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Normalization of Mendeley reader counts for impact assessment

Robin Haunschild[a,*], Lutz Bornmann[b]

[a] Max Planck Institute for Solid State Research, Heisenbergstr. 1, 70569 Stuttgart, Germany
[b] Division for Science and Innovation Studies, Administrative Headquarters of the Max Planck Society, Hofgartenstr. 8, 80539 Munich, Germany

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ABSTRACT

A different number of citations can be expected for publications appearing in different subject categories and publication years. For this reason, the citation-based normalized indicator Mean Normalized Citation Score (MNCS) is used in bibliometrics. Mendeley is one of the most important sources of altmetrics data. Mendeley reader counts reflect the impact of publications in terms of readership. Since a significant influence of publication year and discipline has also been observed in the case of Mendeley reader counts, reader impact should not be estimated without normalization. In this study, all articles and reviews of the Web of Science core collection with a publication year of 2012 (and a DOI) are used to normalize their Mendeley reader counts. A new indicator that determines the normalized reader impact is obtained –the Mean Normalized Reader Score (MNRS) – and compared with the MNCS. The MNRS enables us to compare the impact a paper has had on Mendeley across subject categories and publication years. Comparisons on the journal and university level show that the MNRS and MNCS correlate larger for 9601 journals than for 76 German universities.

1. Introduction

Estimating the citation impact of scientists, research groups, and institutes in different disciplines and time periods faces the problem that discipline and time period influence the citation impact of publications independently of the quality of the publications. Normalization for both factors started in the mid-1980s (Schubert & Braun, 1986). Only since normalized values were obtained did it become possible to assess the citation impact of entities such as researchers or universities across disciplines and time periods. In the calculation of a normalized impact value for a publication, the total number of citations of the publication is counted (times cited). The number of times cited is compared with the citation impact of publications with the same publication year, subject category, and document type (expected impact of the reference set). This technique is referred to as cited-side normalization. Although other methods have been developed in recent years (e.g., normalization on the side of the citing publications, Zitt & Small, 2008), this method is the most established and used in bibliometrics.

In recent years, impact evaluation in scientometric research has been done not only on the basis of citations but also based on alternative metrics (altmetrics) (Borrego, 2014; Mohammadi & Thelwall, 2014; Torres-Salinas, Cabezas-Clavijo, & Jimenez-Contreras, 2013; Priem, 2013, 2014). Altmetrics open the possibility to assess the impact of research faster than with

* Corresponding author.
E-mail addresses: R.Haunschild@fkf.mpg.de (R. Haunschild), bornmann@gv.mpg.de (L. Bornmann).

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citations. Moreover, altmetrics seem suitable to determine the impact of research in a broader manner than with citations (Aguinis, Shapiro, Antonacopoulou, & Cummings, 2014; Bar-Ilan et al., 2012; Bornmann, 2014; Dinsmore, Allen, & Dolby, 2014; Hammarfelt, 2014; Priem, Taraborelli, Groth, & Neylon, 2010). While citations quantify only the impact of research on science, altmetrics could be able to quantify the impact of research on all aspects of society, including science. Current scientometric research studies if this hope is more than a working hypothesis.

2. Literature overview and research questions

Data from Mendeley are among the most important sources for altmetrics: "Mendeley is both a citation management tool and social network for scholars with over two million users" (Rodgers & Barbrow, 2013, p. 12). One basic assumption behind the use of such data in an evaluative context is that Mendeley readers who add a publication to their library can be counted as readers of the publication. Indeed, the results of Mohammadi, Thelwall, and Kousha (in press) show that "82% of the Mendeley users had read or intended to read at least half of the bookmarked publications in their personal libraries." Therefore, Mendeley counts are seen as a very promising possibility to quantify the size of the readership of a paper inside as well as outside of science. Furthermore, a Mendeley reader can be seen as a precursor to a citer, as Mendeley users include a publication into their library when they intend to cite it in a forthcoming manuscript. However, each Mendeley user is counted as *one* reader, while it is possible that they will cite the publication multiple times or not at all.

Several studies have shown that the Mendeley reader impact – similar to the citation impact, although there are differences between the two – varies across scientific disciplines (Jeng, He, & Jiang, 2015; Thelwall & Maflahi, 2015; Zahedi, Costas, & Wouters, 2014; Zahedi & van Eck, 2014). In one discipline, papers are read more often on average (or papers are more frequently included in the user' Mendeley library) than in other disciplines. These variations are not only specific to Mendeley data but also to other altmetric sources, e.g., Twitter counts (Haustein, Costas, & Lariviere, 2015). Moreover, publications with different document types and publication years receive different average numbers of Mendeley readers (Haustein & Lariviere, 2014). Therefore, in almost the same manner as for citation counts, Mendeley reader counts should be normalized with respect to publication year, document type, and scientific discipline before an interpretation is attempted.

The aim of this study is to apply the most established method of normalization (cited-side) in bibliometrics to the field of altmetrics and propose a normalization scheme for Mendeley reader counts. Independently from and coincidental with our efforts (Haunschild & Bornmann, 2015) a similar approach has been suggested by Fairclough and Thelwall (2015), which focuses on country comparisons only. The possibility of defining an indicator similar to the MNCS but based on reader counts instead of citations constitutes our first research question. The second research question addresses to which extent the MNCS correlates with the indicator based on reader counts on the journal and university levels.

3. Data set

It is common practice in scientometrics to evaluate the impact of articles and reviews. Other document types are usually not included in evaluative bibliometrics (Moed, 2005). We retrieved the Mendeley reader statistics for articles and reviews published in 2012 and having a DOI (n_A = 1133,224 articles and n_R = 64,960 reviews) via the Mendeley API made available in 2014. The DOIs of the papers from 2012 were exported from the in-house database of the Max Planck Society (MPG) based on the WoS and administered by the Max Planck Digital Library (MPDL). We used R (http://www.r-project.org/) to interface to the Mendeley API. DOIs were used to identify papers in the Mendeley API; 1074,407 articles (94.8%) and 62,771 reviews (96.6%) were found at Mendeley.

