Disciplinary differences of the altmetric impact

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Abstract

The main objective of this article is to group altmetric indicators according to their relationships and detect disciplinary differences in a set of 3,793 research articles published in 2013 with regard to their altmetric impact. Three of the most representative altmetric providers (Altmetric, PlumX and CrossRef Event Data (CED)) and Scopus were used to extract information about these publications and their metrics. Principal Component Analysis (PCA) was used to summarize the information of these metrics and detect group of indicators. Results show that these metrics can be grouped in three components: Social media gathers metrics from social networks and online media, Usage includes metrics on downloads and views, and finally, Citations and saves group metrics related to research impact and saves in bookmarking sites. According to disciplinary differences, articles in General category attract more attention of Social media, Social Sciences indicate higher usage than Physical Sciences and General articles are more cited and saved than Health Sciences and Social Sciences.

Keywords: Altmetrics, Disciplinary differences, Principal Component Analysis (PCA), PlumX, Crossref

Introduction

Web 2.0 supposed a transformation of the Web as communication medium. New technological means (SOAP, XML, RSS) made possible the creation of web spaces where users became active producers of information instead of passive consumers (Ellison and Boyd, 2013). Blogs, wikis, social networks and other collaborative spaces were rising up as new ways of social, decentralized and no-mediated knowledge production (Paroutis and Al Saleh, 2009). This new digital environment favored the appearance of metrics that counted and valued the actions of the users and the content that they generated/inserted. Today, likes, mentions, retweets reflect the way in which users are engaged with social platforms as well as they are suitable measurements to track the energy and profitability of these services (Murdough, 2009).

This transformation also affected the academic world. Specialized sites for scientists were appearing with the aim of improving the collaboration between researchers and strengthening the dissemination and sharing of academic outputs. CiteULike (2006), Nature Network (2007), Mendeley (2008) and ResearchGate (2008) were born under the Web 2.0 philosophy with the purpose of encouraging the open exchange of scholarly results and fostering the web visibility of their users (Ortega, 2016). Nowadays, these new spaces have been consolidated as alternative places for research communication, becoming serious competitors of the traditional publishing system. Based on a free-of-charge model, both for users and readers, document sharing sites offer an open and faster way to spread academic results and alternative mechanisms for research assessment.

From a bibliometric view, these platforms have developed a range of metrics and counts that measure the performance of users and publications, not only into each platform but in the entire Web. Altmetrics as research topic has studied these metrics with the aim of evaluating the importance of social media in the research impact, the meaning and origin of these new indicators and the existing relationships among them (Tattersall, 2016). But, above all, most of the altmetric studies have focused on the connection between these novel metrics and the traditional assessment indicators, with the aim of understanding how these measures fit into the overall research evaluation.

However, the same as other impact indicators, Altmetrics could be influenced by disciplinary differences. This study attempts to explore the relationship between a wide range of metrics and their differences according to the main research areas. Although this issue has been addressed by several studies, the novelty of this work lies in the use, for the first time, of a wide range of metrics from three of the most relevant altmetric providers: Altmetric, PlumX and Crossref Event Data (CED).

Related Research

Before the appearance of the altmetrics concept, many authors sought to study the relationship between citation impact and the usage of publications. Bollen et al. (2009), exploring 39 journal level metrics, observed that usage metrics set a different component from bibliometric indicators. Yan and Gerstein (2011) noticed that the usage of *PLOS One* articles followed two trends, a short-term behavior driven by the fame of a paper, and a long-term behavior consistent with citation statistics. Schloegl and Gorraiz (2010, 2011) found that the rank correlation between downloads and citations was high at the journal level but only medium-sized at the article level.

