Who Publishes, Reads, and Cites Papers? An Analysis of Country Information

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Abstract
The research field of altmetrics has gathered increased attention within scientometrics. Here, we pay particular attention to the connection between countries of readers of papers (at Mendeley) and countries of authors as well as citers of papers (from Web of Science). This study uses the Mendeley application programming interface to gather Mendeley reader statistics for the comprehensive F1000Prime publication set (n_r=149,227 records, n_p = 114,582 papers). F1000Prime is a post-publication peer-review system for papers of the biomedical research. The F1000 papers are rated by experts as good, very good, or exceptional. We find no significant differences between authorship, readership, and authorship of citing papers broken down into countries across quality levels. Most authors, citers, and readers are located in the USA followed by UK and Germany. Except for a few cases, we find that percentages of readers, citers, and authors are rather well balanced. Although Russia and China host many large research groups with a large publication output, both countries are below the top 10 countries ordered according to readership percentages.

Conference Topic
Altmetrics

Introduction
Online reference managers can be seen as the scientific variant of social bookmarking platforms, in which users can save and tag web resources (e.g. blogs or web sites). The best known online reference managers with a social networking component are Mendeley (www.mendeley.com) and CiteULike (www.citeulike.org), which were launched in 2004 (CiteULike) and 2008 (Mendeley), and can be used free of charge (Li et al., 2012). Mendeley – in 2013 acquired by Elsevier (Rodgers and Barbrow 2013) – has developed since then into the most popular product among the reference managers (Haustein 2014), and most empirical studies involving reference managers have used data from Mendeley. Mendeley has obtained a rather unique position as an online reference manager with desktop and mobile app versions. Furthermore, Mendeley offers social networking services, which go beyond the capability of most reference managers.

The platforms allow users to save or organize literature, to share literature with other users, as well as to save keywords and comments on a publication (or to assign tags to them) (Bar-Ilan, et al., 2014, Haustein et al., 2014). Even if it is literature that is mainly saved by the users, they can also add to a library other products of scientific work (such as data sets, software and presentations). The providers of online reference managers make available a range of data for the use of publication by the users: The most important numbers are the user counts, which provide the number of readers of publications via the saves of publications (Li et al., 2012). The readers

can be differentiated into different status and country groups as well as scientific sub-disciplines. The readers' data from Mendeley is also evaluated to make suggestions to the users for new papers and potential collaborators (Priem & Hemminger, 2010, Galloway et al., 2013). Although it is not quite known what Mendeley reader counts mean exactly, they can be viewed as citations to be. Many Mendeley users bookmark a paper in Mendeley with the intend to cite this paper in a forthcoming manuscript. As this is not the only reason to bookmark a publication in Mendeley, it is clear that Mendeley reader counts measure also something different than citations. This additional part of a publication's impact is another means to measure its usage.

In this study, the country information of Mendeley readers is used to compare the readers of papers with their authors as well as those authors who have cited the papers. We are interested in differences and similarities between the countries worldwide: Which are the countries in which the scientists read (or cite) more than publish and vice versa? In which countries are the numbers of authors, readers, and citers similar? As publication set, we used papers from the post-publication peer review system of F1000. It is an advantage of this dataset that each paper is classified according to its quality (based on expert scores). Thus, we are able to investigate the distribution of authors, readers, and citers for papers with different quality.

Literature review

Mendeley is used chiefly by science, technology, engineering and mathematics researchers (Neylon et al., 2014). According to a questionnaire in the bibliometric community (Haustein et al., 2014), 77% of those questioned know Mendeley. But Mendeley is actually used by only 26% of those questioned. However, with respect to the number of saved papers there are large differences between disciplines: Thus, for example, only about a third of the humanities articles indexed in the Web of Science (WoS) can also be found in Mendeley; however, in the social sciences, it is more than half (Mohammadi & Thelwall, 2013). Among the reference managers, Mendeley seems to have the best coverage of globally published literature (Haustein et al., 2014, Zahedi et al., 2014). The large user population and coverage result in Mendeley being seen as the most promising new source for evaluation purposes (among the online reference managers) (Haustein, 2014). Priem (2014) sees Mendeley already as a rival to commercial databases (such as Scopus and WoS).