In total, the articles were registered in Mendeley 9352,424 times and the reviews were registered 1335,764 times. For 118,167 articles (10.4%) and 4348 reviews (6.7%), we found the paper at Mendeley but without a reader. Papers without any readers indexed by Mendeley may originate from former readers who removed the paper from their library or closed their Mendeley account. If Mendeley users include too little bibliographic data for a paper in their library, they are not counted as readers either, because there is insufficient information to link them to a Mendeley database entry. Also, Mendeley adds papers to the database without any reader in the first place from publisher feeds. Therefore, papers with zero reader counts should be excluded in this study, or, if they are included, the papers not found at Mendeley should also be counted as papers with zero readers. We tested both approaches and found no significant differences regarding the scope of this study. In the end, we decided to include the papers with zero readers as well as the papers we did not find in the Mendeley API. This is consistent with the way citations are handled in bibliometric databases. The requests to the Mendeley API were made from December 11–23, 2014. All data in this study are based on a partial copy of our in-house database (last updated on November 23, 2014) supplemented with the Mendeley reader counts.

4. Results

4.1. Differences in reader impact between subject categories

Like the citation distribution (Albarran, Crespo, Ortuno, & Ruiz-Castillo, 2011; Rodriguez-Navarro, 2011; Seglen, 1992), the reader distribution is skewed across subject categories, as shown in Fig. 1 for articles and Fig. 2 for reviews.

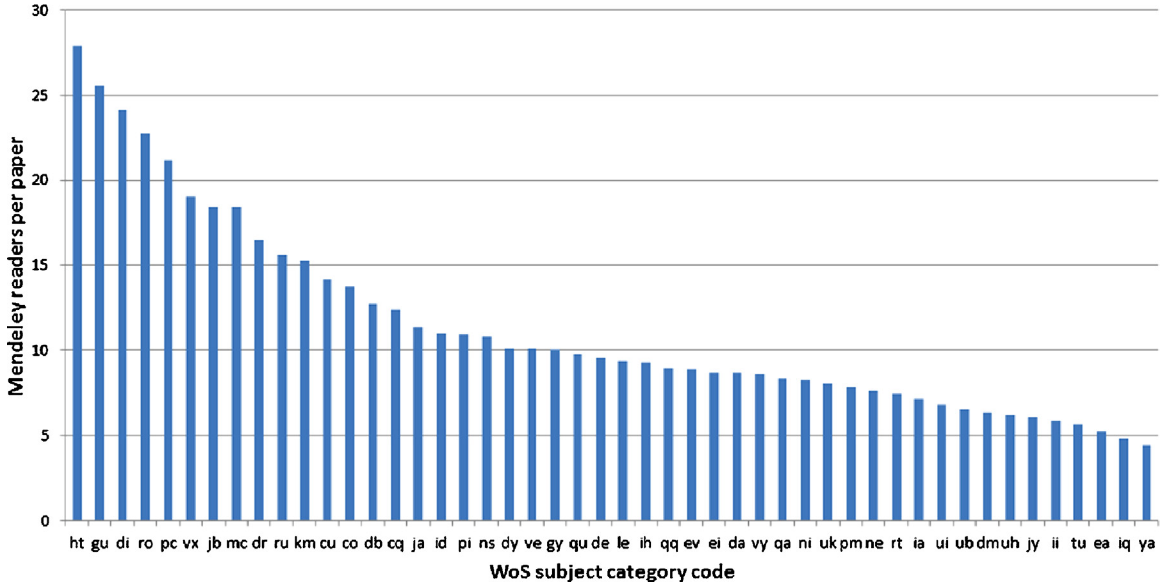

Fig. 1. Distribution of Mendeley readers per paper across WoS subject categories for the document type article. Only subject categories including papers with articles registered in Mendeley at least 90,000 times in total are shown. A table with all the WoS subject categories and the explanation of the two-letter codes is located in the Appendix.

The reader distribution across the categories ranges from 0.22 readers per paper in Poetry (not shown in Fig. 1; see Table A1 in the Appendix) to 27.94 readers per paper in Evolutionary Biology (WoS category "ht" in Fig. 1). The 30 most highly populated WoS categories (12% of the 251 categories) comprise 50% of the readership of the articles studied here.

For reviews, the highest number of readers per paper (85.22) is found in the WoS category Psychology, Experimental (WoS category "vx" in Fig. 2), while the lowest (non-zero) number (0.27) is in Literature (not shown in Fig. 2; see Table A1 in the Appendix). Fifty percent of the readers are found in the 18 (7.5% of the 239 categories) most highly populated WoS categories.

Usually, reviews are cited more often than articles. This seems to hold true for Mendeley reader counts. Figs. 1 and 2 as well as Table A1 in the Appendix show that reviews are also read more often than articles, on average. The overall average value of readers per paper is 8.25 for articles and 20.56 for reviews. This shows the need for a normalization of Mendeley reader counts with respect to subject categories and document types. Thus, the normalization procedure is done separately for articles and reviews. A more general discussion about the WoS document types can be found elsewhere (Harzing, 2013).