But it was the arrival of the first altmetric providers that provoked the proliferation of studies about these alternative measurements and their relationships. The purpose of those articles was to understand the meaning of these metrics and their implications in the research evaluation. These first studies were based on metrics supplied by PLOS. Priem et al. (2011), analyzing the altmetrics of 24,000 articles, perceived that bookmarking could slightly influence the prediction of citations. Further, Liu et al. (2013) also studied a set of PLOS publications and, using Multidimensional Scaling, they detected three clusters: traditional metrics (citation and download metrics), active altmetrics (trackback, rating, note, and comment metrics), and inactive altmetrics (blog and social bookmark metrics).

In 2012 appeared Altmetric.com and ImpactStory, the first providers independent from a publishing house. Thelwall et al. (2013) used for the first time Altmetric.com data and they found statistically significant associations between higher metric scores and higher citations for articles with positive altmetric scores. Otherwise, ImpactStory was used by Zahedi et al. (2014) to extract the altmetric information of 20,000 publications. Using also PCA, they observed that Mendeley readers are located aside citations, while tweets are placed in a distinct component. Costas et al. (2015) employed more than 1.5 million of publications from Altmetric.com and Web of Science to analyze the relationship between altmetric and bibliometric indicators. They detected that social network metrics (Facebook, Twitter, Goggle+ mentions) were located in a different component from social media (blogs, news). Bornmann (2015) carried out a meta-analysis of previous literature and he supported that bookmarks is the closest metric to citation impact. Li and Fred (2015) analyzed 66 Library and Information Science journals, but they did not find differences among metrics. PlumX, another altmetric aggregator also created in 2012, has been used but with less frequency for altmetric studies, highlighting the works of Ortega (2016, 2017) about the presence of authors and journals on Twitter and Torres-Salinas et al. (2017) about the altmetric coverage of books. However, there are much less studies that had used different data providers, and most of them were articles focused on comparing the coverage of each tool (Jobmann et al., 2014; Zahedi et al., 2015).

A fundamental issue to take into account about the impact of altmetrics is to know if there are disciplinary differences when these metrics are calculated. This would allow to obtain a better understanding of the scholarly communication on the Web 2.0 and drawing conclusions about the use of altmetrics in certain research areas. The first studies in this sense were about disciplinary differences in the use of research publications. Gorraiz et al., (2014) found little differences in downloads among disciplines and, in any case, these were due to the size of the particular user population. More recently, Vaughan et al., (2017) studied the relationship between downloads and citations, and they indeed detected a higher connection in social sciences and humanities than the disciplines of science, engineering and medicine. According to other altmetric indicators, Ortega (2015) observed disciplinary differences in the use of academic social networks. Thelwall and Sud (2016) also perceived differences between subject matters in the distribution of Mendeley readers. Hassan et al. (2017) found that blog count was the most important factor in the citations of Health Sciences papers, while tweets increase the number of citations in the field of Physics and Astronomy.

Objectives

The main objective of this article is to explore the existing relationships between altmetrics and group them according to their performance in a set of research articles. To this end, we have selected the largest set of metrics that the three main altmetric aggregators (Altmetric, PlumX and CED) provide. In addition, this work attempts to observe disciplinary differences in the performance of these metrics, observing if these metrics could under or over value determined research areas. Two research questions were formulated:

- Can altmetric indicators be grouped into different components according to their meaning and relationships?
- Is it possible to detect disciplinary differences with regard to altmetric impact?

Methods

Sources

This study has used several sources to extract and gather the data. This is because several studies have evidenced that some providers cover some metrics better than others (Jobmann et al., 2014; Zahedi et al., 2015). In the event that a metric is provided by different sources we select the source that has better coverage (Ortega, in press):

Altmetric: It was the first altmetric provider and was born in 2012 by Euan Adie, with the support of Digital Science. Altmetric is centered in the publishing world, signing agreements with publisher houses to monitor the altmetric impact of their publications. This information is accessible through a public API. Today, Altmetric tracks the social impact of close to 8 million of research papers. However, this platform does not include metrics about citations and usage. Most of the metrics were selected from this provider (blogs, Facebook pages, Google+ users, News outlets, Reddit posts, Tweeters, CiteULike saves). The remaining metrics (Weibo, Youtube, Linkedin, Peer_review, Pinterest, Policy_papers, Questions, and Research_highlights) were discarded due to their low incidence and therefore their poor contribution to the model.

