metadata is sufficient to achieve a match, and in a range of databases such as *PubMed* or the open-access *arXiv*, just one example of a specialized eprint repository for the sciences where meaningful metrics are of obvious value. The handy *Lazy Scholar* browser extension developed by Colby Vorland for *Chrome* (but recently disabled for *Firefox*) is something of a Swiss Army knife for academics, presenting the *Altmetric* score, the citation count from *Google Scholar*, and the Journal Impact Factor for a journal article; in addition the *Lazy Scholar* toolbar allows one to locate the full text, save to *Mendeley*, share on *Twitter*, and annotate documents. Finally, there is *Scholarmeter*, from the School of Informatics and Computing at Indiana University, a browser plugin in beta that offers analytics on *Google Scholar* citation patterns.

Want to boost your scholarly visibility? *Kudos* is a service (free to individuals) that provides a set of tools to raise the profile of academics and their publications.

Researchers create a *Kudos* account, add their publications or import them from ORCID, and then have access to existing metrics as well as tools to maximize the visibility of each item ("increase publication performance") by allowing authors to explain their research output ("What's it about?" Why is it important?"), link to research data sets or supplemental information, and promote their work on social media channels. In addition to reporting on usage through embedded system widgets, *Kudos* pulls in the article Attention Score from *Altmetric* and the Times Cited number from *Web of Science*. Dubbed by one wag "*Hootsuite* for academia,"[18] *Kudos* is proof that the altmetrics phenomenon has reached its next evolutionary stage: marketing.

What's Next

Altmetrics clearly have not supplanted but instead have supplemented the Journal Impact Factor. However, merely replacing one contested number with a suite of metrics lacking context or nuance would only give campus administrators and research funders a new yardstick to misapply and misunderstand in the same old ways. The challenge for proponents and adopters of altmetrics is to work toward shared understanding of (and standards for) what to measure and precisely what the measurements mean. In addition to the NISO and *Snowball Metrics* initiatives mentioned above, it is encouraging to see organizations building a new open framework for metrics. The DOI registration agency *Crossref*, for example, expects to launch its *Crossref Event Data* service in 2017. This service will track DOIs as mentioned, shared, bookmarked, or discussed outside of the formal literature, beginning with *Wikipedia*, *Facebook*, *F1000Prime, Twitter*, and other sites. Such "event" statistics (which cover linking, bookmarking, commenting, social sharing—estimated to be more than 100,000 occurrences daily) will be freely available to individuals to process and interpret. This level of coordination is an important step in moving toward the interoperability and transparency that Euan Adie has called for, assuring that source data is auditable, open, and meaningful.[19]

Endnotes

1. Johan Bollen (Indiana Univ.), quoted in Van Noorden, "Metrics," 864.

2. Monastersky, "The Number That's Devouring Science."

3. Garfield, "The Impact Factor."

4. Garfield, "The History and Meaning of the Journal Impact Factor."

5. *Beyond Bibliometrics*, 115–121.

6. For a comprehensive history, see De Bellis, *Bibliometrics and Citation Analysis*.

7. Hirsch, "An Index to Quantify an Individual's Scientific Research Output," 16569.

8. Borgman, *Scholarship in the Digital Age*, 239.

9. Björneborn and Ingwersen, "Toward a Basic Framework for Webometrics."

10. Garfield, "Citation Indexes for Science," 108, 110.

11. Priem, et al., "Altmetrics: A Manifesto."

12. Mounce, "Open Access and Altmetrics."

13. Barbic, et al., "An Analysis of Altmetrics in Emergency Medicine."

14. "Science Metrics."

15. Krausman, Bishop, and Ottogalli, "Promoting Research beyond Publication."

16. *The Formation of CrossRef: A Short History.*

17. *Goethe on Art*, 7.

18. Rapple, "Hootsuite for academia?"

19. Adie, "The Rise of Altmetrics," 80.

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