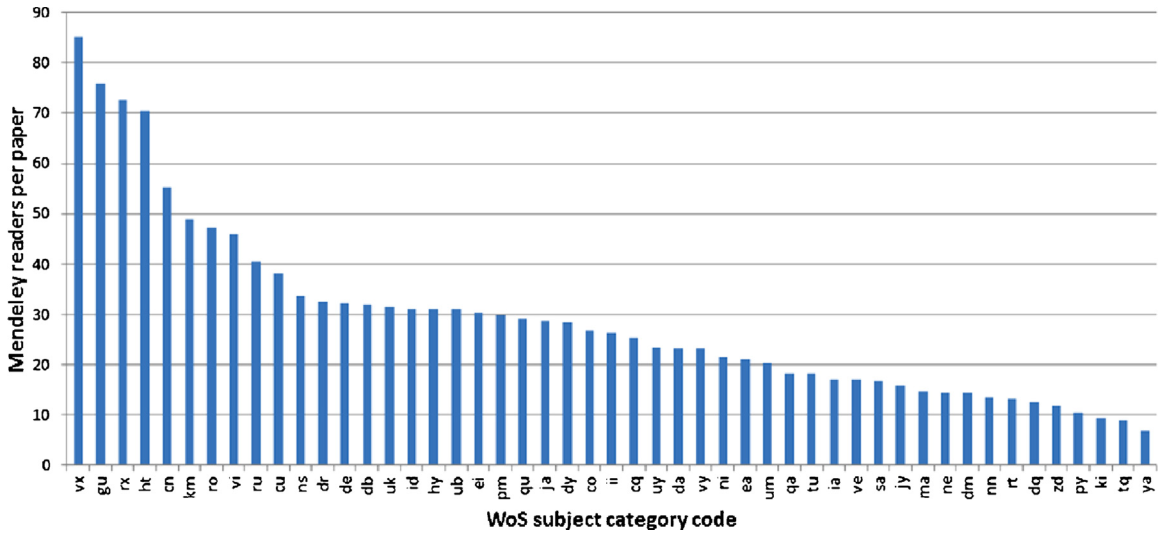

Fig. 2. Distribution of Mendeley readers per paper across WoS subject categories for the document type review. Only subject categories including papers with reviews registered in Mendeley at least 10,000 times in total are shown. A table with all the WoS subject categories and the explanation of the two-letter codes is located in the Appendix.

4.2. Normalization of reader impact

For normalization purposes in bibliometrics, the citation impact of a focal paper is compared with the expected citation impact. The expected value is the average citation impact in the same discipline, publication year, and document type as the paper in question. Sometimes, publications of different document types are considered together in the calculation of the expected value (as in the Leiden Ranking) or separately (as in InCites from Thomson Reuters, SciVal from Elsevier, and the Institutions Ranking published by the SCImago group). The paper set determining the expected value is referred to as the reference set. The ratio of observed and expected citations is the Normalized Citation Score (NCS). Currently, the NCS is the established standard in bibliometrics to normalize citation impact. A NCS of 1 for a publication indicates an average citation impact. A NCS of 1.5 can be interpreted as a citation impact that is 50% higher than the average (Waltman, van Eck, van Leeuwen, Visser, & van Raan, 2011a, b).

If a paper has been assigned (e.g., by a database provider such as Thomson Reuters) to more than one subject category, the average value of all NCS values is used (resulting in a mean NCS). The assignment of papers to multiple subjects leads to an average value over all papers of a publication year that differs from 1. To alleviate this disadvantage, one can employ fractional counting (Waltman & van Eck, 2015), multiplicative counting (Herranz & Ruiz-Castillo, 2012), or full counting with a scaling of all NCS values (Haunschild & Bornmann, submitted). We decided to use the multiplicative counting method, although other counting methods could be used, too. We do not expect different conclusions of our study if other reasonable counting methods were to be used.

In the case of aggregations of papers (normalized impact of a researcher or university), the average value of the NCS values of all papers in the set is calculated. This average value is referred to as the Mean Normalized Citation Score (MNCS). The MNCS is used in the SCImago Institutions Ranking (SCImago Reseach Group, 2013) (in SCImago Institutions Ranking, the MNCS is referred to as the Normalized Impact[1]), InCites[2], and in the Times Higher Education Ranking (THE Ranking[3]).

Following the definition of the MNCS, we propose a Mean Normalized Reader Score (MNRS) using the multiplicative counting method for papers categorized to multiple subjects. Our normalization procedure for Mendeley reader impact starts with the calculation of the average number of Mendeley readers per paper (ρ_c) in each WoS category (cf. Fig. 1 and Table A1 in the Appendix):

$$\rho_c = \frac{1}{N_c}\sum_{i=1}^{N_c} R_{ic}$$

here R_{ic} denotes the raw Mendeley reader count of paper i, which has been assigned to WoS category c, and N_c is the number of papers assigned to WoS category c. Afterwards, the raw Mendeley reader count is divided by the average number of Mendeley readers per paper in WoS category c (ρ_c), yielding the normalized reader score (NRS) for paper i in subject category c:

$$\mathrm{NRS}_{ic} = \frac{R_{ic}}{\rho_c}$$

The average value over all NRS values equals exactly one (due to the multiplicative counting method).

Since we include only papers that were published in 2012, the publication year does not have to be included in the normalization procedure. The overall reader impact of a specific aggregation level (e.g., researcher, institute, or country) can be analyzed on the basis of the mean value over the paper set. This results in the mean NRS (MNRS) for the paper set.

As an illustrative example, we show a step by step calculation of the NRS for the article at http://dx.doi.org/10.1061/(asce)co.1943-7862.0000464. We recorded a reader count of 8 for this article. The article is classified in the WoS subject categories Constructions & Building Technology (fa), Engineering, Civil (im), and Engineering, Industrial (ij). The average reader counts for these WoS subject categories are 9.30, 7.51, and 11.69, respectively. Therefore, we obtain $\mathrm{NRS}_{\mathrm{fa}} = 0.86$, $\mathrm{NRS}_{\mathrm{im}} = 1.07$, and $\mathrm{NRS}_{\mathrm{ij}} = 0.68$. This paper has a reader impact slightly above average in the category "im" but below average in the categories "fa" and "ij." Using the multiplicative counting method, papers assigned to multiple categories do not have a single impact value. For example, if this paper belongs to the publication set of a country and the MNRS is calculated for this set, the paper is not considered only once but three times (with potentially different impact values in each subject category) in the calculation of the average NRS value.

