The thematic orientation of publications mentioned on social media: large- scale disciplinary comparison of social media metrics with citations

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Purpose

A general discussion of the disciplinary orientation of scientific publications that receive mentions from different social media sources is presented. The main purpose is to analyze the disciplinary orientation of scientific publications that were mentioned on different social media platforms, focusing on their differences and similarities with citation counts.

Design/methodology/approach

Considering a set of 500,216 publications from the Web of Science database, social media metrics and readership counts have been collected from Altmetric.com and Mendeley. Citations have been calculated based on the Web of Science database. Results are presented through descriptive statistical analyses together with science maps generated with VOSviewer.

Findings

Our results confirm Mendeley as the most prevalent social media source with similar characteristics to citations in their distribution across fields and their density in average values per publication. The humanities, natural sciences and engineering disciplines have a much lower presence of social media metrics. Twitter has a stronger focus on general medicine and social sciences. Other sources (blog, Facebook, Google+ and news media mentions) are more biased towards the multidisciplinary journals.

Originality

This paper reinforces the relevance of Mendeley as a social media source for analytical purposes from a disciplinary perspective, being particularly relevant for the social sciences (together with Twitter). Key implications for the use of social media metrics on the evaluation of research performance (e.g., the concentration of some social media metrics, such as blogs, news items, etc. around the multidisciplinary journals) are identified.

Keywords

Altmetrics; social media metrics; disciplinary analysis; science mapping; citation analysis; bibliometrics

Introduction

Web-based applications are starting to have an impact in scholars' daily practices (Wouters and Costas, 2012), involving a broad set of activities, from managing their literature using Mendeley, CiteULike or Zotero (Li *et al.*, 2011), to writing and reading blogs (Shema *et al.*, 2012), sharing publications in Facebook or Google+ (G+) (Zhu and Procter, 2012), tweeting about scientific papers (Haustein *et al.*, 2014c), or commenting on and rating books in Goodreads (Zuccala *et al.*, 2014; see also Zuccala *et al.* in this issue).

One important characteristic of these web-based practices is that they often leave 'traces' in the form of saved publications in online reference managers, tweets, blogs, Facebook wall posts, etc. The collection and study of these traces is the main target of the so-called 'altmetrics' (Priem *et al.*, 2010), which have opened the door to new ways of studying scientific communication and its different forms of perception by diverse audiences. However, 'altmetrics' is not considered as a proper term for a series of metrics that are very diverse and complex (Rousseau and Ye, 2013). Instead 'social media metrics' has been proposed (Haustein *et al.*, in press b) as these metrics come from sources that are embedded in the social web (Bar-Ilan *et al.*, 2012), although the discussion on the proper term (or terms) for the different 'traces' and events captured by these sources is still open (Haustein *et al.*, 2015).

Research in altmetrics has mostly focused on aspects about the description of the different sources and metrics (Galligan and Dyas-Correia, 2013; Khodiyar *et al.*, 2014; Piwowar, 2013), the coverage of publications by the different sources (Peters *et al.*, 2014; Robinson-García *et al.*, 2014; Zahedi *et al.*, 2014) and the adoption/use of social tools by different communities (Haustein *et al.*, 2014b; Mas-Bleda *et al.*, 2014; Thelwall and Maflahi, in press); correlations (particularly with citations) (Costas *et al.*, in press; Haustein *et al.*, in press b; Haustein *et al.*, 2014c; de Winter, 2015) or data problems and quality (Chamberlain, 2013; Zahedi *et al.*, 2014).

In several of these previous works some disciplinary analyses have been performed (Hammarfelt, 2014; Haustein *et al.*, 2014c; Mohammadi and Thelwall, 2014; Zahedi and van Eck, 2014), pointing to differences in social media metrics across fields of science. However, a broader and detailed disciplinary analysis in a global map of science is still missing, which is essential to better understand the presence and role of social media metrics across disciplines. This paper intends to fill this gap.

Objective & research questions

The main objective is to analyze the disciplinary orientation of scientific publications that received mentions from different social media sources, and particularly to establish their main differences/similarities with citations. The following research questions are targeted:

- What is the presence and density of social media metrics across scientific disciplines? (with 'density' here we mean strictly the average of metrics per paper (see similar terminology in Haustein *et al.*, in press b), not to be confused with the 'density view' from the VOSviewer tool explained below).
- How is the distribution of social media metrics across fields?
- What are the scientific disciplines that have a higher propensity to present some social media activity vs. citation impact?

Methods

For this study we have considered the same set of publications analyzed in a previous study (Costas *et al.*, in press). This set is composed of 500,216 Web of Science (WoS) publications (articles and reviews) from July until December 2011 with a Digital Object Identifier (DOI). The DOI is used as the linking element across the different data sources. Citation data have been collected up to week 39 (August) 2014, considering a citation window of more than 2.5 years. Mendeley readerships have been collected (using the Mendeley REST API) up to mid October 2014 and Altmetric.com data has been collected (through their API) up to 12 November 2014. As a result, the dataset allows the analysis of publications with a substantially larger window for citations and social media metrics (as compared to most previous studies).

The 250 Thomson Reuters Subject Categories (http://ip-science.thomsonreuters.com/mjl/scope/scope_scie/#AA) have been used as disciplinary scheme. Each journal in WoS is assigned to one or more subject categories. Whenever a publication (by extension of the journal classification) is assigned to more than one discipline, the publication is fractionalized by the number of different disciplines and the same is applied to the different metrics. The aim of the fractionalization is to avoid the multiplicative effect of the database by the multi-classification of some journals (Herranz and Ruiz-Castillo, 2012).

