Aslib Journal of Information Management

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Are Mendeley reader counts high enough for research evaluations when articles are published?

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Received 22 January 2017
Revised 28 February 2017
Accepted 6 March 2017

Abstract

Purpose – Mendeley reader counts have been proposed as early indicators for the impact of academic publications. The purpose of this paper is to assess whether there are enough Mendeley readers for research evaluation purposes during the month when an article is first published.

Design/methodology/approach – Average Mendeley reader counts were compared to the average Scopus citation counts for 104,520 articles from ten disciplines during the second half of 2016.

Findings – Articles attracted, on average, between 0.1 and 0.8 Mendeley readers per article in the month in which they first appeared in Scopus. This is about ten times more than the average Scopus citation count.

Research limitations/implications – Other disciplines may use Mendeley more or less than the ten investigated here. The results are dependent on Scopus's indexing practices, and Mendeley reader counts can be manipulated and have national and seniority biases.

Practical implications – Mendeley reader counts during the month of publication are more powerful than Scopus citations for comparing the average impacts of groups of documents but are not high enough to differentiate between the impacts of typical individual articles.

Originality/value – This is the first multi-disciplinary and systematic analysis of Mendeley reader counts from the publication month of an article.

Keywords Mendeley, Bibliometrics, Citation analysis, Altmetrics, Early impact, Mendeley readers

Paper type Research paper

Introduction

Academic research is evaluated for appointment, promotion, tenure, for university league tables, for national research evaluation exercises and for self-reflection purposes. Some of these use quantitative data or are supported by numerical evidence of impact. Citation counts for refereed journal articles are a common source of this quantitative data, including in the form of journal impact factors (JIFs) and field normalised citation counts (Garfield, 2006; Waltman *et al.*, 2011; Wilsdon *et al.*, 2015). Citation counts are not suitable for helping to evaluate new research because articles may take three years to attract a substantial number of citations due to publication delays. For this reason, formal evaluations often use a citation window of considerable length, such as three years (Wang, 2013), which excludes newer articles from evaluations. This means that the most recent and, therefore, most relevant research cannot be evaluated with the help of most citation-based indicators because they cannot differentiate effectively between different levels of impact for individual articles.

Two solutions to this problem are to use publishing journal JIFs (or journal rankings: Kulczycki, 2017) as a proxy for citation impact or to use web-based early impact indicators. JIFs can avoid citing article publication delays if it is accepted that the average impact of a journal is an appropriate proxy for the impact of its articles (but see: Lozano *et al.*, 2012; and note also the time dimension: Larivière *et al.*, 2008) and that JIFs are stable over time (which is usually true: Thelwall and Fairclough, 2015). On this basis, say, the 2016 JIF of a journal would be a reasonable indicator for the impact of articles published in that journal in 2016 even though the 2016 JIF calculations are based solely on the citations to articles published in 2014 and 2015 (Garfield, 2006). A more fine-grained alternative is to exploit a

Aslib Journal of Information Management
Vol. 69 No. 2, 2017
pp. 174-183

2050-3806
DOI 10.1108/AJIM-01-2017-0028

faster-growing source of impact evidence from the web for article-level indicators (Priem *et al.*, 2011; or both options can be combined: Haustein and Siebenlist, 2011). Of the various alternative indicators (altmetrics) that have been proposed, Mendeley reader counts are the most promising for early impact evidence because of their relatively high correlations with citation counts and early appearance (Zahedi *et al.*, 2014). Although tweets may appear sooner, they are much less reliable for impact indicators (Haustein *et al.*, 2014; Thelwall *et al.*, 2013).

Mendeley is a free social reference sharing site that allows users to register documents that they are interested in and creates reference lists for them (Gunn, 2013; Henning and Reichelt, 2008; Zaugg *et al.*, 2011). It was bought by Elsevier in 2013 (Bosano, 2013). Mendeley incorporates social features, such as the ability to connect with other members, form groups and examine other users' libraries of registered documents. It also recommends relevant articles to its users (Beel *et al.*, 2016) and supports information seeking (Alhoori and Furuta, 2011). Mendeley is public and so the number of people registering an article in the site is evidence of the impact of that article, even if the article does not have a citation count in traditional research indexes (Maleki, 2015). Since articles are usually registered by people who have read them or who intend to read them (Mohammadi *et al.*, 2016), it is reasonable to consider this as evidence of readership. Nevertheless, intention to read is not the same as reading and so it may be that a lower proportion of articles registered in Mendeley are ever read. An overwhelming majority of users register articles in order to cite them (three quarters or more in all many disciplines), but substantial minorities also use Mendeley to aid teaching and to keep track of literature (Mohammadi *et al.*, 2016). Mendeley reader counts are likely to be substantial underestimates of the amount of interest in an article because presumably only a small minority of the readers of an article use Mendeley (other reference managers exist: Borrego and Fry, 2012) and people may read an article without needing to add it to their Mendeley library.