Table 1 shows the thresholds of NRS values that a paper has to have at least in order to become a top 1% and top 10% paper. The differences between the NRS thresholds for reviews and articles are smaller for the top 10% than for the top 1%.

Normalized readership values can be calculated for different units: single researchers, research groups, institutions, countries, journals, etc. As examples, we present in the following the MNRS values for journals and several German universities.

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[1] See http://www.scimagoir.com/methodology.php.

[2] See http://researchanalytics.thomsonreuters.com/m/pdfs/indicators-handbook.pdf.

[3] See https://www.timeshighereducation.com/world-university-rankings-2014-15-methodology.

Table 1
NRS thresholds for top 1% and top 10% papers.

	NRS threshold	
	Articles	Reviews
Top 1%	7.11	6.72
Top 10%	2.43	2.39

Table 2
Top 25 WoS journals with the highest MNRS values in 2012 ordered by decreasing MNRS (only journals with a minimum of 400 unique papers are considered).

Journal	No. of papers (multiplicative counting)	No. of papers (unique papers)	MNRS	MNCS
Cell	830	415	10.03	6.89
Nature	869	869	7.14	8.13
Science	830	830	4.82	5.40
Nano Letters	6462	1077	4.69	3.46
Advanced Materials	5202	867	3.20	3.50
ACS Nano	4764	1191	3.13	2.71
Journal of the American College of Cardiology	426	426	2.91	3.56
Physical Review Letters	3789	3789	2.85	2.33
PLoS Computational Biology	1014	507	2.82	1.65
Cancer Research	625	625	2.82	2.11
Circulation	1236	618	2.80	3.34
Plant Physiology	469	469	2.66	2.71
Energy and Environmental Science	1892	473	2.63	4.79
NeuroImage	3663	1221	2.62	1.71
Bioinformatics	2184	728	2.57	1.48
Journal of Medicinal Chemistry	889	889	2.45	2.25
Nucleic Acids Research	1425	1425	2.43	2.33
Journal of the American Chemical Society	3095	3095	2.43	2.24
PLoS Pathogens	1881	627	2.39	1.99
Analytical Chemistry	1479	1479	2.38	2.03
Pediatrics	686	686	2.34	2.53
Advanced Functional Materials	3414	569	2.30	2.61
Molecular Ecology	1335	445	2.30	1.51
Journal of Neuroscience	1667	1667	2.20	1.73
Solar Energy Materials and Solar Cells	1476	492	2.19	1.62

4.3. Normalized reader impact of journals

Papers from 9601 journals out of the 12,334 WoS journals in 2012 are covered in the papers found at Mendeley. Table 2 shows the 25 journals with at least 400 papers in 2012 and highest MNRS values. The minimum of 400 unique papers published in 2012 ensures the calculation of reliable journal MNRS values on a broad paper basis. Many reputable journals (*Cell*, *Nature*, and *Science*) are also journals with high MNRS values. For example, *Cell* has an MNRS of 10.03. This means that papers published in *Cell* have been read on average ten times as often as papers in the corresponding reference sets (papers published in the same subject categories). Papers published in *Solar Energy Materials and Solar Cells* also have more readers on average than one can expect. However, these papers are only read twice as often on average as papers in the corresponding subject categories. We have included the MNCS in addition to the MNRS in Table 2 (the MNCS is also based on the multiplicative counting method and the same data set as the MNRS).

The MNRS of all 9601 journals correlates much larger than typical with the MNCS, which is indicated by the Spearman rank coefficient of 0.70 (for the interpretation of correlation coefficients, see Cohen, 1988; Kraemer et al., 2003). A scatter plot of the MNCS and MNRS values for 9601 WoS journals is shown in Fig. 3. Any comparison of the MNRS and MNCS values has to be done carefully, as citations do not aggregate as quickly as Mendeley reader counts. Papers published in 2012 have had a short citation window, as citations were gathered for this study until November 23, 2014.

4.4. Normalized reader impact of universities

Table 3 shows the MNCS and MNRS values as well as papers published in 2012 for the top 10 German universities according to the Leiden Ranking 2013 (http://www.leidenranking.com/ranking/2013) ordered by decreasing MNRS. The indicator-specific values of all universities are similar and above the average reader impact of MNRS = 1: The range is from 21% to 46% above average in their corresponding subject categories. The MNCS value is consistently higher than the MNRS value for the universities in Table 3.