Thomson Reuters' classification contains a category of 'Multidisciplinary sciences', which is not a real discipline as it covers generalist journals such as *Nature*, *PLoS ONE*, *Proceedings of the National Academy of Sciences,* and *Science*, which publish articles from all fields of science. In order to avoid the effect of this category, publications from the category have been individually re-allocated, as far as possible, to other more specific subject categories on the basis of their references (following a similar methodology as suggested by Glänzel *et al.* (1999)).

Based on the previous data set, several size-dependent (total counts) and size-independent indicators (ratios of indicators per publication) have been calculated (table 1).

Table 1. Main indicators calculated (size-dependent and size-independent)

Indicator	Name	Definition
Size-dependent		
P	Total publications	Total number of articles and reviews in a discipline. Values are fractional due to the multi-classified publications (this applies to all indicators).
TCS	Total citation score	Sum of all citations received by P (including self-citations).
TRS	Total readership score	Sum of all readerships accounted for P as computed by Mendeley.
TTS	Total Twitter mentions	Sum of all Twitter mentions received by P as captured by Altmetric.com.
TBS	Total blog mentions	Sum of all times blog mentions received by P as captured by Altmetric.com.
TNS	Total mentions in mainstream news media	Sum of all mentions by mainstream news media received by P as captured by Altmetric.com.
TFS	Total Facebook mentions	Sum of all mentions in Facebook received by P as captured by Altmetric.com.
TGS	Total Google Plus [G+] mentions	Sum of all mentions in G+ received by P as captured by Altmetric.com.
Size-independent (calculated only for the re-classified set of publications)		
MCS	Mean citation score	TCS/P
MRS	Mean readership score	TRS/P
MTS	Mean Twitter score	TTS/P
MBS	Mean blogs score	TBS/P
MFS	Mean Facebook score	TFS/P
MGS	Mean G+ score	TGS/P
MNS	Mean mainstream news media score	TNS/P

Several additional supplementary material to this paper have been published in a Figshare fileset in Costas *et al.* (2015) [http://dx.doi.org/10.6084/m9.figshare.1335773] including two files: 'Supplementary material 1' and 'Supplementary material 2'. In Appendix 2 of 'Supplementary material 1' the list of 250 subject categories together with all the size-dependent indicators is presented. Based on this table, all the size independent indicators as well as all maps and results presented in this paper can be reproduced. Appendix 2 also includes all the metrics (with the indicators followed by the string 'reclas') for the 249 fields with the re-classified publications. In 'Supplementary material 2' all underlying data for the VOSviewer maps are also presented.

The analysis of the data has been performed using SPSS and the VOSviewer 1.5.7 (http://www.vosviewer.com/). Several classifications of disciplines by the median and quartiles have been performed using the NTILE() command in SQL, which basically divides the distribution of fields in two or four parts of equal size (https://msdn.microsoft.com/en-us/library/ms175126.aspx).

VOS viewer visualizations

In order to explore and compare the presence of social media metrics across disciplines in a global map of science the VOSviewer has been used (http://www.vosviewer.com/), particularly the 'density view' and 'label view' techniques (van Eck and Waltman, 2010; Van Eck and Waltman, 2011). In addition, a global map of science has been used for the visual inspection of the disciplines. This underlying map can be obtained from the VOSviewer website-(http://www.vosviewer.com/maps/wos_subject_categories). This map has been already applied for the exploration of different Mendeley readerships (Zahedi and van Eck 2014). It is important to notice that this underlying map is created based on citations (not on altmetric scores). Thus, the map allows detecting areas of 'thematically' closely related disciplines in terms of citation linkages.

The VOS viewer 'density view' technique allows to explore in which disciplines the different metrics are more prominent. This is possible because the density view reveals the general structure of the map by drawing the attention to the most important disciplinary areas. It has however the disadvantage that it can hide some individual disciplines that may have particularly high values in some of the indicators but are surrounded by neighboring disciplines with low densities (and vice versa). In the context of this paper is important to distinguish the 'density view' from the analysis of the density of metrics per publication (i.e. the average presence of metrics per paper across disciplines).

Complementary to the density view, the 'label view' has been also considered. In this view, disciplines are indicated by their label and by a circle. The more important the discipline is in terms of the metric (i.e. its size-dependent indicator), the larger its label and its circle. Colors have been assigned to the disciplines based on the quartile value sorted by the density of the metric in the discipline (i.e. the average of the metric per publication per discipline). Thus, red circles refer to disciplines in the first quartile, orange to disciplines in the second quartile, yellow to disciplines in the third quartile and grey to disciplines in the fourth quartile. Compared to the density view, the label view allows for the identification of disciplines with the highest values of metrics per paper.

Limitations

This study has the following limitations. In the first place, the set of publications is only composed of WoS-covered scientific articles and reviews. This means that mostly

English-language scientific journals articles and reviews are considered (see also Alperin (2015) in this issue) and that other outputs (e.g., books, book chapters, articles in local languages, etc.) are not considered. This implies that areas like the humanities are less visible (Hammarfelt, 2014; Moed, 2005). A second limitation has to do with the use of the DOI as the linking element for the different data sources (Altmetric.com and Mendeley). Not all publications from all fields have incorporated the DOI standard (Haustein *et al.*, in press b) and altmetrics data providers may fail in their proper collection (Bar-Ilan *et al.*, 2012). Other more general problems related with altmetrics data such as data quality, robustness, consistency, or missing data (Zahedi *et al.*, 2014) are also to be expected, therefore the data collection standards (and limitations) by Altmetric.com and Mendeley need to be observed. Nevertheless, given the large scale of this study we consider it informative and relevant for a better understanding of the field distribution of social media metrics and their comparison with citations.

Results

What is the presence and density of social media metrics across scientific disciplines?