Despite the above issues, it seems reasonable to consider the presence of an article in a user's Mendeley library as a judgement that the article is useful or interesting. Combining this with substantial evidence that Mendeley reader counts have a moderate correlation with citation counts (Aduku *et al.*, 2016; Li *et al.*, 2012; Schlögl *et al.*, 2014; Thelwall and Sud, 2016) and peer review judgements (HEFCE, 2015) in most disciplines, Mendeley reader counts can be thought of as similar to citation counts, with two differences. First, Mendeley readers accrue about a year in advance of citation counts (Maflahi and Thelwall, 2016; Thelwall and Sud, 2016; see also Pooladian and Borrego, 2016; Alperin, 2015), making them suitable for early impact evaluations. Second, Mendeley is not quality controlled and can therefore be spammed. Because of this, it should not be used for evidence in evaluations where those evaluated know the method of evaluation in advance, but would still be useful for self-evaluations (Wouters, and Costas, 2012). An additional consideration is that Mendeley readers can reflect types of impacts that are ignored by citation counts, including for interest in specific topics (Haustein and Larivière, 2014). Most Mendeley users are junior academics or postgraduates (Mas-Bleda *et al.*, 2014; Mohammadi *et al.*, 2015), which may bias Mendeley data in comparison to citation counts.

Although several previous studies have demonstrated that Mendeley reader counts appear before citation counts in the long term, only one has focussed on the year in which an article is published to assess the value of the earliest possible impact evidence. Journals with long publication delays had much higher average reader counts for articles at their publication date but Mendeley readers tended to build up steadily after this, without a sudden increase caused by a journal issue being published (Maflahi and Thelwall, in press). This study examined six journals in one discipline (library and information science). Other than this, there is no evidence about the Mendeley readers of an article when it is published or about disciplinary differences at this time. In theory, it is possible that articles will have readers when they are first published because of early view versions, pre-print sharing as well as some from the minority of readers who browse the latest issues of journals (Tenopir *et al.*, 2009).

Research questions

Although it is known that there are disciplinary differences in the number of Mendeley readers per article and the ratio of readers to citations in the long term, it is not clear what differences exist when an article is first published, which is when it could reasonably first be used for any kind of systematic research evaluation. The research questions are therefore as follows. These build towards the overarching goal of assessing if and when Mendeley reader counts can be used for research evaluation purposes. For this goal it would be useful to assess the correlation between Scopus citations and Mendeley readers but this would need a longer term study to give useful results because almost all articles have no citations when they are first published (for the relationship between time and correlation strengths, see Figures 1-6 of Thelwall and Sud, 2016):

RQ1. Are there enough Mendeley readers for research evaluation purposes when an article is first published?

RQ2. Are there disciplinary differences in the proportion of citations per Mendeley reader when an article is first published?

Methods

The research design was to gather Scopus citations and Mendeley readers on a range of different disciplinary areas monthly for half a year in order to assess the magnitude of both and the ratio between them. Scopus categories were used for the subject areas. These categories assign articles to a subject based on the journal that publishes them. This is an oversimplification since journals can be multi-disciplinary. The categories are also designed for information retrieval rather than research evaluation but are nevertheless a widely used standard source of categorised articles. Although article-level classification methods are probably more coherent (e.g. Waltman and Eck, 2012), journal-level classifications seem to be adequate given that averages are calculated across entire categories. Scopus has wider coverage than the common alternative, the Web of Science (Moed and Visser, 2008) and the ten categories were chosen to represent substantially different areas (Table I).