With a view to the use of the data from online reference managers in research evaluation, bookmarks to publications (i.e. the saving of bibliographic data about publications in libraries) express the interest of a user in a publication (Weller & Peters 2012). But this interest is very variable; the spectrum extends from simple saving of the bibliographic data of a publication up to painstaking reading, annotation and use of a publication (Shema et al., 2014, Thelwall & Maflahi, in press). According to Taylor (2013), the following motives could play a role in the saving of a publication: "Other people might be interested in this paper … I want other people to think I have read this paper … It is my paper, and I maintain my own library … It is my paper, and I want people to read it … It is my paper, and I want people to see that I wrote it" (p. 20). The problem of the unclear meaning of the saving (or naming) of a publication is common to bookmarks in reference managers and also many other traditional and alternative metrics: Thus, for example, traditional citations can mean either simple naming citations in the introduction to a paper, as well as extensive discussions in the results or discussion sections (Bornmann & Daniel, 2008). Traditional citations can also be self-citations.

The data from online reference managers is seen as one of the most attractive sources for the use of altmetrics in research evaluation (Sud & Thelwall, in press). The following reasons are chiefly given for this:

- The collection of literature in reference managers is – similar to the way this is the case with citations and downloads of publications – a by-product of existing workflows (Haustein 2014). This is why saves are appropriate as an alternative metric chiefly for the measurement of impact in areas of work where literature is collected and evaluated (such as with researchers in academic and industrial research, students and journalists).
- Whereas the impact of classical papers can be measured very well via citations in databases (such as the WoS), this is hardly possible with other types of publication such as books or reports.
- According to Mohammadi and Thelwall (2014), usage data of literature may be partially available (i.e. from publishers); but there is a shortage of global and publisher-independent usage data.
- Data sets of online reference managing platforms are highly accessible. The data may be available via API or database dumps (Priem & Hemminger, 2010).

However, the use of data from online reference managers is not only seen as advantageous, but also as problematic:

- Since not everybody who reads and uses scientific literature works with an online reference manager (and Mendeley, particularly), there is the problem that the evaluation of saved data only takes into account a part of the actual readership. Among researchers this part is probably younger, more sociable and more technologically-oriented than average for researchers (Sud & Thelwall, in press).
- The data which are entered by users into the online reference managers are erroneous or incomplete. This can lead to saves not being able to be associated unambiguously with a publication (Haustein, 2014).

Similar to Twitter citations, readership counts can also be manipulated relatively simply (for example with artificially generated spam) (Bar-Ilan et al., 2014).

Many of the empirical-statistical studies into social bookmarking – according to Priem and Hemminger (2010) – deal with tags and tagging. Seen overall, the studies come to the conclusion that exact overlaps of tags and professionally created metadata are rare; most matches are found when comparing tags and title terms (Haustein & Peters, 2012). A large part of the studies into online reference managers has evaluated the correlation between traditional citations (from Scopus, Google Scholar and the WoS) and bookmarks in Mendeley and/or CiteULike. The meta-analysis of (Bornmann, 2015) shows that the correlation is medium to large (CiteULike pooled r=0.23; Mendeley pooled r=0.51).

Two studies have already investigated country information from Mendeley: (1) Haustein and Larivière (2014) analyzed the journal *Aslib Proceedings* (AP) with a set of indicators from several perspectives. The results show that the largest share of AP papers in the last eight years were written by authors affiliated to UK (58 %), Iran (6 %), South Africa and USA (both 5 %). In contrast, Mendeley readers of AP articles were mainly from the USA (14 %), UK (12 %), Spain (6 %), India (4 %), Canada (3 %), South Africa (3 %) and Malaysia (2 %). (2) For some WoS categories, Thelwall and Maflahi (in press) downloaded all article (article meta data) that were written in English from 2011. The country affiliation of the authors was extracted from the WoS affiliation field; each article was searched for in Mendeley to receive the number of readers from each country. The results of the study show that there is a tendency for articles to be more read in

countries with a higher share of their authorship. Possible reasons for the tendency are that authors are often readers of their own articles and that the readers often know or have heard of the authors.

Methods

Peer ratings provided by F1000Prime

F1000Prime is a post-publication peer review system of the biomedical literature (papers from medical and biological journals). F1000 Biology was launched in 2002 and F1000 Medicine in 2006. The two services were merged in 2009 and today form the F1000 database. Papers for F1000Prime are selected by a peer-nominated global Faculty of leading scientists and clinicians who then rate them and explain their importance (F1000, 2012). This means that only a restricted set of papers from the medical and biological journals covered is reviewed, and most of the papers are actually not (Kreiman & Maunsell, 2011, Wouters & Costas, 2012).