The 'Multidisciplinary sciences' category exhibits the highest counts for all the metrics (citations and all social media metrics) and also has the highest rates of metrics per publication of all categories (cf. Appendices 2 and 3 in Supplementary material 1). The values of all metrics in the 'reclas' section are higher for all disciplines, which is the result of the impact added by those re-classified publications from the multidisciplinary journals. The sum of Mendeley readerships tends to be higher than the sum of citations for most disciplines (39 fields are exceptions to this pattern, including disciplines such as 'Oncology', 'Chemistry: physical', 'Chemistry: multidisciplinary', 'Physics: multidisciplinary' or 'Astronomy & astrophysics' among others). In other words, 210 fields (84%) have the same or a higher number of readerships than citations.

All size-dependent indicators increase when the 'Multidisciplinary sciences' publications are re-classified (Table 2). Citations and readerships present the highest overall counts, with readerships being higher than citations. The next source in overall number of counts is Twitter, followed by Facebook, mentions in blogs, G+ and finally mainstream news media mentions. This is in line with the observations by Robinson-García *et al.* (2014) regarding the coverage of different types of altmetrics sources from Altmetric.com for WoS publications.

Table 2. Main descriptive values (size dependent indicators)

All categories	**p**	**tcs**	**trs**	**tts**	**tbs**	**tfs**	**tgs**	**tns**
Median	1034.17	5126.42	9679.52	182.04	12.50	17.83	4	3.68
Mean	2000.86	14986.17	21387.85	939.17	65.87	101.45	27.18	21.94
Std. Deviation	2450.85	25595.40	37578.43	3251.25	246.09	285.62	146.08	117.13
N (WoS categories)	250	250	250	250	250	250	250	250
Minimum	11	1	3	0	0	0	0	0
Maximum	13900.95	207475	399314	46271	3621	3140	2237	1811
Sum	500216	3746542	5346963	234793	16468	25363	6796	5484
Re-classified	**p**	**tcs**	**trs**	**tts**	**tbs**	**tfs**	**tgs**	**tns**
Median	1075.49	5262.81	10103.33	309.44	18.18	26.94	8.85	6.59
Mean	2008.90	15046.35	21473.75	942.94	66.14	101.86	27.29	22.02
Std. Deviation	2428.05	23844.87	31624.94	1709.58	117.52	220.90	51.32	38.85
N (WoS categories)	249	249	249	249	249	249	249	249
Minimum	11	1	3	0	0	0	0	0
Maximum	14636.67	169439.04	248018.82	15796.88	794.51	1729.20	329.43	249.69
Sum	500216	3746542	5346963	234793	16468	25363	6796	5484

The main descriptive values for the size-independent indicators (Table 3) confirm the higher rate of readerships per paper for the different subject categories as compared to citations (both in average and median). The other metrics basically present the same order in density values, with Twitter being the most important, followed by Facebook, Blogs and G+ and news. In contrast with citations and readerships, the size-independent indicators of the other metrics are below 1 in most of the cases. Actually, there are only 30 disciplines (12%) where the density of tweets per publication is higher than 1, and only 6 (2%) where this value is higher than 2 ('Medicine: general & internal', 'Nutrition & dietetics', 'Sport sciences', 'Psychology: social', 'Integrative & complementary medicine' and 'Psychology: biological'). For all the other data sources, the density is always below 1, this meaning that on average publications receive less than one mention.

Table 3. Main descriptive values (size-independent indicators)

Reclassified Mult.	**mcs**	**mrs**	**mts**	**mbs**	**mfs**	**mgs**	**mns**
Median	4.91	9.49	0.32	0.02	0.03	0.01	0.01
Mean	5.47	10.41	0.48	0.03	0.05	0.01	0.01
Std. Deviation	3.23	6.53	0.54	0.04	0.08	0.02	0.01
N (WoS categories)	249	249	249	249	249	249	249
Minimum	0.05	0.18	0.00	0.00	0.00	0.00	0.00
Maximum	15.93	34.97	3.31	0.23	0.86	0.24	0.08

Which fields accumulate more social media metrics and which ones have the highest density of metrics per publication?

A series of figures (from Figure 1 to 4) is presented. Figure 1 is composed by 2 graphs. The graph on top shows the 'density view' map for citations; the graph on the bottom presents the 'label view', with the size of the circles defined by the total sum of citations per discipline while the colors are defined by the mean citation score of the discipline (i.e. the size independent indicator).

Considering the general distribution of citations across fields in the WoS (Figure 1), the shape of the maps are in line with the general distribution of publications and citations across disciplines in the Web of Science (Moed, 2005 and cf. also Appendix 1 in Supplementary material 1), where biomedical and natural science disciplines (on the top and right sides of the map) exhibit a stronger presence of citations (and publications) than the engineering disciplines (on the bottom part of the map), and the social sciences and humanities (on the left side of the map). Notice that there is no great difference between these maps and the graphs based on the same indicator (TCS) considering the 'Multidisciplinary sciences' (graph A3.2 in Supplementary material 1), although still some concentration of citations in the 'Multidisciplinary sciences' category is visible.

Mendeley (Figure 2, graph *a*) exhibits a strong similarity with citations but with readerships having more disciplinary areas highlighted across the map, particularly in the fields related with psychology, social sciences and economics. The mean readerships per publication across disciplines (Figure 2, graph *b*) shows a broader dispersion across the disciplines in the map, with disciplinary areas from all over the map showing relatively high values of readerships per publication. Similar to previous results (Zahedi and van Eck, 2014) the more technical and engineering fields also exhibit a lower density of readerships per publication (right and bottom areas of the map in Figure 2, graph *b*).