During the first week of every month from June to December 2016, up to 10,000 articles from each subject area with an official publication date of 2016 in Scopus were downloaded from Scopus (10,000 is a system limitation). In cases where there were more than 10,000 articles in a subject and year, the first and last 5,000 from that year were downloaded to give a time-balanced set. Only documents of type "article" were downloaded, excluding conference papers, editorials and reviews. Also during the first week of each

Broad area	Subject
Life science	Genetics
Health science	Maternity and midwifery
Environmental science	Geochemistry and petrology
Applied social science	Occupational therapy
Social science	Sociology and political science
Applied physical science	Electrochemistry
Engineering	Industrial and manufacturing engineering
Computing	Computer science applications
Physical science	Condensed matter physics
Humanities	History

Table I.
The ten Scopus subject areas analysed. Subjects are in the same order as the figures

month, the Mendeley applications programming interface was queried to obtain the number of readers of each article found in Scopus. Since articles can be registered in Mendeley with or without digital object identifiers (DOIs), articles were queried by title/author/year and by DOI, with all matching results combined using approximate matching (for details of the matching process, see: Thelwall and Wilson, 2016). Using double queries in this way gets more comprehensive results than either title searches or DOI searches alone (Zahedi *et al.*, 2014).

The first month average citation/reader count for each subject was calculated by averaging the values for all articles that did not appear the previous month. Thus, for example, there were 2,461 genetics articles for the seventh month (July) that had not appeared in Scopus in June (at the time of data collection) and so the seventh month genetics Scopus citation and Mendeley reader averages were calculated from these 2,461 articles alone. These articles were then excluded for the remaining months (Table II).

Since, as described above, the raw data were incomplete for subject/year combinations with over 10,000 articles, this could cause articles to be falsely identified as occurring first in a given month (for the above average calculations) because they had been published during the previous month but not returned within the sample of 10,000 articles. This would not happen in practice, however, as the following examination of the two possible cases shows.

(1) If an article appeared in the most recent 5,000 articles of month n but not for month $n-1$ then it cannot have been published in month $n-1$ because it would also have been in the most recent 5,000 for the older time period. Thus, all articles appearing in the first 5,000 for month n cannot have been previously published in Scopus unless they had already been returned by a query for a previous month.

(2) Conversely, if an article appeared in the oldest 5,000 articles for any month then it should appear in the oldest 5,000 articles for all months after its publication. This is because articles in the set of 5,000 oldest articles cannot be displaced by newer articles. Thus, articles from the oldest set also cannot have their month of first appearance in Scopus be falsely identified. In other words, the set of the oldest 5,000 articles is a static set that does not change and would therefore contribute no new articles to any month in Table II.

Since both citation counts and Mendeley reader counts are highly skewed, geometric means were used for the average citation and reader counts.

Subject/month	July	August	September	October	November	December	Total
Genetics	2,461	2,770	2,120	5,588	2,841	2,376	18,156
Maternity and midwifery	52	67	64	310	87	105	685
Geochemistry and petrology	644	869	729	3,573	1,430	938	8,183
Occupational therapy	64	37	35	169	41	39	385
Sociology and political science	1,537	2,149	1,319	4,792	1,899	1,553	13,249
Electrochemistry	802	1,150	822	4,536	971	622	8,903
Industrial and manufacturing engineering	1,705	1,893	1,367	4,531	2,098	1,184	12,778
Computer science applications	2,291	2,656	2,011	5,383	2,299	2,036	16,676
Condensed matter physics	3,262	2,807	2,259	5,629	2,640	2,815	19,412
History	690	1,000	620	1,962	1,020	744	6,036
Total (%)	13,515 (13)	15,406 (15)	11,355 (11)	36,483 (35)	15,337 (15)	12,424 (12)	104,520 (100)

Table II. Number of articles first appearing in Scopus in each subject in the second half of 2016