Scopus: this is one of the most important citation indexes in the market. It is owned by Elsevier and it contains a well-balance distribution of journals and publications from all the disciplines. Scopus was only used to retrieve the number of citations and the Scopus eID of the documents. This ID allows us later to search these documents in PlumX.

PlumX: PlumX is a provider of alternative metrics created in 2012 by Andrea Michalek and Michael Buschman. PlumX is the aggregator that offers more metrics, including citation and usage metrics (i.e. Views and Downloads). It covers more than 52.6 million of artifacts, being then the largest altmetric aggregator. In 2017, Plum Analytics was acquired by Elsevier, allowing now to know the altmetric information of any document indexed in Scopus. Metrics about usage (Linkouts, Abstract views and Html views) and Mendeley readers were extracted from this source. Just as Altmetric, the remaining metrics were dismissed due to their low importance (EPrints_downloads, PDF_views, SSRN_download, etc.).

Crossref Event data (CED): CED is the youngest service, created in 2016 and officially released in 2017. Due to this, the platform claims that the service is still in beta. Unlike the previous ones, CED is not a commercial site and it provides free access to their data though a public API. Another difference is that it does not aggregate the information, but it displays the entire information about each altmetric event. For instead, it shows the information about the mention of an article on Twitter (date, user, tweet, etc.), but it does not show a count of the number of tweets. For that reason, data have to be processed to be comparable with the other services. CED was used exclusively to obtain Wikipedia citations.

Data Extraction

The first stage was to select a representative list of publications from Altmetric (Figure 1). To this end, we generated a random sample of 50,000 Altmetric IDs (from 100000 to 5500000). 44,141 records were retrieved using the public API (api.altmetric.com), the remaining ones produced errors. To cross this information with other sources, only records with a valid DOI were selected. Then, 36,523 publications with DOI were searched now in Scopus. From this citation index we extracted the number of Citations and the Scopus eID, obtaining 31,062 records. Next, PlumX was searched to extract the altmetric of those 31,062 publications, resulting 30,997 documents. Finally, the original 36,523 publications with DOI retrieved from Altmetric were used now to obtain the Wikipedia citations from CED. Therefore, the final list of publications with some altmetric event was 32,668. However, it is possible that the altmetric score of a publication could be influenced by the publication date, because recent papers could still not show the complete impact that these publications have in the research community. Then, we have selected articles published only in 2013 (3,793) to this study. 2013 was selected because we think that, after four years, the altmetric impact of these publications can be fully observed.