In the case of Twitter, a first relevant characteristic is that Twitter counts tend to strongly accumulate around the publications of journals that belong to the 'Multidisciplinary sciences' (see graph A3.4 in Appendix 3). Once the multidisciplinary effect is removed, tweets concentrate mostly around the general medical fields as well as in psychology and social sciences (Figure 2, graph *c*), with a lack of twitter in the disciplines of the right hand side of the map. The distribution of the mean Twitter scores per publication for the different disciplines (Figure 2, graph *d*) shows how are precisely the general medicine, psychology and social sciences disciplines the ones achieving the highest MTS values. It is noticeable the low presence of tweets in the areas of chemistry and physics (at the right hand side of the map, with the exception of 'Physics: mathematical', which is influenced by the more than 4,000 tweets that go to a single article (http://www.altmetric.com/details.php?doi=10.1088/1751-

8113/44/49/492001) with an amusingly short abstract as the answer to the paper title: "Probably not.") and particularly the engineering and technical sciences (bottom of the graph).

Blog mentions also strongly concentrate around the 'Multidisciplinary sciences' (cf. graphs A3.5 in Appendix 3 of the supplementary material 1). However, again when the re-classification of these publications is considered, a broader dispersion across all disciplines is observed, both when considering the size-dependent (TBS) and size-independent indicator (MBS) (Figure 3, graphs *a* and *b*). However, it is remarkable that the humanities (extreme of the left hand side of the maps) and engineering disciplines (bottom-right part of the map) still present the lowest values. Very similar conclusions as for blogs, can be also extracted for the analysis of news and G+ (Figure 4, all graphs).

An interesting difference is noticeable for Facebook (Figure 3, graphs *c* and *d*), in which a strong concentration is observed in some medical fields (particularly 'Oncology' and 'Nutrition & dietetics'), with a similar pattern also for the size-independent indicator (MFS). This pattern is strongly influenced by a single publication with an extremely high amount of Facebook mentions (http://www.altmetric.com/details.php?doi=10.1080/01635581.2011.589959), classified in these two fields of 'Oncology' and 'Nutrition & dietetics'. The fact that this single publication has more than 1,500 Facebook mentions (the next paper in our dataset has 617 Facebook mentions, the next in 'Oncology' has 170 and 65 in 'Nutrition & dietetics') suggests the strong influence that outliers may have when working with these social media metrics, even at the level of entire disciplines. A manual check for outliers has been performed for the other sources, and with the exception of the paper with the funny abstract (previously mentioned) no other relevant cases have been detected. However, the skewness of these metrics and the potential effects of outliers are aspects that clearly deserve future attention.

Fig. 1. Citations (Top: density map of TCS; bottom: TCS nodes size, MCS cluster color: red: 1st quartile, orange: 2nd quartile, yellow: 3rd quartile and grey: 4th quartile)

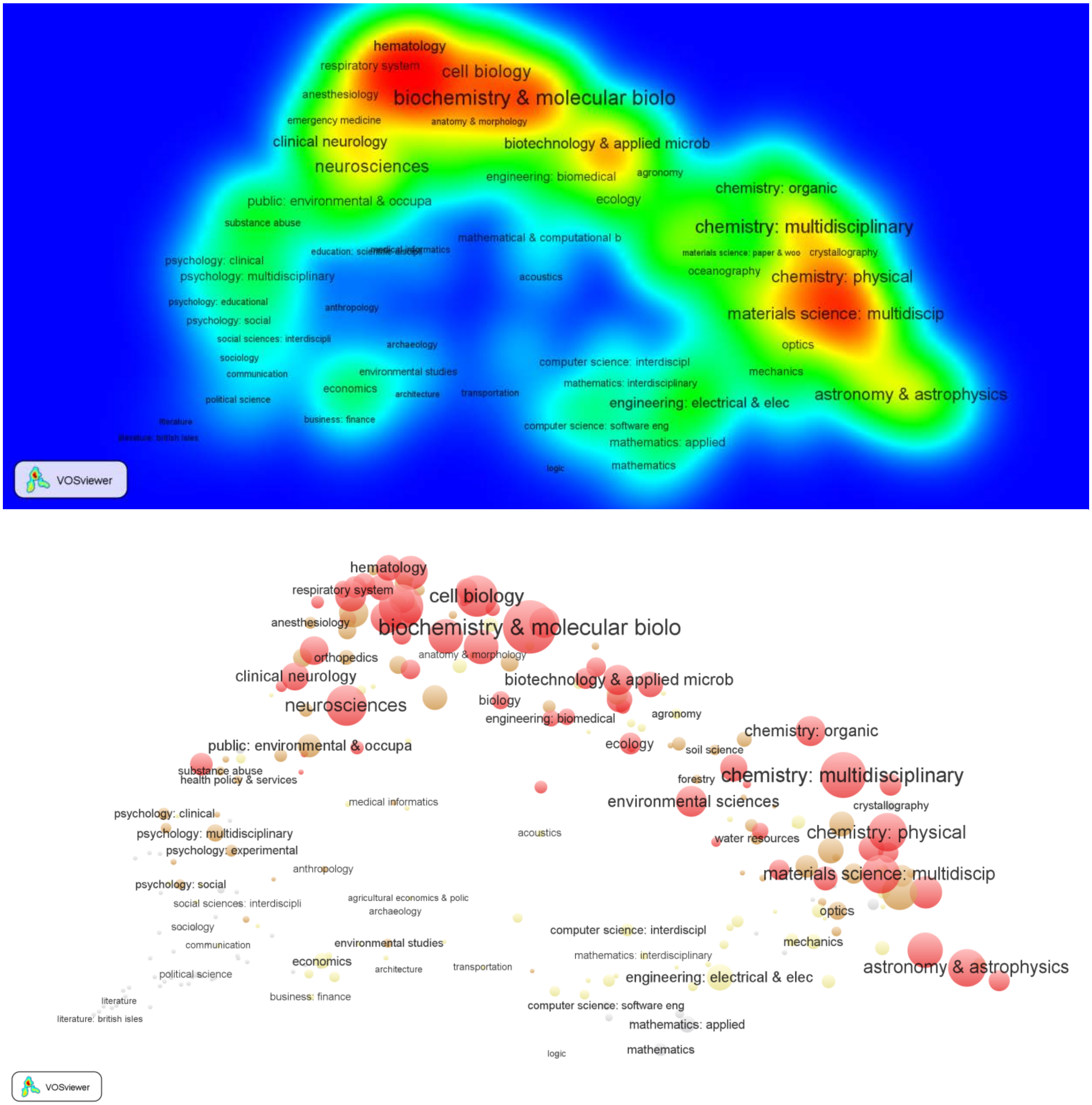


Fig. 2. Mendeley (top graphs). Twitter (bottom graphs). Density view: a) TRS, c) TTS. Labels view: b) MRS and d) MTS (colors: red: 1st quartile, orange: 2nd quartile, yellow: 3rd quartile and grey: 4th quartile)