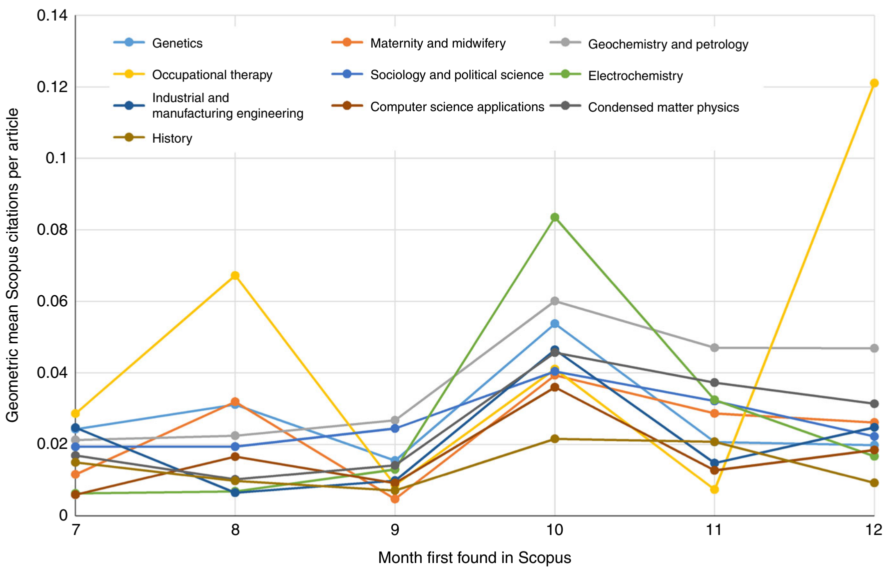
Results

In all fields, the average number of citations per article in the month of first appearance in Scopus is 0.12 or below (Figure 1). Overall, in all fields except the smallest, occupational therapy, at least half of the time, this number is under 0.04. Unsurprisingly, most articles are uncited (over 96 per cent in most fields) when they are published, confirming that citation counts are not numerous enough to differentiate between the impacts of individual articles in their publication month. This small number of citations may be due to author self-citations, pre-print sharing, editor-suggested citations and citations between articles in a themed special issue.

The relatively high average citation counts in the tenth month for nine of the ten subjects are probably due to Scopus indexing practices since twice as many articles first appeared in October 2016 than in any other month (Table II). This suggests that some of these articles were part of a backlog and would therefore have had longer to attract readers and citation by the time that they first appeared in Scopus.

In all fields, the average number of Mendeley readers per article when they first appear in Scopus is between 0.1 and 0.8 (Figure 2). Most articles therefore have no readers when they are published, and so Mendeley reader counts are also not useful to distinguish between the average impacts of typical articles at that time. There are substantial disciplinary differences in the average number of Mendeley readers per article that are reasonably consistent between months. For example, Genetics articles have two to three times as many readers as History. Thus the discriminatory power of Mendeley readers varies greatly by discipline during the year of publication. The peak in the tenth month (October) is probably caused by Scopus indexing practices, as discussed above for Figure 1.

Most of the time there are over ten times as many readers and citations at the publication month (Figure 3). The ratios are unstable for small disciplines due to the low numbers involved (see Table II), however. It is not clear whether there are systematic disciplinary differences in the ratio of readers to citations. For example, electrochemistry



Note: Subjects are in descending order of value in 12th month in Figure 2

Figure 1.
The geometric mean number of Scopus citations per article in the month in which the article first appeared in Scopus, by subject category

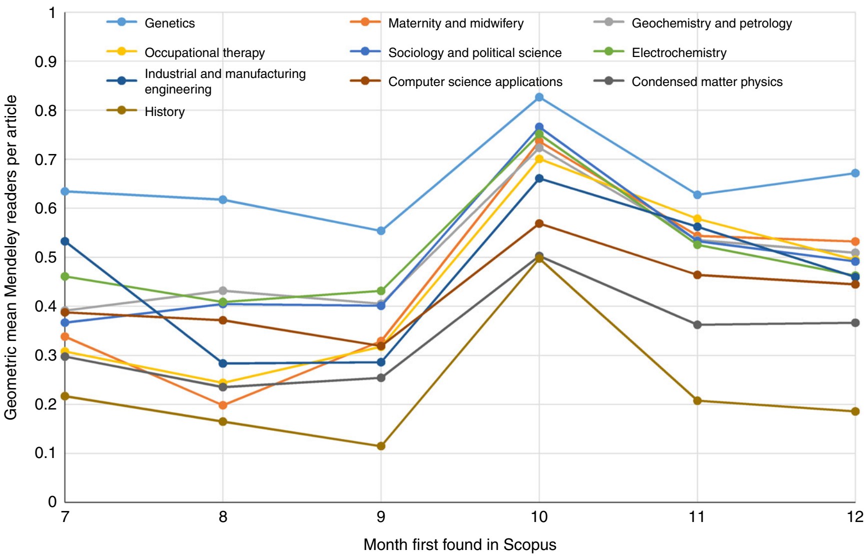
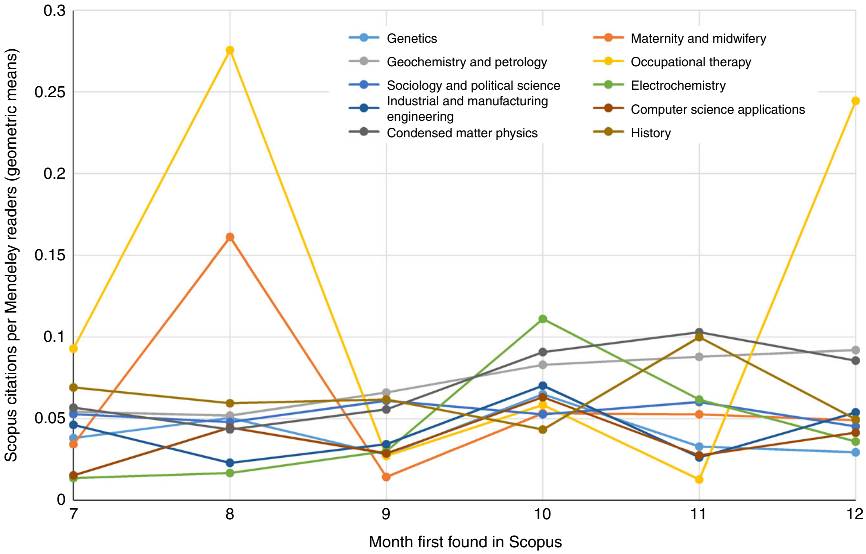