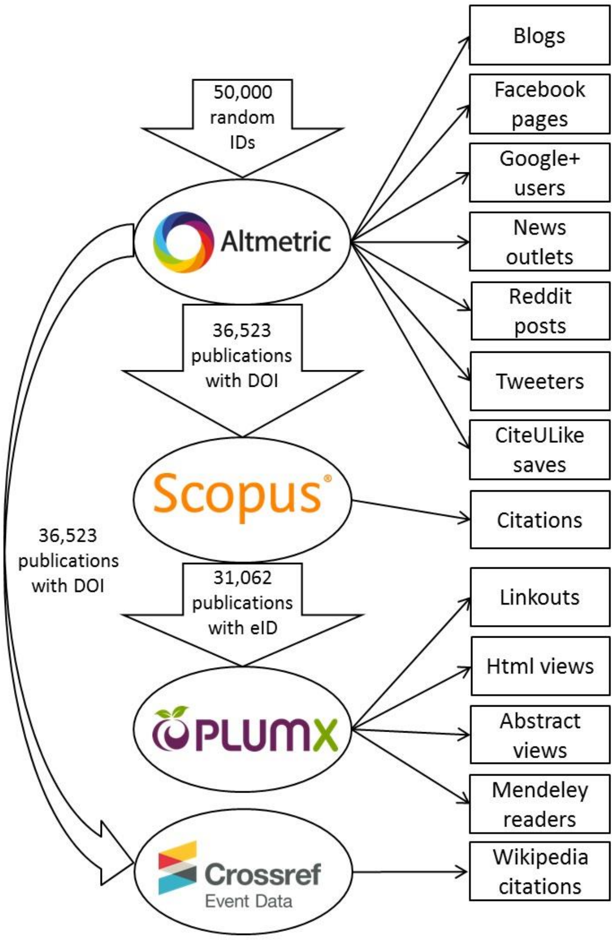

Figure 1. Diagram detailing the data extraction process across sources and the metrics obtained from each provider.

Statistics and Software

Data extraction process was carried out using several *ad-hoc* crawlers. SQL language was used to design those crawlers. SPSS 23 was used to calculate the Principal Component Analysis and XLStat package was employed to plot the observations and components. Data were log-transformed (ln(1+x)).

Results

PCA multivariate statistical technique was employed to group altmetric indicators and build several components that summarize the information of these metrics. Three main components were detected which explain 49.1% of the variance. This low explanation could mean that many of these variables do not share information among them and therefore the meaning of these metrics is very different. Altmetrics can be grouped in three components (Table 1). The first component sets altmetrics related to the social impact in social networks (Facebook, Google+ and Twitter) and online media (blogs, news and Reddit). The second one is related to the use of publications, grouping metrics about viewing, downloading or reading research articles. Finally, the third component contains variables about bibliometric citations (Scopus and Wikipedia) and saves on bookmarking systems (Mendeley and CiteULike), which suggests that document bookmarking is very close to the citation impact (Li et al., 2012; Maflahi & Thelwall, 2016).

	Component		
	1	2	3
Facebook	**.611**	.088	.142
Blogs	**.638**	.032	.231
Google_plus	**.715**	-.005	.033
News	**.660**	.029	.215
Reddit	**.540**	.022	-.054
Tweeters	**.540**	.253	.301
Linkouts	.076	**.816**	.142
Abstract_views	.066	**.917**	.104
HTML_views	.051	**.595**	-.066
Citeulike	.199	-.095	**.508**
Mendeley	.047	.291	**.807**
Scopus	.035	.020	**.846**
Wikipedia	.117	.020	**.318**

Table 1. Correlations between variables and components (after Varimax rotation)