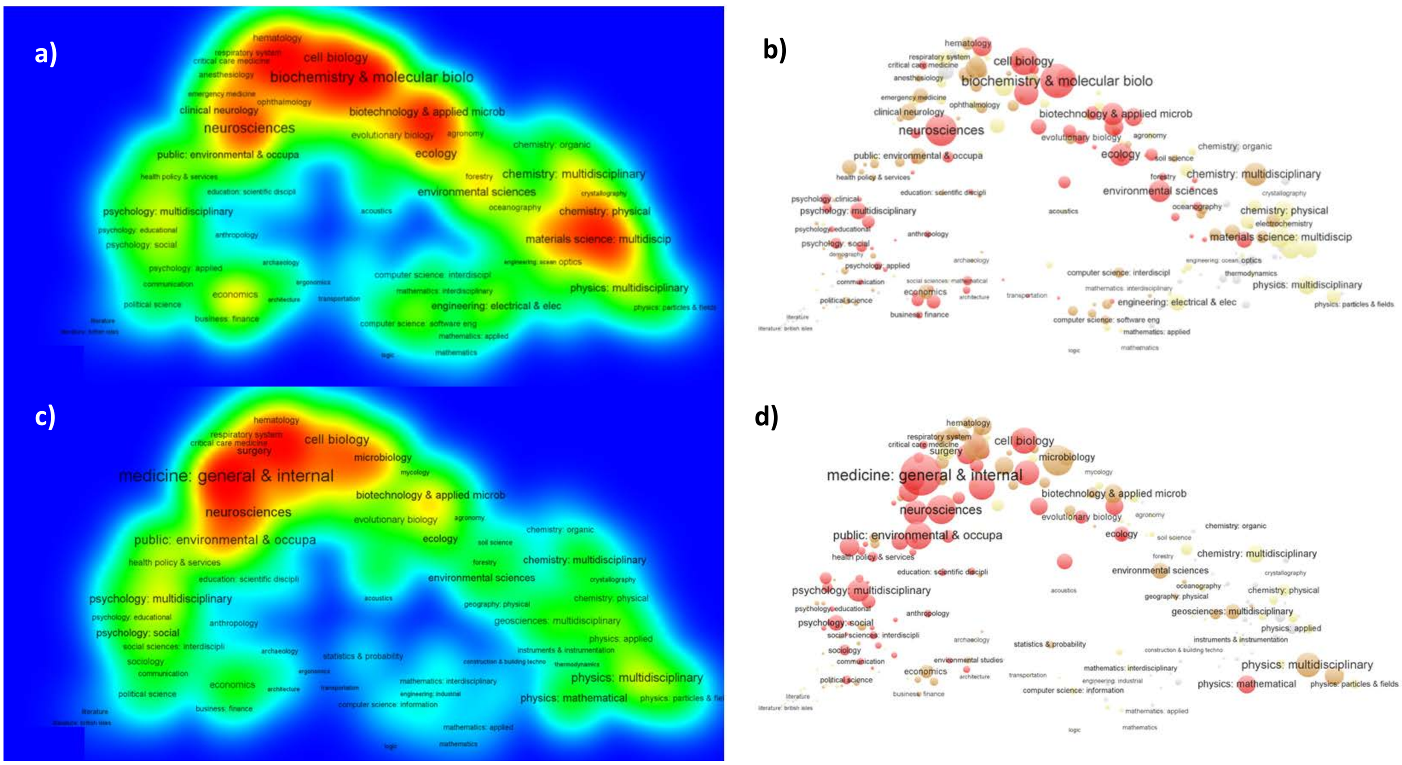


Fig. 3. Blogs (top graphs). Facebook (bottom graphs). Density view: a) TBS and c) TFS. Labels view: b) MBS and d) MFS (red: 1st quartile, orange: 2nd quartile, yellow: 3rd quartile and grey: 4th quartile)