The Faculty nowadays numbers more than 5,000 experts worldwide, assisted by 5,000 associates, which are organized into more than 40 subjects (which are further subdivided into over 300 sections). On average, 1,500 new recommendations are contributed by the Faculty each month (F1000, 2012). Faculty members can choose and evaluate any paper that interests them; however, the great majority pick papers published within the past month, including advance online papers, meaning that users can be made aware of important papers rapidly (Wets et al., 2003). Although many papers published in popular and high-profile journals (e.g. *Nature*, *New England Journal of Medicine*, *Science*) are evaluated, 85% of the papers selected come from specialized or less well-known journals (Wouters & Costas, 2012). Less than 18 months since Faculty of 1000 was launched, the reaction from scientists has been such that two-thirds of top institutions worldwide already subscribe, and it was the recipient of the Association of Learned and Professional Society Publishers (ALPSP) award for Publishing Innovation in 2002 (http://www.alpsp.org/about.htm) (Wets et al., 2003).

The papers selected for F1000Prime are rated by the members as good, very good, or exceptional, which is equivalent to recommendation scores (rs) of 1, 2, or 3, respectively. Since many papers are not rated by one member alone, but by several, we calculated a mean rs for every paper. In order to categorize the F1000 papers into three quality levels, papers with mean rs < 2 have been categorized as Q1 and papers with mean rs > 2.5 as Q3. Papers with rs in-between are categorized as Q2, then. This is not a categorization of low and high quality because all F1000Prime papers have a very high quality compared to other papers in their field. This is merely a further distinction between high quality papers, as papers with low quality do not get recommended into F1000Prime.

Data sets used from Mendeley and WoS

In January 2014, F1000 provided one of the authors with data on all recommendations (and classifications) made and the bibliographic information for the corresponding papers in their system (n_r=149,227 records, n_p = 114,582 papers). Each of these records with either a PubMed-ID or a DOI was used to retrieve the Mendeley usage statistics via the R (http://www.r-project.org, accessed October 14, 2014) API of Mendeley (https://github.com/Mendeley/mendeley-api-r-example, http://dev.mendeley.com/methods/, both accessed October 14, 2014). An example R script is available at http://dx.doi.org/10.6084/m9.figshare.1335688. In the summer of 2014, a new version of the API was released which we used for this study (Bonasio,

2014). The previous API had some limitations, such as providing only the information of the demographics for the top three categories as a percentage. Another problem (which has not been solved yet) is that most users do not record their country and so only some readership country location information is available (Thelwall & Maflahi, in press). We requested the actual numbers of Mendeley users for each F1000 record (and the result was not truncated after the top three categories). We observed several (probably random) connection problems. Overall, about 99% of the F1000 paper set was found on Mendeley, which implies a rather good coverage of scientific papers on Mendeley (Bornmann & Haunschild, 2015). We recorded a total of 5,885,534 Mendeley reader counts.

For bibliometric analysis in the current study, country information of the authors who published a F1000 paper or published a paper citing a F1000 paper were sought in an in-house database of the Max Planck Society (MPG) based on the WoS and administered by the Max Planck Digital Library (MPDL). Despite different meanings of (citing) authors' and readers' countries, we talk about countries of readers and (citing) authors in the same way in the following sections.

Technical limitations

Only about 17.6% of 5,885,534 Mendeley reader counts (n=1,038,449) provided were available with their country association. For only 1,064 records of the F1000 data set, we found that the sum over all reader's countries was equal to the total number of reader counts. Thus, in the majority of cases (99.3%) some Mendeley readers are missing in our statistic because many readers did not share their location.

In contrast to the Mendeley data (in which the country information is reader-specific), the country information for the (citing) authors is address-specific. If two authors have different addresses, the country information is counted twice. However, if the addresses are identical, they are counted once. This limitation is unavoidable using our current WoS data. A second limitation of the data is that papers with different publication years have been considered without time-normalization in the study. For different publication years, one can expect different numbers of readers and citers: The longer the reader and citation window, the more counts are expectable. Since the counts have not been time-normalized in the study, papers with longer windows will have a greater effect on the results than papers with smaller windows. However, the papers with longer and smaller windows are unsystematically distributed across the different quality levels of the papers. Thus, the missing time-normalization of the data won't influence the investigation of the relationship between the distribution of readers and (citing) authors across countries and quality levels.

