Do Altmetrics Follow the Crowd or Does the Crowd Follow Altmetrics?

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ABSTRACT

Changes are occurring in scholarly communication as scientific discourse and research activities spread across various social media platforms. In this paper, we study altmetrics on the article and journal levels, investigating whether the online attention received by research articles is related to scholarly impact or may be due to other factors. We define a new metric, *Journal Social Impact (JSI)*, based on eleven data sources: CiteULike, Mendeley, F1000, blogs, Twitter, Facebook, mainstream news outlets, Google Plus, Pinterest, Reddit, and sites running Stack Exchange (Q&A). We compare *JSI* against diverse citation-based metrics, and find that *JSI* significantly correlates with a number of them. These findings indicate that online attention of scholarly articles is related to traditional journal rankings and favors journals with a longer history of scholarly impact. We also find that journal-level altmetrics have strong significant correlations among themselves, compared with the weak correlations among article-level altmetrics. Another finding is that Mendeley and Twitter have the highest usage and coverage of scholarly activities. Among individual altmetrics, we find that the readership of academic social networks have the highest correlations with citation-based metrics. Our findings deepen the overall understanding of altmetrics and can assist in validating them.

Categories and Subject Descriptors

H.3.7 [**Information Storage and Retrieval**]: Digital Libraries;
J.4 **[Computer Applications]:** Social and behavioral Sciences

General Terms

Measurement, Performance, Human Factors

Keywords

Social Media, Altmetrics, Research Impact, Research Evaluation, Journal Ranking, Journal Impact Factor, Twitter, Facebook, Mendeley, CiteULike, F1000, Online Reference Managers

1. INTRODUCTION

By publishing their results, researchers share their discoveries in the hope that the broadest possible dissemination of ideas and findings will benefit the most people and increase the global body of knowledge. Self-archiving, institutional repositories, and social media platforms enable researchers to distribute and discuss their results online, widen the possible audience of readers who can study and measure the results, and shorten the timeline for information to become available. One traditional approach to measure research impact is to use citation analysis, but this method lacks the ability to measure the holistic impact of scholarly outcomes and has several other limitations.

An increasing number of scholarly content [1][2] are posted daily on social media platforms. The increase in research articles is estimated on the order of 5–10% a month [3]. Social media platforms are playing an active role in the research lifecycle [4]. They assist researchers to stay abreast of updates in their fields, discover related work, share and discuss research data and results [5], connect with other researchers and citizen scientists, collaborate online, and get early feedback on their own work [6].

Governments and research funding agencies are assessing different approaches to determine how public and private funds are being used in order to maximize the return on investment. Since January 2011, the National Science Foundation (NSF) has required grant proposals to submit a data management plan, which is a "supplementary document that describes how the proposal will conform to NSF policy on the dissemination and sharing of research results"[1]. In January 2013, the NSF shifted its evaluation from publication-based to product-based assessments [7].

In February 2013, the United States Office of Science and Technology Policy announced it was expanding public access to the results of federally funded research[2]. In the UK, the higher education funding bodies have decided that "the impact element will include all kinds of social, economic and cultural benefits and impacts beyond academia, arising from excellent research, that have occurred during the period 1 January 2008 to 31 July 2013" [8]. Furthermore, the UK Medical Research Council "grant-application forms specifically ask researchers how they intend to manage and share the results of their work, and to outline their productivity beyond published papers" [9]. From March 2014 onward, the PLOS journals have started a new data policy that requires authors to submit their data while reviewing manuscripts, and in the case of publication, make the data publicly available[3].

In December 2012, a group of editors and publishers of scholarly journals announced the San Francisco Declaration on Research Assessment[4] which recommended looking at a variety of metrics. Research communities and agencies are looking for approaches to measure both the scientific and social impact of research [10]. Research evaluation is increasingly taking into consideration the societal impact of research that includes social, cultural, environmental, and economic impacts [11].

Online social interactions create traceable footprints and new data, which provide a means to monitor and document the impact of scholarship using new models. By analyzing research use of social media platforms, researchers can identify who is interested in their

[1] http://www.nsf.gov/bfa/dias/policy/dmp.jsp
[2] http://www.whitehouse.gov/blog/2013/02/22/expanding-public-access-results-federally-funded-research
[3] http://www.plosbiology.org/article/info%3Adoi%2F10.1371%2Fjournal.pbio.1001797
[4] http://www.ascb.org/dora/

work, and from which disciplines, universities, and countries. As a result, these new models reveal previously unknown metrics and create new opportunities and challenges.