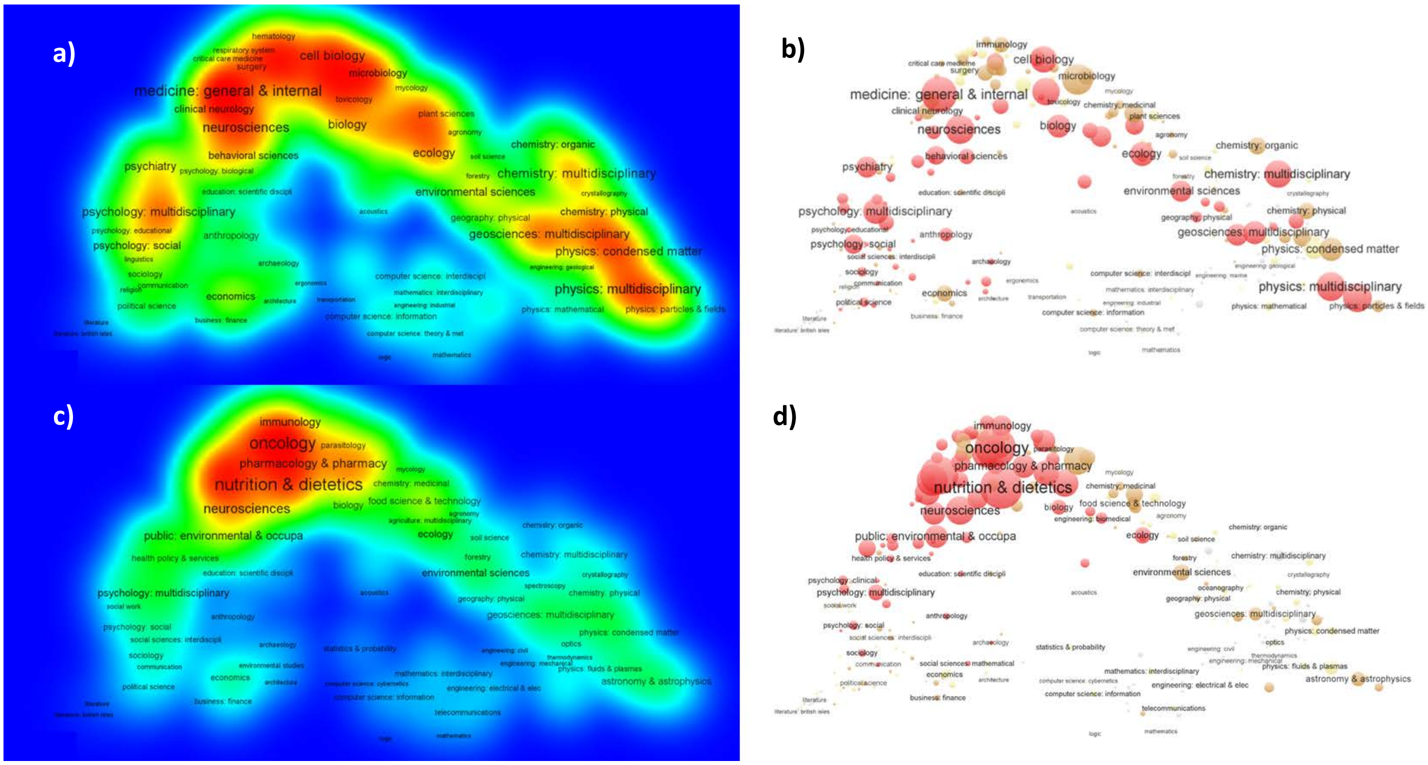
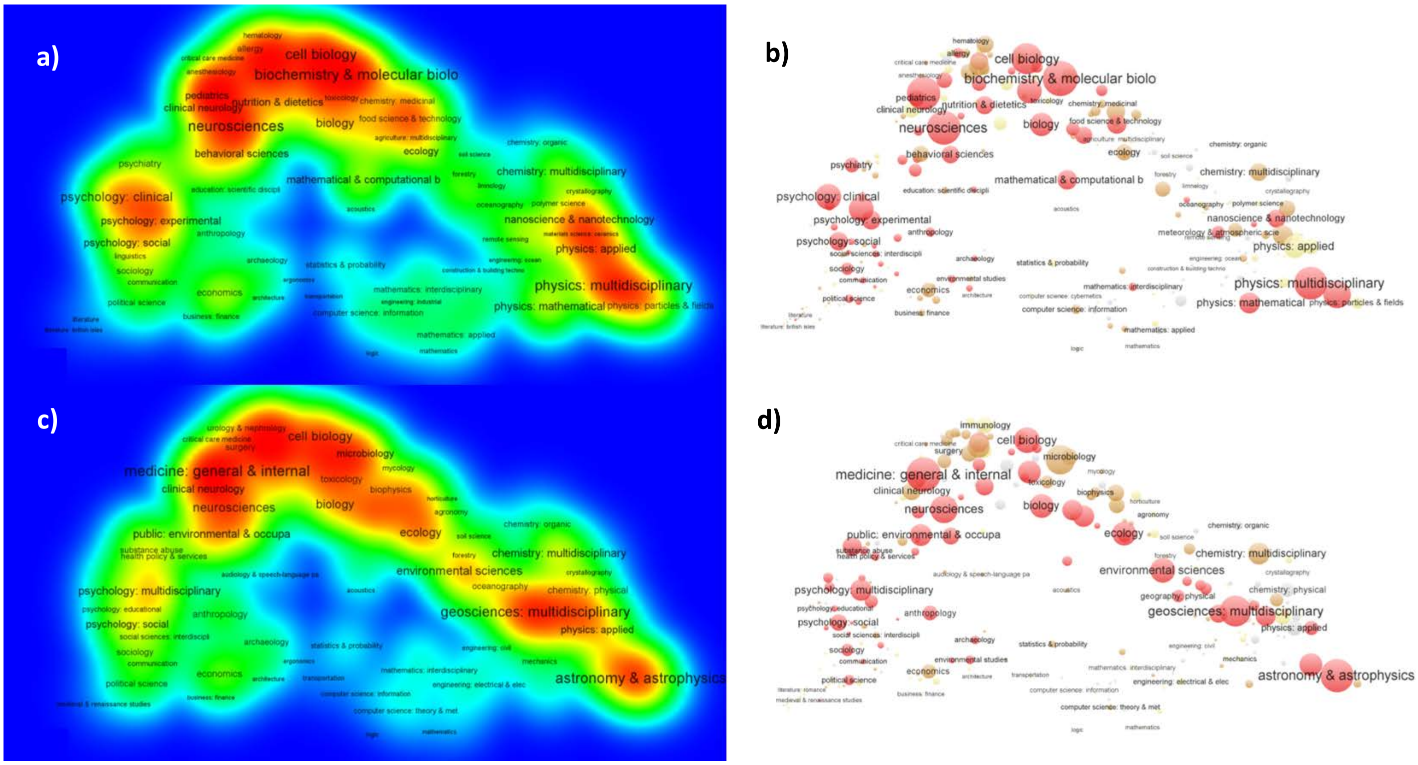


Fig. 4. G+ (top graphs). News (bottom graphs). Density view: a) TGS and c) TNS. Labels view: b) MGS and d) MNS (red: 1st quartile, orange: 2nd quartile, yellow: 3rd quartile and grey: 4th quartile)



What are the scientific disciplines that have a higher propensity to present social media mentions vs. citation impact?