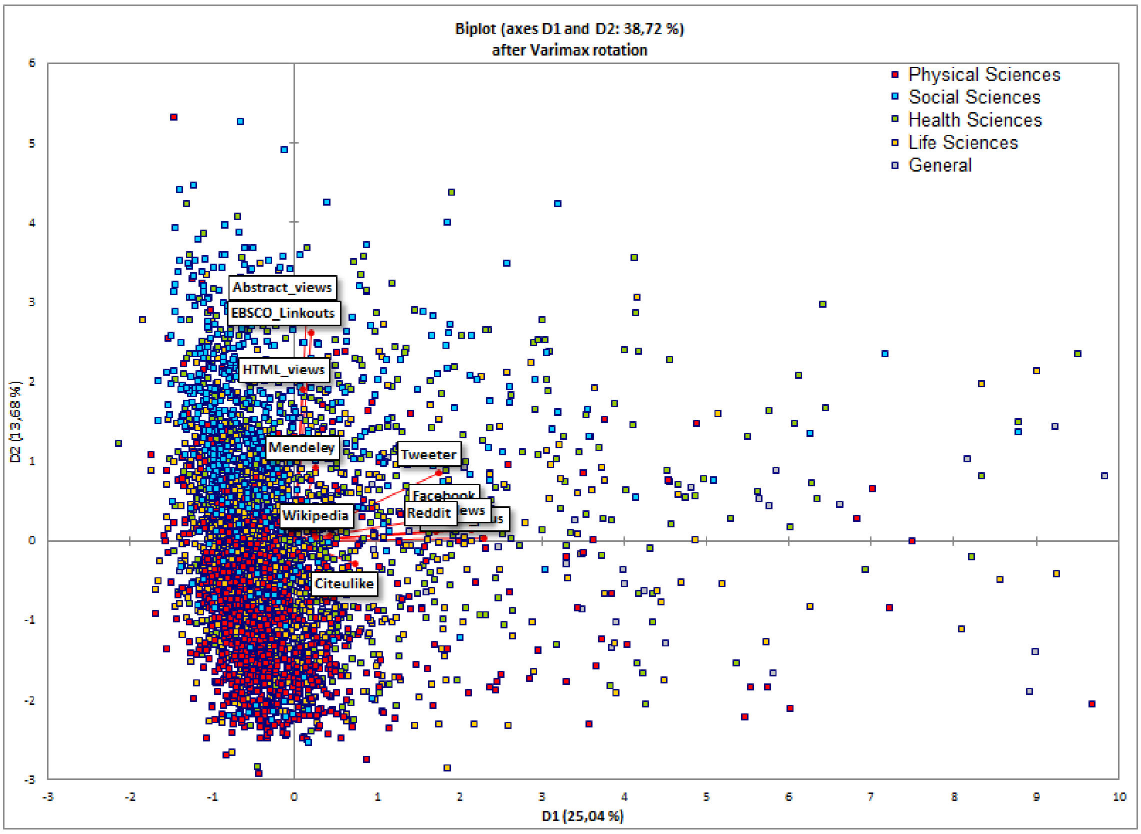

Figure 2. Biplot with the variables and observations after Varimax rotation (Variance: 38.72%).

Figure 2 maps metrics and articles according to the first two components. Colors of the articles correspond to their research area (General, Health Sciences, Life Sciences, Physical Sciences and Social Sciences) with regard to Scopus's Research Areas. This information was provided by Altmetric. The plot shows that there is high dispersion of the first component (Social media), while most of the articles are distributed along the second component (Usage). The third component (Citations and saves) is not perceptible in this representation. This elevated dispersion means that the social media indicators have a very irregular impact and there is not a disciplinary pattern. However, Usage component is more uniformly distributed where it is possible to observe disciplinary differences.

Research Areas	C1 (Social media)	C2 (Usage)	C3 (Citations and saves)
General	**(±.25) 1.64**	(±.059) -0.08	**(±.147) 0.93**
Health Sciences	**(±.015) -0.02**	**(±.015) 0.11**	(±.016) -0.11
Life Sciences	(±.017) -0.13	(±.016) -0.21	**(±.022) 0.25**
Physical Sciences	(±.024) -0.11	**(±.021) -0.60**	**(±.025) 0.16**
Social Sciences	(±.027) -0.13	**(±.03) 1.12**	(±.033) -0.09

Table 2. Means punctuations and standard errors of each group by component. In bold: difference statistically significant at α=.05 (Student's t-test).

Table 2 illustrates these differences in a clearer way. It displays the mean of the punctuations of each research area by component. In bold the means that are statistically different using the Student's t-test for independent samples. According to the Social media component, General articles are, by far, the most mentioned in social networks. This could be due to this category groups top-tier journals (Nature, Science, PNAS, etc.) which receive a great attention from the media and social networks. The second component, perceptible in the Figure 2, shows that Social Sciences articles are those that are more viewed and downloaded, while Physical Sciences papers present a low usage pattern. This elevated use of Social Science documents was already reported in previous studies (Wan et al., 2010; Vaughan, Tang and Yang, 2017) and it could be due to a different academic behavior. Finally, the third component displays a better citation and bookmarking behavior for General articles, while Health Sciences and Social Sciences present negative scores. The elevated punctuations of General could be due to similar reasons than the first component; it groups articles from very prestigious journals with a high citation impact. However, it is surprising that Health Science articles have low performance. Viewing in detail this component, Health Sciences shows low averages in Mendeley readers ((±.02) 2.75) and Scopus citations ((±.03) 2.2). A possible reason could be Health Sciences groups clinical disciplines with citation rates (Dentistry, Nursing, etc.) lower than Biology and Physics. In fact, if only Medicine articles are considered the average increase to (±.03) 2.23.