Figure 2. The geometric mean number of Mendeley readers per article in the month in which the article first appeared in Scopus, by subject category



Note: Higher values indicate more citations per Mendeley reader

Figure 3. The ratio of the Figure 1 values to the Figure 2 values

has the lowest ratio in the seventh and eighth month but the highest in the tenth month. Similarly, history has the second highest ratio in two months (seven and nine) but the lowest in the tenth month.

Discussion and conclusions

The results show that there are more Mendeley readers than Scopus citations per article at the month of publication but there are probably still not enough Mendeley readers for article-level evaluations, however, since the average is under 0.8 for all subjects. There are substantial disciplinary differences, with genetics having consistently the most readers per article, and history the fewest. The relatively high position of the humanities/social science field sociology and political science does not suggest a science/humanities divide, however. The differences here may be due to disciplinary culture factors, such as the average publication delays for articles (longer publication delays are likely to result in higher citation counts and more Mendeley readers) as well as the uptake of Mendeley or the success of competing reference managers.

For the second research question, although there are disciplinary differences in the number of citations per reader these are not consistent over time and the results are inconclusive. Thus, the disciplinary differences in the total number of readers per article may be directly inherited from the (known) disciplinary differences in the average number of citations per article rather than Mendeley-specific factors, such as the use of reference sharing in different disciplines. A previous study of individual articles with relatively many Mendeley readers per citation and vice versa has shown that differences in uptake of Mendeley by specific communities can be an explanation, as can educational uses (Thelwall, in press). The results here suggest that these factors may not have a strong effect on the overall early readers of a paper across entire disciplines.

In terms of practical implications, academics and research evaluators seeking early evidence of the impact of academic research are much more likely to find Mendeley reader counts to be useful than Scopus citations in the publication month, but neither are large enough to be able to differentiate between the impacts of typical articles because less than half of all the articles had at least one Mendeley reader, when published. Given this finding, it is logical to seek a clear answer for the number of months to wait before the Mendeley reader counts are large enough to be useful. There is not a simple answer to this question because it requires assumptions about the purpose of an assessment as well as the number of articles examined and the degree to which they should be able to be differentiated between in terms of reader counts. For citation-based evaluations, an informal rule is to wait for three years of citations for typical evaluations (e.g. Aksnes, 2003; Glanzel, 2002; Wang *et al.*, 2015) and so, given that previous research has found citations to lag Mendeley readers by about a year (Thelwall and Sud, 2016), two years seems like a reasonable heuristic delay for an effective analysis at the individual publication level.

Despite the conclusions about individual articles, even averages well below 1 can be adequate when comparing the impacts of groups of articles (Thelwall, 2017a), such as to compare departments or universities. For comparing groups of articles at or close to their publication month, Mendeley reader counts are substantially more powerful than Scopus citations and this increased power may be approximately constant between disciplines. Although it cannot be directly checked from the data available, Mendeley readers at publication time seem likely to be less unusual than Scopus citations at the publication time, since the latter may occur through factors such as advance notice of publication, author self-citation and special issues. This may be part of the reason that early citations are not always good predictors of long-term citations (Stegehuis *et al.*, 2015) and so it is not clear whether the same would also be true for early Mendeley readers. Mendeley reader counts should not be used for evaluations when there is an opportunity for those evaluated to manipulate the results in advance, because this is not difficult (Thelwall, 2017b; Wouters and Costas, 2012). Mendeley-specific biasing factors should also be taken into account, such as national differences in uptake and reading patterns (Thelwall and Maflahi, 2015) and its relatively young user base (Mohammadi *et al.*, 2015).

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