The presence of citations and social media metrics differ across disciplines. The distribution of all the fields has been partitioned in two halves (using the NTILE() SQL function) sorting the fields in decreasing order by each of the size-independent indicators under study. Disciplines are classified respectively as 'High' and 'Low' based on which of the halves they belong to (i.e., above or below the median). Those disciplines that are high (or low) compared to other disciplines in terms of citations, but low (or high) in any other of the social media metrics are detected. In order to simplify the analysis the disciplines have been categorized by 'Sciences', 'Social Sciences' and 'Arts & Humanities' as determined by the three databases that compose the Web of Science (i.e. *Science Citation Index*, *Social Sciences Citation Index* and *Arts & Humanities Citation Index*), of which 173 (69%) are Sciences, 49 (20%) are Social Sciences and 27 (11%) are Arts & Humanities. Table 4 presents the raw number of disciplines per main disciplinary area together with the share of disciplines of that area that belong to that combination of the high/low grouping (between brackets).

The majority of the disciplines (around 60%) have the same positioning (high-high or low-low) regardless of whether this is based on citations or social media metrics. Among the high-high group of Sciences we have 'Biochemistry & molecular biology', 'Oncology', 'Neurosciences', 'Environmental sciences' or 'Biotechnology & applied microbiology' among others. There are between 11 and 14 Social Sciences disciplines (depending on the metric) that are high both in citations and social media metrics (e.g., psychology-related disciplines or 'Health policy & services', 'Anthropology', 'Gerontology' or 'Social sciences: biomedical'). Arts & Humanities disciplines mostly belong to the low-low group. Just a small set of Arts & Humanities fields are among the high group with social media metrics (including 'Religion', 'History & philosophy of science' or 'Archaeology', this last one being the only Arts & Humanities discipline above the median in all social media metrics). Between 41% and 59% (depending on the metric) of the Social Sciences disciplines are generally high with social media metrics and low in citations (e.g. 'Sociology', 'Social sciences: interdisciplinary' or 'Communication'). Only a few disciplines from the Social Sciences are low both in citations and social media metrics (including here among others: 'Social work', 'Law' or 'Area studies'). Similarly, some Sciences fields are low in both types of metrics, including 'Engineering: electrical & electronic', 'Mathematics: applied', 'Mathematics' or 'Crystallography'. Between 23% and 27% of the Sciences disciplines have lower numbers in social media metrics while they score high in citations (i.e. the high-low combination). These include fields such as 'Engineering: chemical', 'Polymer science', 'Optics', 'Chemistry: inorganic & nuclear', 'Electrochemistry', 'Chemistry: applied' and 'Physics: nuclear' among others.

Table 4. Disciplines by citations and social media metrics. Number of fields and share of fields for main areas (Sciences, Social Sciences, Arts & Humanities) are in brackets.

MCS	**MRS**	**Sciences**	**Social Sciences**	**Arts & Humanities**
High	High	65 (38%)	14 (29%)	0 (0%)
Low	High	17 (1%)	28 (57%)	1 (04%)
High	Low	46 (27%)	0 (0%)	0 (0%)
Low	Low	45 (26%)	7 (14%)	26 (96%)
MCS	**MTS**	**Sciences**	**Social Sciences**	**Arts & Humanities**
High	High	64 (37%)	14 (29%)	0 (0%)
Low	High	14 (08%)	29 (59%)	4 (15%)
High	Low	47 (27%)	0 (0%)	0 (0%)
Low	Low	48 (28%)	6 (12%)	23 (85%)
MCS	**MBS**	**Sciences**	**Social Sciences**	**Arts & Humanities**
High	High	69 (4%)	14 (29%)	0 (0%)
Low	High	16 (09%)	21 (43%)	5 (19%)
High	Low	42 (24%)	0 (0%)	0 (0%)
Low	Low	46 (27%)	14 (29%)	22 (81%)
MCS	**MFS**	**Sciences**	**Social Sciences**	**Arts & Humanities**
High	High	71 (41%)	11 (22%)	0 (0%)
Low	High	18 (1%)	20 (41%)	5 (19%)
High	Low	40 (23%)	3 (06%)	0 (0%)
Low	Low	44 (25%)	15 (31%)	22 (81%)
MCS	**MGS**	**Sciences**	**Social Sciences**	**Arts & Humanities**
High	High	65 (38%)	14 (29%)	0 (0%)
Low	High	17 (1%)	21 (43%)	8 (3%)
High	Low	46 (27%)	0 (0%)	0 (0%)
Low	Low	45 (26%)	14 (29%)	19 (7%)
MCS	**MNS**	**S**	**SS**	**AH**
High	High	65 (38)	14 (29%)	0 (0%)
Low	High	17 (1%)	24 (49%)	5 (19%)
High	Low	46 (27%)	0 (0%)	0 (0%)
Low	Low	45 (26%)	11 (22%)	22 (81%)

Discussion

The emerging field of altmetrics (Kwok, 2012) has been perceived by some as a 'revolution' in the field of scientometrics (Bornmann, 2014a), although still important debates are taking place on their proper taxonomy (Rousseau and Ye, 2013), meaning(s) (Bornmann, 2014b; Priem *et al.* 2012a, 2012b), reliability (Costas *et al.*, in press; Waltman and Costas, 2014), validity (Colquhoun, 2014), and potential uses (Crotty, 2014; Neylon, 2014).