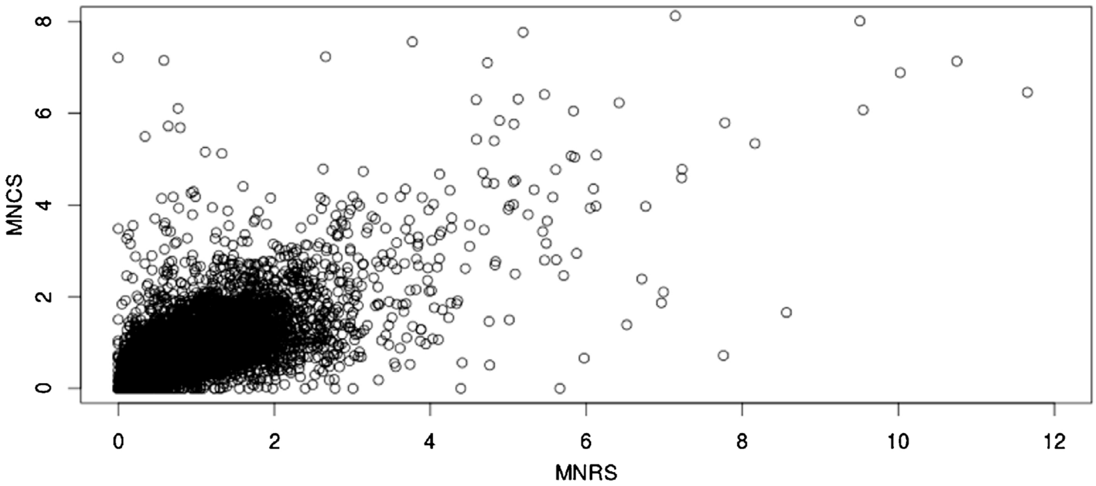

Fig. 3. Scatter plot of MNCS and MNRS values for 9601 WoS journals.

Table 3
Top 10 German universities with MNCS, MNRS, and papers published in 2012 (unique and multiplicative counting), ordered by decreasing MNRS.

University	MNCS	MNRS	Papers in 2012 (unique paper counting)	Papers in 2012 (multiplicative counting)
TU Munich	1.51	1.46	3399	7033
LMU Munich	1.62	1.42	4500	9214
University Würzburg	1.62	1.41	2035	3883
University Freiburg	1.45	1.40	2582	5819
University Göttingen	1.62	1.34	2528	4819
Heidelberg University	1.54	1.30	3721	7625
University Bonn	1.64	1.26	2780	5350
University Münster	1.46	1.26	2210	4803
RWTH Aachen	1.54	1.22	2539	5732
Goethe University Frankfurt	1.49	1.21	2341	4607

Although the MNRS values of the top 10 German universities indicate that the universities perform up to 46% better than average, their MNRS average values are still quite far away from the top 10% and top 1% thresholds of individual papers: top 10%: 2.43 for articles and 2.39 for reviews; top 1%: 7.11 for articles and 6.72 for reviews (see also Table 1).

A broader comparison of MNCS and MNRS can be performed when all German universities with at least 100 papers in 2012 are included. The MNRS correlates slightly larger than typical with the MNCS in this case, as indicated by the Spearman rank coefficient of 0.41 (for the interpretation of correlation coefficients, see Cohen, 1988; Kraemer et al., 2003). A scatter plot of the MNCS and MNRS values for the 76 German universities is shown in Fig. 4. It is to be expected that the correlation

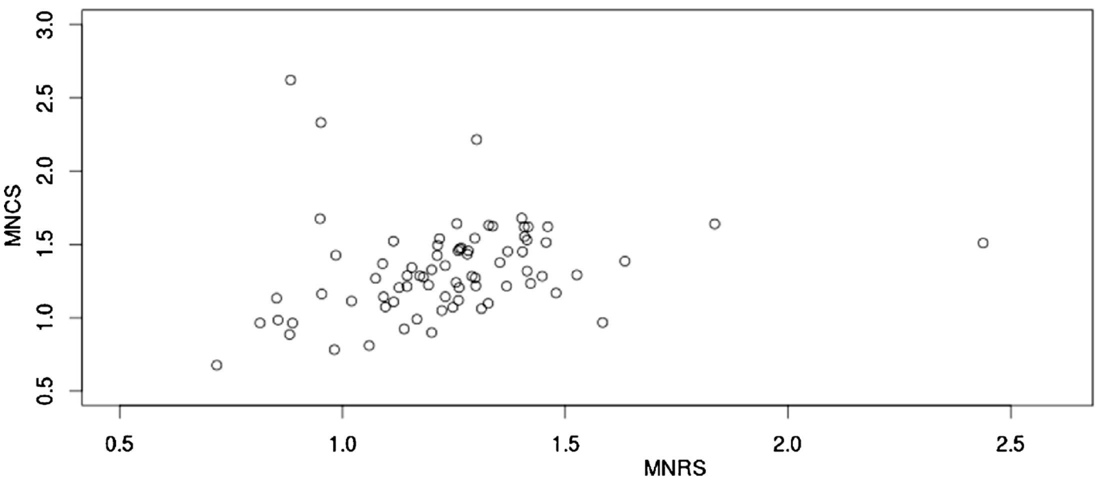

Fig. 4. Scatter plot of MNCS and MNRS values for 76 German universities.

between MNRS and MNCS is higher for journals (see Section 4.3) than for universities because the MNRS and MNCS are normalized with respect to WoS subject categories which are journal sets.

5. Discussion

The Directorate for Science, Technology, and Innovation in Brussels stated that the "use of indicators of social media is relatively well established in advertising and marketing. Some organisations are starting to collect altmetrics on a commercial basis in relation to research publications. In this context, little is known about what individual altmetrics mean. This appears to provide a rich set of opportunities for research – though we are probably some time away from being able to think in a precise way about concepts such as a 'field-normalised tweet'" (Committee for Scientific & Technological Policy, 2014, p. 43). Here we proposed a field-normalized indicator based on altmetrics. Successful applications for journal and university rankings have been shown. The MNRS values can also be applied for individual researchers and other aggregation units. Although we used Mendeley readership counts, a normalization procedure similar to the one used for MNRS can also be performed for tweets and other types of altmetrics.

We found a high correlation between the MNCS and MNRS values for the ranking of journals. The MNRS values can be interpreted (analogously to MNCS values) such that a value of 1.5 indicates that a paper has 50% more Mendeley readers than an average paper in the same subject category. Following the rules of thumb by van Raan (2005) for citation-based indicators, an MNRS between 0.8 and 1.2 should be regarded as an average impact, while one above 1.2 and below 0.8 should be regarded as above and below average impact, respectively.