While previous studies focused on a narrow spectrum of social media platforms, little is known about coverage, usage, distribution, validity, and trustworthiness of different platforms in research activities. Such information would have broad benefits to: researchers who explore online platforms to find a suitable environment for their scholarly activities; bibliometricians who select which platforms to use when measuring altmetrics; and editors, publishers, research agencies and social media platforms to provide better services for research-oriented communities.

In this study, we aim to answer the following research questions:

1. How do social media platforms differ in the coverage, usage, and distribution of scholarly works?
2. How do altmetrics differ at the article and journal levels?
3. How can we build and validate a comprehensive journal social-metric?
4. Has the influence of journal rankings on researchers and readers been extended from scholarly communities to online communities?

In the next sections, we discuss the related work, describe our approach, and present and analyze our results.

2. RELATED WORK

Research communities have complained about using only one measure, such as citations, to evaluate the impact of scholarly entities [12], and alternative measures were proposed. Neylon and Wu [13] found that various usage-based metrics can be used to measure article and journal impact, such as downloads, comments, and bookmarks, and each of these metrics has its benefits and limitations. Bollen et al. [14] concluded that "the notion of scientific impact is a multi-dimensional construct that cannot be adequately measured by any single indicator". At TPDL 2013, Borgman stated that "being cited in a tweet is a citation"[5].

While citations measure an impact within scholarly boundaries, social-based metrics or altmetrics [15][16] provide the ability to measure different influences, including readers who share, read or discuss an article with others, but do not formally cite it. Altmetrics are diverse metrics and are considered complementary to the citation metrics. They can measure the impact of other scholarly products, such as datasets, software, and presentations.

An increasing number of academic digital libraries and publishers are providing altmetrics on their websites such as Nature[6], Springer[7], BMJ, Cambridge Journals Online, and Scopus[8]. In an editorial article, *Nature Chemistry* concluded that "Despite its limitations, Twitter is useful for quickly disseminating information to an audience who has chosen to listen"[9].

Several researchers have begun to study the relationship between citation-based and social-based metrics. Thelwall et al. [17] found an association between tweets and citations. Haustein et al. [18] found that 9.4% of PubMed articles were tweeted, but a low correlation exists between citations and tweets. Shuai et al. [19] also reported a positive weak to moderate correlation between citations and Wikipedia mentions. Waltman and Costas [20] found a weak correlation between citations and F1000 recommendations. Bar-Ilan et al. [21] reported a moderate correlation between Scopus citations and Mendeley readerships.

A number of studies have examined using non-citation-based metrics as an early indicator of the scholarly impact of articles and journals. Brody et al. [22] found a significant correlation between the citations and downloads of articles in physics, mathematics, and astrophysics. They used download data from within six months after publication as a predictive feature. In [23], we proposed a venue-ranking approach based on data from CiteULike. The data selected was one year older than the matched data from traditional rankings. We compared their social-based metrics with journal rankings and found significant correlations.

Costas et al. [24] reported weak correlations between citations and altmetrics, and disciplinary differences using altmetrics. Jiang et al. [25] used Mendeley groups to study the interactions of disciplines and found interdisciplinary structures. Most previous studies have attempted to understand altmetrics using only a few measures and focused on the article-level but not on the journal-level that we explored.

3. DATA AND METHODS

We downloaded a dataset of 820 science journals from Journal Citation Reports (JCR) 2013 based on citation count. The data contains abbreviated journal title, ISSN, impact factor (IF), five-year impact factor (5-IF), citation count, article count, immediacy index, cited half-life, Eigenfactor, and article influence score.

We matched each abbreviated journal title with its full journal title. We then paired our data with the full set of SJR journal rankings using ISSNs and the full journal names since some ISSNs did not match. We obtained the SJR, h-index, total articles (three years), total citations (three years), and total references. Next, we matched this data against data from altmetric.com [3], which collects article-level metrics, and downloaded the article-level altmetrics for the past year.

Altmetrics from altmetric.com include research articles posts or mentions in CiteULike, Mendeley, F1000 reviews, blogs, Twitter, Facebook walls, mainstream news outlets, Google Plus, Pinterest, Reddit, and sites running Stack Exchange (Q&A). Since some JCR journals did not match with SJR rankings or altmetrics, our dataset was narrowed to 785 journal titles, with 373,427 articles resulting in altmetrics count of 13,221,827. We define a new social-based metric, *Journal Social Impact* (JSI), which represents the average number of posts or mentions for research articles in online platforms for a journal (j) as shown in equation (1).

$$JSI(j) = \frac{\sum_{s \in S} \sum_{a \in A} a_s}{|A|} \qquad (1)$$

s represents one of the social media platforms from the set S. a represents an article from the set of all articles A in a journal. $|A|$ denotes the total number of articles from a journal that were posted on online platforms. a_s represents how many times an article a was posted in s by different users. We used Spearman's rank correlation coefficient, ρ(rho), to compare JSI and altmetrics with different citation-based metrics. We compared altmetrics with the altmetric.com score, a weighted score that is based on volume, sources, and authors of online mentions. We also compared altmetrics with the number of different social media platforms that an article had reached.