Processing and visualization of the data

The Mendeley reader data, as well as the WoS author and citer data, were processed by Perl (http://www.perl.org/) and Gawk (http://awk.info/) scripts. Visualization of the data was carried out using Tableau (http://www.tableausoftware.com/). Plots of country and world maps use the Mercator projection.

Results

The results of the study including all F1000 papers with data from WoS and Mendeley are shown in Figures 1 and 2, as well as Table 1 (all papers). For each country, we calculated the percentage of authors, readers, and citers. In Figure 1, the percentage of authors (red colour), citers (blue colour), and readers (green colour) are visualized for all countries worldwide. Figure 2 shows a

more detailed analysis of Europe as very many circles are overlapping in this region in Figure 1. The left panel of Figure 2 compares readers (green colour) and authors (blue colour) while the right panel compares citers (red colour) and authors (blue colour). The bigger the circle on the maps, the higher the percentage for a country is.

As the results in Figure 1 show most authors, readers, and citers are located in the USA. The results in Table 1 (all papers) point out that 29.2% of all readers, 38.3% of all authors, and 39.9% of all citers come from the USA. The USA is the country with the most readers, authors, and citers – significantly more than any other country. The high percentages of authors and citers point to a high level of research activity in the USA. The population and number of research groups in the USA are significantly higher compared to most other countries. In Table 1 (all papers), the USA is followed by the UK (all papers: readers=10.7%, citers=6.6%, and authors=9.3%). Further countries in the table (Germany, France, Japan, and Canada) show small differences in the percentages compared to the UK (less than 10 percentage points). Despite the rather large number of research groups in Russia and China, it is quite surprising that both do not appear in the top 10 list ordered by the number of Mendeley readers. In fact, we find China on rank 13 and Russia on rank 25, close to Poland and the Czech Republic.

As the results in Table 1 further show, many countries have different percentages of authors, readers, and citers. The US has a similar percentage of authors and citers (see e.g. the numbers for all papers), but the percentage of readers is lower than both other percentages. This result seems to reflect the fact that Mendeley is only one reference manager software among others in the USA. For other countries it is the other way around. For example, while 4.7% of all readers come from Brazil (all papers), less than 1% of all authors and citing authors are working in this country.