In addition to normalization methods which are based on average reader scores (MNRS), one can also use percentile-based approaches. Percentile-based approaches produce more robust normalized scores because they are not based on average values (of citations or readers) (Wilsdon et al., 2015). The percentile impact is the proportion of papers in a reference set that are cited or read, respectively, equal to or less often than the paper in question (Bornmann, Leydesdorff, & Mutz, 2013). We made one step in the direction of calculating percentiles by determining the MNRS values that are needed for a paper to be among the top 1% and top 10% most-read papers.

What are the limitations of our study? One can see our retrieval strategy on Mendeley reader counts via the API using the DOI as a limitation. However, as we found the vast majority of papers (94.8% of articles and 96.6% of reviews) with this method, we expect no major influence on our results from this retrieval strategy. Another limitation of our study is the exclusion of articles and reviews without a DOI. This reduces the number of publications from 1390,504 to 1198,184. Therefore, 86.2% of the articles and reviews of the WoS core collection of 2012 are included in this study. Under the assumption that publications with and without a DOI are evenly distributed across high and low impact publications, this will not alter our results significantly. This study is not intended to provide reader counts as reference values for later use. The main aim is to explore an established method from bibliometrics in the realm of altmetrics and to propose a method to normalize Mendeley reader counts in order to judge the reader impact of individual publications as well as aggregates of publications.

The normalization procedure proposed in this study can in principle also be applied to other altmetrics data, such as tweets and blog posts, as it relies on an external classification system assigned to individual papers (or journals where the paper was published). However, normalization with respect to other altmetrics data requires that a large proportion of the publication set is covered by the specific type of altmetrics source. This is the case for Mendeley reader counts, but this might not be the case for other sources of altmetrics data.

The interpretation of Mendeley reader counts seems to be more problematic than the interpretation of citation counts. Many scientists do not read papers in the Mendeley application or on the web interface. Often, scientists add a paper to their Mendeley library when they intend to read it. Although there are reasons to include a paper in one's Mendeley library other than reading it later, it has been proposed to interpret Mendeley reader counts as the number of citers to be (see above).

6. Conclusions

In this study, we have proposed a method for the normalization of Mendeley reader counts that is based on an established method of normalization for citation counts. We have shown that this method is able to normalize Mendeley reader counts. Comparisons on the journal and university level show that the MNRS and MNCS correlate larger for 9601 journals than for 76 German universities.

Since the MNRS has been derived from a well-known and accepted variant used in bibliometrics, the conceptual justification of the new indicator seems to be given. However, further large-scale empirical investigations are necessary. We encourage other researchers in scientometrics to calculate MNRS values for different research units (journals, researchers, institutions, etc.) in order to test the reliability and validity of this indicator (e.g., by comparing the MNRS with other performance indicators).

The calculation of the MNRS needs further data besides data from Mendeley in order to have a field-classification scheme for normalization. In this study, we used the WoS subject categories as classification scheme. Since Mendeley users classify themselves in scientific disciplines (Haunschild, Bornmann, & Leydesdorff, 2015) the Mendeley classification scheme could in principle be used for normalization, too. However, the use of the Mendeley classification scheme would entail the transfer of another kind of bibliometric normalization to Mendeley reader counts which works on the citing-side. In the citing-side normalization every citation of a paper is normalized with respect to its subject category (Bornmann & Marx, 2015). The transfer of the citing-side bibliometric normalization to Mendeley reader counts is not as straightforward as the transfer of the cited-side bibliometric normalization and therefore beyond the scope of our present study.

Acknowledgements

The bibliometric data used in this paper are from an in-house database developed and maintained by the Max Planck Digital Library (MPDL, Munich) and derived from the Science Citation Index Expanded (SCI-E), Social Sciences Citation Index (SSCI), and Arts and Humanities Citation Index (AHCI) prepared by Thomson Reuters (Philadelphia, Pennsylvania, USA). The Mendeley reader counts were retried via the Mendeley API.

Appendix A.

Table A1

Table A1
WoS subject categories and their two-letter codes with the average Mendeley reader counts for articles and reviews (ordered alphabetically by WoS subject category).

WoS subject category	Code	Average no. of readers per paper	
		Articles	Reviews
Acoustics	aa	5.84	9.48
Agricultural Economics, & Policy	af	8.83	27.20
Agricultural Engineering	ae	13.88	52.62
Agriculture, Dairy & Animal Science	ad	4.90	12.88
Agriculture, Multidisciplinary	ah	7.01	16.35
Agronomy	am	7.18	22.41
Allergy	aq	7.05	9.23
Anatomy & Morphology	ay	6.27	16.88
Andrology	az	3.09	10.07
Anesthesiology	ba	7.52	14.44
Anthropology	bf	13.16	14.87
Archaeology	bi	8.95	13.33
Architecture	bk	2.97	3.00
Area Studies	bm	4.28	3.94
Art	bp	3.32	2.20
Asian Studies	or	1.69	1.67
Astronomy & Astrophysics	bu	4.85	14.22
Audiology & Speech-Language Pathology	cl	9.58	17.39
Automation & Control Systems	ac	4.36	13.55
Behavioral Sciences	cn	15.22	55.16
Biochemical Research Methods	co	13.73	26.75
Biochemistry & Molecular Biology	cq	12.42	25.38
Biodiversity Conservation	bd	25.24	53.08
Biology	cu	14.14	38.20
Biophysics	da	8.65	23.31
Biotechnology & Applied Microbiology	db	12.76	32.08
Business	di	24.13	43.77
Business, Finance	dk	13.66	20.83
Cardiac & Cardiovascular System	dq	5.98	12.62
Cell & Tissue Engineering	ct	12.18	31.50
Cell Biology	dr	16.48	32.41
Chemistry, Analytical	ea	5.23	21.09
Chemistry, Applied	dw	5.46	12.81
Chemistry, Inorganic & Nuclear	ec	3.57	11.35
Chemistry, Medicinal	dx	5.10	13.58
Chemistry, Multidisciplinary	dy	10.15	28.48
Chemistry, Organic	ee	4.60	11.29
Chemistry, Physical	ei	8.66	30.29
Classics	eo	0.55	0.33
Clinical Neurology	rt	7.44	13.14
Communication	eu	12.67	17.29
Computer Science, Artificial Intelligence	ep	9.58	23.69
Computer Science, Cybernetics	er	11.45	12.22
Computer Science, Hardware & Architecture	es	6.21	53.22
Computer Science, Information Systems	et	9.08	25.80
Computer Science, Interdisciplinary Applications	ev	8.88	26.50
Computer Science, Software Engineering	ew	8.31	43.30