In order to unveil the main characteristics and properties of these new metrics, several studies have focused on their main patterns, comparing them with citations and other bibliographic characteristics (Costas *et al.*, in press; Haustein *et al.*, 2014a, 2014c; Waltman and Costas, 2014). Here a large-scale disciplinary analysis is presented, using a combination of quantitative and explorative techniques, contributing to the understanding of the thematic and disciplinary orientation of these new social-media metrics.

Main results show that all metrics achieve their highest scores in the 'Multidisciplinary sciences' category, especially in some of the social media metrics (i.e., blogs, news and G+), suggesting the importance of considering classification schemes that avoid the problem of heterogeneous multidisciplinary categories. This bias towards multidisciplinary journals of blog mentions has been already discussed (Groth and Gurney, 2010; Shema *et al.*, 2012) and supports the idea that these sources mostly reflect the mainstream media's tendency to cover publications from leading journals (e.g., *Nature*, *Science* or *PNAS* among others). This strong concentration in multidisciplinary journals also needs to be considered when working with these sources. However once the multidisciplinary effect is removed, these metrics tend to be dispersed across the whole map of science, although it is not clear to what extent this is also an effect of the multidisciplinary nature of the publications from these journals.

Most of the social media metrics (Twitter, blogs, news, G+ and Facebook) show density values below 1 across all disciplines, and only Twitter has values above 1 for some fields. This low density implies that the potential construction of indicators based on these sources may be challenged by their limited reliability. For example it could happen that with small changes in the counts, the indicators can be substantially modified in a relatively short period of time or with different data collection methodologies, and they will be sensitive to outliers (the two extreme cases for Facebook and Twitter discussed in this paper are good examples of this point).

The observed higher density of Mendeley readerships over citations for most disciplines has been previously discussed (Mohammadi and Thelwall, 2014; Zahedi *et al.*, 2014) and could be attributed to the faster accumulation of readerships compared to citations, although other reasons such as the potential increase in Mendeley users over time may also need to be considered. Future research should study if this pattern would remain with longer citation windows. This finding supports the idea of Mendeley readerships as one of the strongest social media metrics for analyzing journal articles (Hammarfelt, 2014; Torres-Salinas *et al.*, 2013).

VOSviewer maps show that Mendeley has a stronger presence across a larger variety of disciplines, in contrast to citations that concentrate more in the medical and natural sciences. The distribution of Twitter mentions across disciplines exhibits an *inverse* pattern compared to citations with Twitter having a stronger presence in the more general medical fields, psychological disciplines and social sciences (although still low in the humanities fields). This finding supports previous results (Costas *et al.*, in press) on the prominent presence of tweets around the social sciences and provides some support to the potential interest of Twitter for capturing 'popular' or 'socially relevant' publications (Bornmann, 2013, 2014b), although this needs further exploration given the complexity of motivations and limitations related to Twitter activity (Haustein *et al.*, 2014c).

Most disciplines tend to remain in the same half of the distributions (high-high or low-low) when ranked both by citations and social media metrics. There are however interesting deviations. Firstly, a substantial number of the social sciences disciplines improve their position with respect to other science fields when considering social media metrics, thus reinforcing the potential value of these metrics for these disciplines (Mohammadi and Thelwall, 2014; Zahedi, Costas, *et al.*, in press). Secondly, important science disciplines that are high in their positioning based on citations (including mostly Engineering disciplines, and some physics and chemistry fields) are lower ranked based on the social media metrics, suggesting that social media metrics are not equally relevant for all disciplines.

In contrast to this improved position of the Social Sciences, the Arts & Humanities disciplines are systematically placed in the lower positions of the distributions of both citations and social media metrics. Thus, humanities journal articles basically remain among the lowest both cited and social media mentioned publications, an aspect that has been already pointed out by (Hammarfelt, 2014) and could be related to the greater focus on journal articles by most altmetrics tools.

Conclusions

Mendeley is the strongest social media source with similar characteristics to citations in terms of their distribution across fields. Particularly relevant is the higher density of readerships over citations (after almost 3 years) in most disciplines.

The social sciences is one of the areas that changes the positioning of its disciplines more substantially in its benchmark with the more science disciplines. This is the case for most social media metrics, and particularly for Mendeley and Twitter. This is in line with previous results (Torres-Salinas *et al.*, 2013) suggesting that Mendeley readerships could play an important role in these fields, where also citations tend to be more problematic (Nederhof, 2006). On the other hand, the more humanistic, natural and engineering sciences have a very low presence across all social media metrics and therefore their use in these fields needs to be more carefully considered.

Twitter has a stronger focus on general medicine, psychology and social sciences as these disciplines have a higher density of tweets per publication than other disciplines. This supports the idea of a more ‘social’ orientation of this source, although still more research is necessary in order to better understand the problems (e.g. automated mentions, Haustein *et al.*, in press a) and potential value of this source as a proper ‘societal impact’ indicator.

With the exception of Mendeley (and to some degree also Twitter) the less prevalent social media sources (blogs, G+ or mainstream news mentions) have an important bias around multidisciplinary journals like *Nature*, *Science*, or *PNAS*. Thus, their potential usefulness is limited by this bias towards this type of journals, although the effect of this bias might be reduced by using classification without such a multidisciplinary category. Also, their susceptibility to outliers must be bear in mind when working with them.

Finally, more research is still necessary on issues related with data collection and data quality (Zahedi *et al.*, 2014), particularly on how to identify and characterize outliers, strange and funny cases, data errors, biases, etc., as well as issues related with the skweness and distribution of metrics across publications. Also, similarly to citations, which have been researched for many years and still pose important conceptual challenges (Nicolaisen, 2007; Wouters, 2014), social media metrics need a better understanding of their meaning, value, realistic uses and conceptual limitations (Haustein *et al.*, 2015) before they can be reasonably fully incorporated in the study of scientific communication and evaluation practices.

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