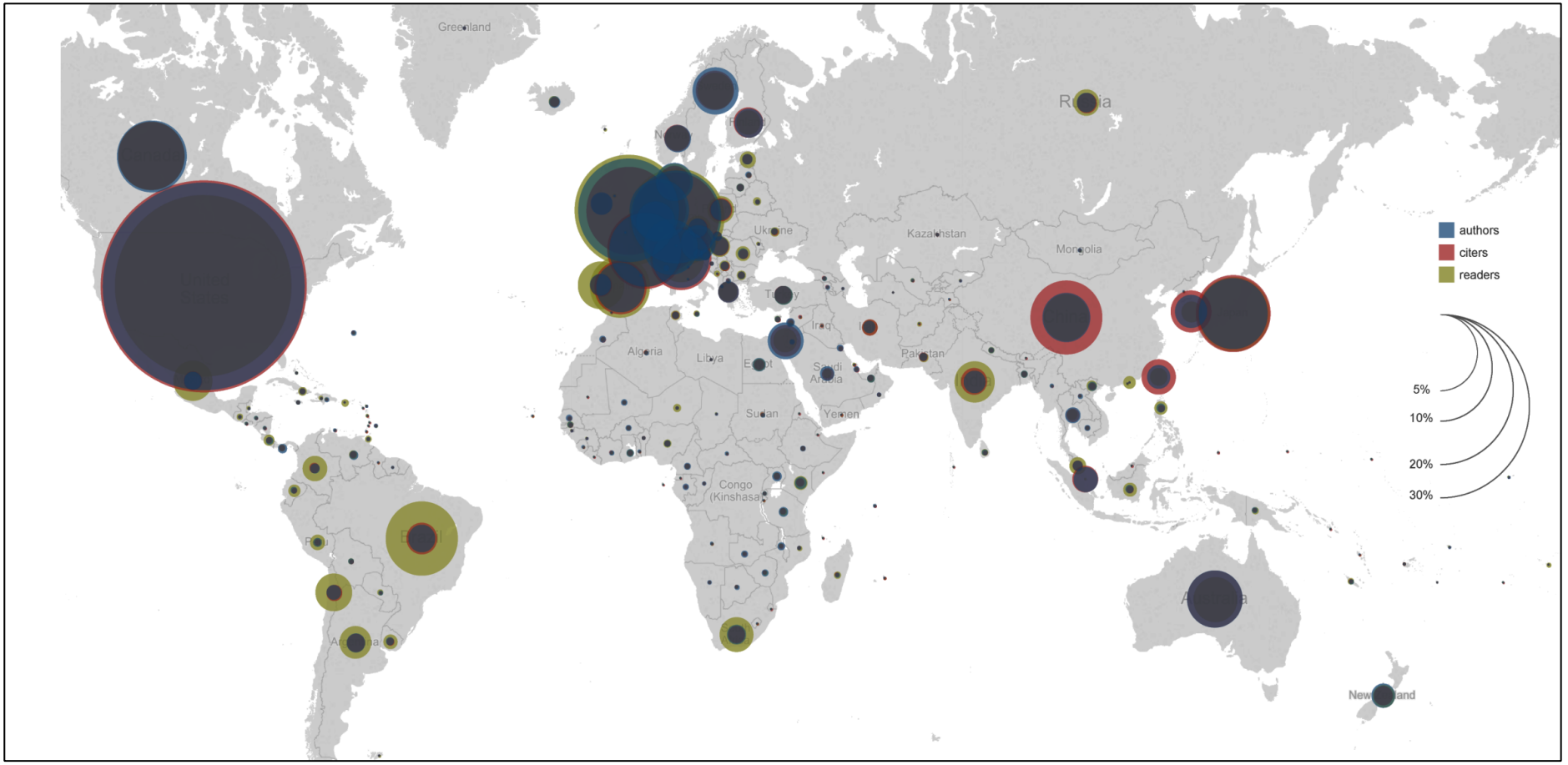

Figure 1. Percentage of authors (blue colour), citers (red colour), and readers (green colour). The circle sizes indicate the share of the country in the amount of readers, citers and authors, respectively. The map is based on all F1000 papers.