Table A1 (*Continued*)

WoS subject category	Code	Average no. of readers per paper	
		Articles	Reviews
Computer Science, Theory & Methods	ex	7.13	42.27
Construction & Building Technology	fa	7.93	24.75
Criminology & Penology	fe	7.15	16.24
Critical Care Medicine	ds	9.96	17.13
Crystallography	fi	2.85	8.71
Cultural Studies	en	5.25	4.00
Dance	fs	1.46	0.00
Demography	fu	8.27	11.56
Dentistry, Oral Surgery & Medicine	fy	9.18	14.03
Dermatology	ga	3.86	8.49
Developmental Biology	hy	13.57	30.96
Ecology	gu	25.61	76.02
Economics	gy	10.03	16.07
Education & Educational Research	ha	12.48	25.13
Education, Scientific Disciplines	hb	9.53	13.94
Education, Special	he	9.50	17.03
Electrochemistry	hq	6.39	26.16
Emergency Medicine	ff	5.78	10.68
Endocrinology & Metabolism	ia	7.15	17.15
Energy & Fuels	id	11.04	31.13
Engineering, Aerospace	ai	2.85	11.19
Engineering, Biomedical	ig	9.34	25.23
Engineering, Chemical	ii	5.88	26.36
Engineering, Civil	im	6.41	23.91
Engineering, Electrical & Electronic	iq	4.82	16.09
Engineering, Environmental	ih	9.32	28.13
Engineering, Geological	ix	4.33	4.33
Engineering, Industrial	ij	11.00	26.64
Engineering, Manufacturing	ik	6.67	17.34
Engineering, Marine	il	3.00	4.50
Engineering, Mechanical	iu	3.82	20.11
Engineering, Multidisciplinary	if	4.24	9.38
Engineering, Ocean	io	4.26	5.00
Engineering, Petroleum	ip	3.77	4.83
Entomology	iy	5.65	20.34
Environmental Sciences	ja	11.33	28.60
Environmental Studies	jb	18.46	26.99
Ergonomics	ji	14.34	15.14
Ethics	hf	10.05	8.19
Ethnic Studies	jm	7.56	4.73
Evolutionary Biology	ht	27.94	70.39
Family Studies	jo	9.34	15.63
Film, Radio, & Television	js	3.75	6.50
Fisheries	ju	7.75	22.47
Folklore	jw	0.86	0.00
Food Science & Technology	jy	6.09	15.88
Forestry	ka	10.84	22.08
Gastroenterology & Hepatology	ki	4.75	9.55
Genetics & Heredity	km	15.27	48.74
Geochemistry & Geophysics	gc	7.13	23.48
Geography	ku	14.29	15.20
Geography, Physical	kv	15.26	38.23
Geology	ky	7.91	12.59
Geosciences, Multidisciplinary	le	9.36	22.09
Geriatrics & Gerontology	li	8.33	15.92
Gerontology	lj	7.83	10.85
Health Care Sciences & Services	hl	9.77	14.38
Health Policy & Services	lq	9.34	14.83
Hematology	ma	7.51	14.57
History	mm	1.81	1.50
History & Philosophy of Science	mq	6.57	6.52
History of Social Sciences	mr	3.59	1.22
Horticulture	mu	7.01	19.89
Hospitality, Leisure, Sport, & Tourism	mw	13.55	33.25
Humanities, Multidisciplinary	bq	2.39	4.96
Imaging Science & Photographic Technology	ue	9.98	40.45
Immunology	ni	8.30	21.51
Industrial Relations & Labor	nm	8.65	16.10
Infectious Diseases	nn	7.48	13.37

Table A1 (*Continued*)