[5] https://twitter.com/tpdl2013/status/382053871444844544

[6] http://www.nature.com/press_releases/article-metrics.html

[7] http://www.springer.com/about+springer/media/pressreleases?SGWID=0-11002-6-1453458-0

[8] http://support.altmetric.com/knowledgebase/articles/83246-altmetric-for-scopus

[9] http://www.nature.com/nchem/journal/v5/n4/full/nchem.1608.html

4. RESULTS AND DISCUSSION

4.1 Coverage, Usage and Distribution

As shown in Figure 1, Mendeley and Twitter have the highest coverage of articles shared on online platforms. 10% of the shared articles are covered in the mainstream news. Next, we found that Mendeley was the predominant platform on which research articles were shared, with 74% of the total altmetrics count, and the second most prevalent platform was Twitter with 19%. The remaining 7% was distributed among all other tested sites, as shown in Figure 2. Pinterest and the Q&A sites have the lowest levels of coverage and usage. Figure 3 shows that around 46% of all articles have been shared on two platforms.

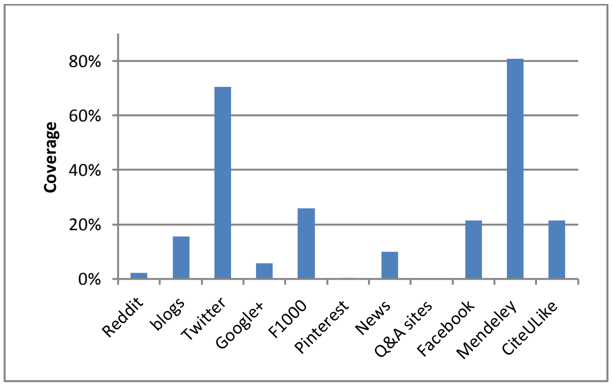

Figure 1. Coverage of research articles in different platforms

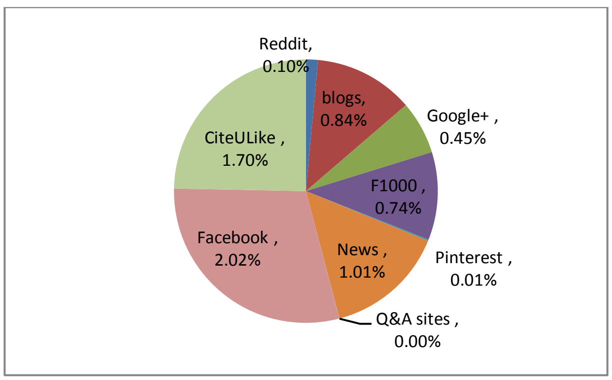

Figure 2. Research use of 9 online platforms

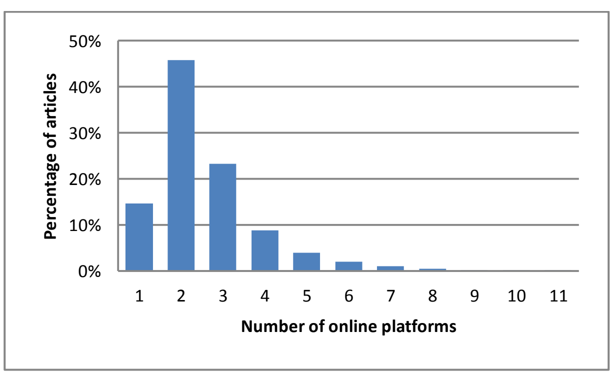

Figure 3. Distribution of articles across different platforms

4.2 Article-Level Altmetrics

We found that altmetrics at the article-level have weak correlations with citations-based metrics, with the highest correlation being between Mendeley and the article influence score ($\rho = 0.353$, $p < 0.01$). In general, the article-level altmetrics also have weak correlations among themselves, except in a few cases. In other words, articles that receive social attention on one online platform would not necessarily receive similar attention on other platforms. All correlations were significant at ($p < 0.01$).