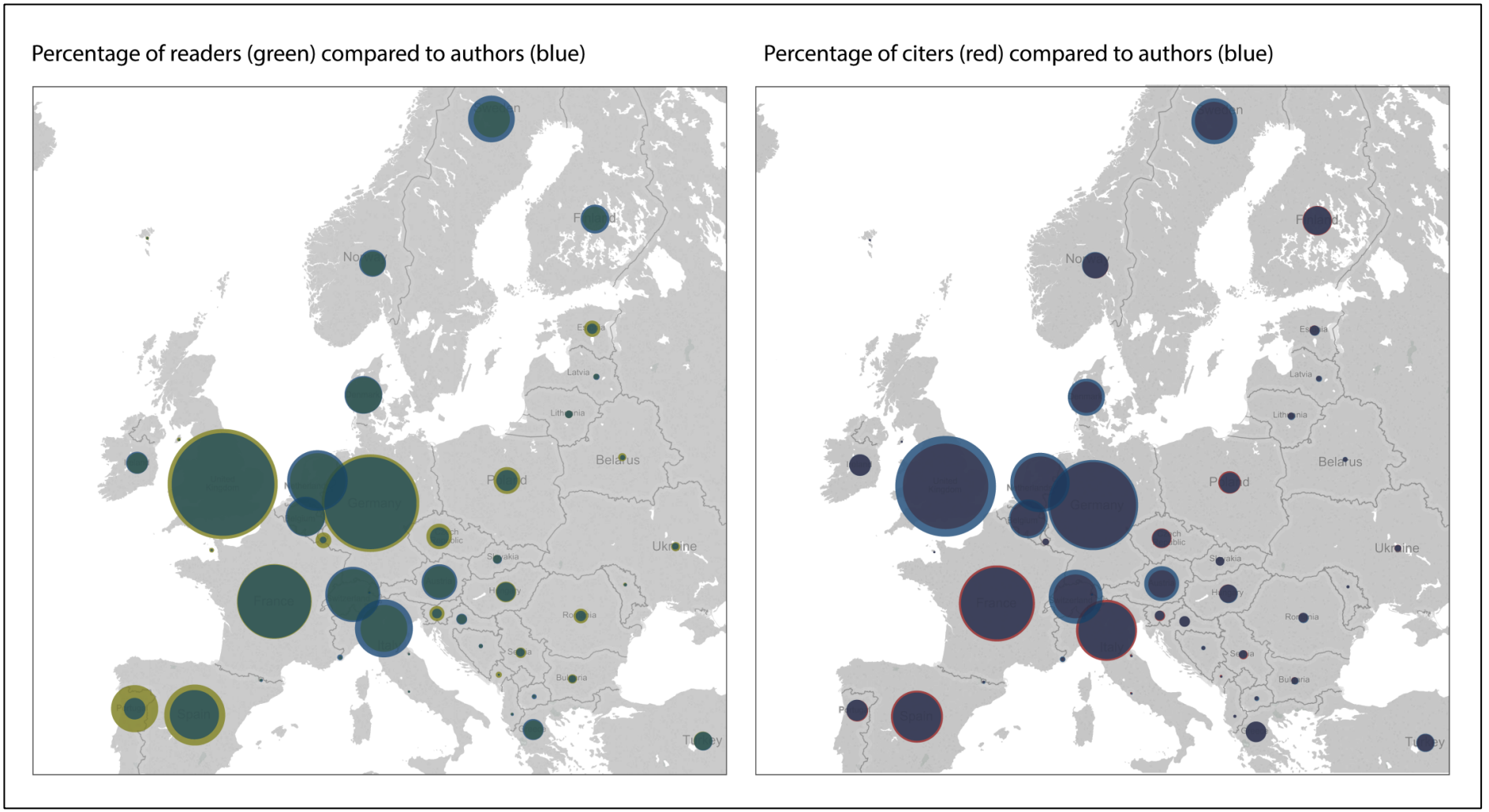

Figure 2. Percentage of readers (green colour) and authors (blue colour) on the left panel, as well as percentages of citers (red colour) and authors (blue colour) visualized on the right panel for European countries. The circle sizes indicate the share of the country in the amount of readers, citers and authors, respectively. The map is based on all F1000 papers.

Table 1. Percentage of authors, citers, and readers from different countries. The percentages are presented for all papers, as well as for papers with Q1 (rs<2), Q2 (rs>=2 and rs<=2.5), and Q3 (rs>2.5) quality. The ten countries are listed with the highest percentage of readers.

All papers	Authors	Citers	Readers	Q1	Authors	Citers	Readers
USA	38.3	39.9	29.2	USA	37.7	39.4	28.7
UK	9.3	6.6	10.7	UK	9.2	6.6	10.7
Germany	7.4	6.8	8.4	Germany	7.4	6.7	8.3
France	4.7	5.2	4.9	Brazil	0.6	0.8	5.0
Japan	4.3	5.1	4.7	France	4.7	5.3	4.9
Brazil	0.6	0.8	4.7	Japan	4.3	5.0	4.5
Canada	4.4	4.0	4.0	Canada	4.5	4.0	4.0
Spain	2.0	2.4	3.2	Spain	2.1	2.5	3.3
Netherlands	3.1	2.5	2.6	Netherlands	3.2	2.5	2.6
Switzerland	2.6	1.7	2.2	Switzerland	2.4	1.6	2.2
Q2	Authors	Citers	Readers	Q3	Authors	Citers	Readers
USA	39.0	40.4	29.4	USA	40.7	41.2	30.6
UK	9.5	6.7	10.7	UK	9.3	6.6	10.7
Germany	7.5	6.9	8.5	Germany	8.0	6.8	8.4
Japan	4.3	5.1	5.0	Japan	4.2	5.4	5.1
France	4.5	5.2	4.8	France	4.6	5.0	4.6
Brazil	0.5	0.7	4.4	Canada	4.2	3.7	4.0
Canada	4.3	3.9	3.9	Brazil	0.6	0.8	4.0
Spain	2.0	2.3	3.1	Spain	1.5	2.2	3.0
Netherlands	3.1	2.4	2.6	Netherlands	2.9	2.3	2.7
Switzerland	2.8	1.7	2.2	Switzerland	2.9	1.7	2.1

This result points out that Brazil rather receives than produces scientific results in the field of biomedical research: Since a low percentage of citing authors reflects a low number of subsequent published papers (following and basing on the F1000Prime papers), this percentage is not only an indicator of reception but also of productivity. Similar results as for Brazil are not only visible on the map in Figure 1 for other south-American countries (such as Argentina or Chile), but also for India and African countries.

From the European countries, Spain and Portugal receive more F1000 papers than they produce (c.f. left panel of Figure 2). Spain is located on rank 8 (see Table 1), and Portugal is located on rank 11. The northern European countries produce more F1000 papers than they cite (c.f. right panel of Figure 2). This is vice versa for most southern European countries.