WoS subject category	Code	Average no. of readers per paper	
		Articles	Reviews
Information Science & Library Science	nu	17.48	23.67
Instruments & Instrumentation	oa	3.91	18.68
Integrative & Complementary Medicine	oi	5.64	10.92
International Relations	oe	9.45	6.33
Language & Linguistics Theory	oy	5.29	5.03
Law	om	4.93	4.37
Limnology	ou	8.77	25.14
Linguistics	ot	8.62	15.87
Literary Reviews	oz	3.09	0.00
Literary Theory & Criticism	ox	3.41	0.00
Literature	pa	1.07	0.27
Literature, African, Australian, & Canadian	pd	0.72	0.00
Literature, American	pf	2.45	0.67
Literature, British Isles	pg	0.26	0.00
Literature, German, Dutch, & Scandinavian	ph	0.60	0.00
Literature, Romance	qc	0.78	0.50
Literature, Slavic	qd	0.38	0.00
LOGIC	ql	1.97	0.00
Management	pc	21.22	39.42
Marine & Freshwater Biology	pi	10.94	28.65
Materials Science, Biomaterials	qe	9.85	36.75
Materials Science, Ceramics	pk	3.49	8.98
Materials Science, Characterization, Testing	qf	3.08	7.23
Materials Science, Coatings & Films	qg	4.69	9.19
Materials Science, Composites	qh	5.19	25.48
Materials Science, Multidisciplinary	pm	7.83	29.75
Materials Science, Paper & Wood	pj	3.58	11.78
Materials Science, Textiles	qj	3.63	11.58
Mathematical & Computational Biology	mc	18.42	38.54
Mathematics	pq	0.92	0.76
Mathematics, Applied	pn	1.67	3.42
Mathematics, Interdisciplinary Applications	po	3.94	8.90
Mechanics	pu	4.00	16.42
Medical Ethics	oo	6.31	7.86
Medical Informatics	pt	9.29	26.60
Medical Laboratory Technology	pw	3.72	9.66
Medicine, General & Internal	py	7.24	10.46
Medicine, Legal	op	6.46	7.99
Medicine, Research & Experimental	qa	8.30	18.20
Medieval & Renaissance Studies	qk	0.75	0.00
Metallurgy & Metallurgical Engineering	pz	3.34	9.81
Meteorology & Atmospheric Sciences	qq	8.95	24.41
Microbiology	qu	9.77	29.05
Microscopy	ra	5.55	10.32
Mineralogy	re	4.08	9.91
Mining & Mineral Processing	zq	3.61	8.33
Multidisciplinary Sciences	ro	22.73	47.08
Music	rp	4.24	1.80
Mycology	rq	6.50	19.45
Nanoscience & Nanotechnology	ns	10.82	33.66
Neuroimaging	rx	23.13	72.67
Neurosciences	ru	15.60	40.51
Nuclear Science & Technology	ry	2.44	6.35
Nursing	rz	5.90	9.76
Nutrition & Dietetics	sa	8.24	16.80
Obstetrics & Gynecology	sd	4.45	8.15
Oceanography	si	10.03	27.78
Oncology	dm	6.32	14.35
Operations Research & Management Science	pe	8.83	28.07
Ophthalmology	su	5.09	7.39
Optics	sy	4.60	29.06
Ornithology	ta	12.92	32.93
Orthopedics	tc	6.97	10.66
Otorhinolaryngology	td	3.63	5.90
Paleontology	te	6.53	14.78
Parasitiology	ti	11.22	26.70
Pathology	tm	4.64	12.46
Pediatrics	tq	5.08	8.94
Peripheral Vascular Diseases	zd	6.35	11.82

Table A1 (*Continued*)

WoS subject category	Code	Average no. of readers per paper	
		Articles	Reviews
Pharmacology & Pharmacy	tu	5.66	18.13
Philosophy	ua	3.82	3.55
Physics, Applied	ub	6.58	30.94
Physics, Atomic, Molecular, & Chemical	uh	6.18	15.29
Physics, Condensed Matter	uk	8.09	31.48
Physics, Fluids & Plasmas	uf	4.89	27.87
Physics, Mathematical	ur	3.99	7.02
Physics, Multidisciplinary	ui	6.82	20.04
Physics, Nuclear	un	2.59	3.32
Physics, Particles & Fields	up	3.10	3.80
Physiology	um	8.12	20.33
Planning & Development	uq	15.42	25.38
Plant Sciences	de	9.57	32.14
Poetry	ut	0.22	0.00
Political Science	uu	8.76	8.08
Polymer Science	uy	5.23	23.39
Primary Health Care	ml	6.81	13.02
Psychiatry	ve	10.10	16.94
Psychology	vi	14.54	45.97
Psychology, Applied	nq	17.03	38.66
Psychology, Biological	bv	15.52	40.98
Psychology, Clinical	eq	11.48	21.10
Psychology, Developmental	my	14.68	22.65
Psychology, Educational	hi	14.04	30.04
Psychology, Experimental	vx	19.06	85.22
Psychology, Mathematical	vs	13.10	28.85
Psychology, Multidisciplinary	vj	16.12	41.02
Psychology, Psychoanalysis	vp	3.38	3.38
Psychology, Social	wq	17.28	27.71
Public, Administration	vm	9.10	12.27
Public, Environmental & Occupational Health	ne	7.68	14.39
Radiology, Nuclear Medicine, & Medical Imaging	vy	8.63	23.25
Rehabilitation	wc	9.12	14.39
Religion	yi	2.19	6.22
Remote Sensing	sr	9.67	43.91
Reproductive Biology	wf	5.30	12.07
Respiratory System	we	6.06	9.72
Rheumatology	wh	6.58	10.87
Robotics	rb	8.61	22.73
Social Issues	wm	7.23	17.32
Social Sciences, Biomedical	wv	10.51	18.12
Social Sciences, Interdisciplinary	wu	10.56	16.84
Social Sciences, Mathematical Methods	ps	7.54	25.80
Social Work	wy	7.20	16.14
Sociology	xa	10.67	11.74
Soil Science	xe	7.93	21.91
Spectroscopy	xq	3.68	12.31
Sport Sciences	xw	11.44	15.54
Statistics & Probability	xy	4.42	13.10
Substance Abuse	gm	7.49	14.72
Surgery	ya	4.45	6.90
Telecommunications	ye	4.21	14.33
Theater	yg	1.40	0.00
Thermodynamics	dt	5.28	34.88
Toxicology	yo	5.68	13.46
Transplantation	yp	4.26	7.59
Transportation	yq	13.89	12.12
Transportation Science & Technology	yr	6.05	9.87
Tropical Medicine	yu	10.82	23.13
Urban Studies	yy	14.21	15.21
Urology & Nephrology	za	3.88	7.44
Veterinary Sciences	zc	7.33	14.98
Virology	ze	8.93	16.84
Water Resources	zr	6.93	23.29
Women's Studies	zk	6.97	5.68
Zoology	zm	12.81	23.90

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