Scholarly blogs have weak correlation with news ($\rho = 0.313$). Twitter also showed a weak correlation with Facebook wall posts ($\rho = 0.304$), and Mendeley has a moderate correlation with CiteULike ($\rho = 0454$). F1000 showed a positive moderate correlation with Mendeley readers ($\rho = 0.454$) and a negative moderate correlation with tweets ($\rho = -0.464$), which shows the scholarly nature of online reference managers' data. The altmetric.com score has a moderate correlation with blogs, tweets, news, and the number of platforms on which an article was mentioned ($\rho = 0.570, 0.580, 0.488, 0.526$). The latter also has moderate correlation with blogs, Facebook posts, Mendeley, and CiteULike ($\rho = 0.469, 0.463, 0.585, 0.577$).

4.3 Journal-Level Altmetrics

Some of the metrics we studied did not correlate with any of the others, such as cited half-life and total references, so we removed them from the results. Table 1 shows that most journal-level altmetrics have moderate correlations with journal citation count, H-index, and Eigenfactor, and weak correlations with other citation-based metrics. However, the *JSI* has a significant positive moderate correlations with the IF, 5-IF, Immediacy Index, SJR, and article influence score. In addition, *JSI* has a higher correlation with the 5-IF and article influence score than with the Immediacy Index, which shows that *JSI* has a stronger relationship with reputable journals that have a history of scholarly impact.

Table 1. Correlations between journal-level altmetrics and traditional metrics. Highest correlations per column are in bold

	Citation Count	IF	5-IF	Immediacy Index	Article count	Eigenfactor	Article Influence	SJR	H-index
Reddit	0.36	0.19	0.20	0.30	0.19	0.45	0.23	0.17	0.37
blogs	0.48	0.23	0.25	0.36	0.25	0.57	0.30	0.27	0.51
Twitter	0.45	0.19	0.21	0.34	0.27	0.55	0.23	0.20	0.48
Google+	0.44	0.21	0.23	0.35	0.25	0.54	0.26	0.21	0.47
F1000	0.40	0.17	0.19	0.30	0.16	0.46	0.23	0.21	0.51
Pinterest	0.11	0.25	0.26	0.25	-0.01	0.21	0.26	0.23	0.18
News	**0.51**	0.14	0.16	0.30	0.37	**0.59**	0.17	0.17	0.45
Q&A	0.17	0.24	0.24	0.24	-0.05	0.20	0.24	0.23	0.23
Facebook	0.46	0.16	0.17	0.31	**0.29**	0.53	0.17	0.13	0.46
Mendeley	0.46	0.35	0.39	0.41	0.14	0.55	0.43	0.41	**0.59**
CiteULike	0.41	0.33	0.36	0.42	0.10	0.52	0.45	0.41	0.56
JSI	-0.04	**0.58**	**0.63**	**0.46**	-0.39	0.07	**0.67**	**0.58**	0.23

Among individual journal-level altmetrics, Mendeley and CiteULike readers have the highest correlations with all journal rankings, which shows that these online reference managers are more related to scholarly impact. Mainstream news has the highest correlation with citation count and Eigenfactor, which indicates that disseminated research to the public is related to popular and quality journals. All correlations were significant at ($p < 0.01$).

We found moderate to strong correlations between journal-level altmetrics (except with Pinterest and the Q&A site), which is different from article-level altmetrics. The lowest correlations were between F1000 and Reddit (ρ = 0.587), and between F1000 and Google Plus (ρ = 0.610). The highest correlations were between Twitter and Facebook (ρ = 0.914), and between Mendeley and CiteULike (ρ = 0.912). Comparing article-level altmetrics from different disciplines seems like comparing apples to oranges, but comparing clustered altmetrics based on journals would be like comparing apples to apples. General and academic social media platforms cluster together and present higher correlations among themselves.

The absence of high correlations between altmetrics and citation-based metrics shows the existence of differences between scholarly and social importance. In addition, it can be explained that the social attention measures new findings, public interest, gaming to the altmetrics system, or even spam that would target specific communities, such as the scholarly world [26].

5. CONCLUSION AND FUTURE WORK

In this paper, we proposed and investigated our new measure JSI, which is computed using non-citation-based metrics, and compared it with several citation-based metrics. We found significant correlations between JSI and IF, 5-IF, Immediacy Index, SJR, and article influence score. Our findings suggest that, at least for the time being, the journal rankings remain a trusted proxy for the quality of scholarly social media attention. Although altmetrics have the potential to predict delayed citation-based metrics, the latter metrics can also be used to validate the former. We also found that usage and coverage of social media for research activities is high within a few platforms.

In the future, we plan to compare JSI with itself and with citation-based metrics during different years to check the validity and reliability of altmetrics. We plan to build a theoretical multi-dimensional model to improve our understanding of altmetrics. We plan to examine scholarly mentions in the news from different angles such as size and geographic location (e.g., local, national, and international).

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