Table 1 shows the percentage of authors, citers, and readers from different countries not only for all papers, but also for papers with different rs: Q1 (rs < 2), Q2 (2 <= rs <= 2.5), and Q3 (rs > 2.5) section. Comparing the numbers of authors, citers, and readers for different paper quality levels, we see only minor differences for most countries: Brazil shows a somewhat higher amount of readers in the Q1 section (5%) than in the Q3 section (4%), while the percentage of authors and citers does not differ at all between Q3 and Q1 section papers. The USA shows a somewhat higher amount of authors, citers, and readers in the Q3 section (40.7%, 41.2%, and 30.6%, respectively) than in the Q1 section (37.7%, 39.4%, and 28.7%, respectively). The UK shows a nearly constant percentage across quality levels for authors, citers and readers: 9.2%, 6.6%, and 10.7%, respectively for Q1, 9.5%, 6.7%, and 10.7%, respectively for Q2, and 9.3%, 6.6%, and 10.7%, respectively for Q3.

Discussion

By far the highest number of authors, citers, and readers are located in the USA. More F1000 papers are authored, cited, and read in western European countries than in eastern European countries. The amount of F1000 papers authored, cited, and read in China and Russia is small compared to the large number of research groups located there (rank 13 and 25, respectively, according to Mendeley readers). Other reference softwares might be more popular in these countries (or this kind of software is scarcely in use). Traffic data from Alexa.com can be used as an estimate for the Mendeley distribution. The top 5 countries where Mendeley is used seem to be USA (30.4%), India (20.7%), UK (4.3%), Pakistan (3.9%), and Malaysia (3.0%) (http://www.alexa.com/siteinfo/www.mendeley.com, visited on 19 December 2014). Roughly a year earlier, the top 5 countries were somewhat different: USA (16.1%), India (13.2%), Belgium (9.9%), Germany (6.2%), and UK (5.9%) (Thelwall and Maflahi, in press). This relative gain of Mendeley traffic from India, Pakistan, and Malaysia is different from our results, as they do not appear on our top 10 list of Mendeley readers. Within the F1000 readership on Mendeley, India is on rank 15, Malaysia on rank 38, and Pakistan on rank 59. Probably, scientists who use Mendeley in these countries are not that active in the bio-medical research. Belgium, which was in the top 5 list of Mendeley traffic a year ago, is on rank 17 according to our Mendeley readership results of the F1000 paper set.

We find only minor differences in the readership of papers with different quality levels Q1-Q3. The similarities of the results across paper quality levels can be explained with the very high standard of all publications in the F1000Prime set. Also, papers within the Q1 quality section in the F1000 publication set gather a rather high amount of citations (Bornmann 2014). Considering that all papers in the F1000 publication set are of a higher than average quality in the biomedical area, one probably cannot expect a clear difference between quality levels in the Mendeley readership.

Most countries show a quite good balance between consumption and production of F1000 papers. See for example in Table 1, the percentages of Germany are 7.4% authors, 6.8% citers, and 8.4% readers. Although scientists in Germany seem to consume somewhat more of

the literature of the F1000 paper set, the difference between authors (citers) and readers can be neglected, considering the limitations of our study and the (necessary) counting of authors (citers) and readers on unequal footing. In contrast to Germany, the number of readers is significantly higher than the number of authors and citers in some south-American countries (e.g. Brazil, Mexico, Chile, and Argentina) and some European and Asian countries (e.g. Portugal and India).

It is important to keep in mind that we measure authors and citers based on their institutional affiliation and readers on a personal level.

Another problem in the interpretation of the results is that the distribution of the Mendeley software is probably different for each country. Mendeley is free of charge. Thus, one could expect a higher number of Mendeley users in countries with tight research budgets. However, scientists in countries with tight research budgets might not author, cite, or read many publications which got recommended into F1000Prime, as many F1000Prime papers were published in journals with rather high subscription fees.

A third problem in the interpretation of the results is that a rather small number of readers provide their country, as it is not mandatory information. While we found approximately 99% of the F1000 papers at Mendeley, country information were available only for nearly 18% of the reader counts. This is significantly less than the value reported in a previous study done using a much smaller amount of papers (Haustein and Larivière 2014). However, it is reasonable to expect that Mendeley users who do not provide their location are evenly distributed over the world and are reading all quality classes of the F1000 papers.

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