Discussion

Before discussing the results, this work has been one of the biggest integration efforts, upon including a wide range of metrics from several altmetric providers and bibliographic sources: Altmetric, PlumX, Scopus and CED. This method has made possible the selection of the most appropriated sources for each metric, as well as to group indicators that are dispersed across different providers. In this way, we have attempted to gather the most assorted range of altmetrics to describe their relationships and differences according to research areas. We think that this procedure is recommendable for altmetric studies because there are different sources that include multiple metrics and, in many cases, these are computed in a distinct way (Jobmann et al., 2014; Zahedi et al., 2015; Ortega, in press). Moreover, Big data techniques (crawler design, APIs search, sources integration, etc.) should be more frequent in bibliometric practice in order to improve their results and explore new connections.

PCA results have shown low relationship among altmetrics as results of the low percentage of the explained variance (49%). This confirms that the origin and meaning of these metrics are very different among them. In fact, many other Altmetric's indicators (Weibo, Youtube, Linkedin, etc.) were rejected due to their low incidence and poor contribution to the model. Thirteen metrics with the most information were selected and grouped in three sets by the PCA. A first cluster gathers metrics from social networking sites (Facebook, Google+, Twitter) and online media (blogs, Reddit, news outlets). This is the component that collects more metrics and information (25%) and represents the core of altmetrics, being the indicators that describe, in general, the social impact of science. This "social" component was previously detected by Zahedi et al. (2014), who identify a component with tweets and Delicious bookmarks separated from Mendeley readers, Wikipedia mentions and citations, confirming the distinction between bibliometrics and altmetrics. However, Costas et al. (2015) observed similar results but now distinguishing media metrics (news and blogs) from social network metrics (Twitter, Facebook, Google+).

The second component groups a very different set of metrics, but all of them related to the usage of publications (views, downloads, etc.) (13.7%). This second component is uncorrelated with the first one, meaning that usage metrics are poorly related to social impact. In this sense, Bollen et al. (2009) were the first ones that noticed that usage metrics constituted a different component, distinct from bibliometric indicators. Ortega (2015) showed that usage metrics are highly dependent from the site that counts those metrics.

Finally, the third component groups two types of metrics: citations (Scopus, Wikipedia) and saves on bookmarking sites (Mendeley, CiteULike). This result makes evident the narrow relationship between citations and saves and it suggests that saves/readers could be considered early indicators of citation impact. Many works have verified this relationship, confirming high correlations between readers and citations (Li et al., 2012; Maflahi and Thelwall, 2016). Even more, Zahedi et al. (2014) also found that both types of measures are grouped together when they used PCA in a set of altmetric indicators.

But, perhaps, the most interesting result is the detection of disciplinary differences between altmetric indicators. PCA has shown that there are significant differences between research areas when they are distributed along the three components. Thus, according the first one (social media), General articles show very high scores. This is because this category groups publications from top-tier journals, which attract a lot of attention from the social media (Shema et al., 2012; Haustein et al., 2014; Zahedi et al., 2014). The second component (usage) contains important differences, where Social Sciences articles are significantly more used (Views and downloads) than publications from Physical Sciences. Wan et al. (2010) found that journal download immediacy index is higher for Social Sciences journals than for other categories; while Vaughan et al. (2017) observed that Social Sciences and Humanities are the disciplines with the highest download rates. A possible explanation for this result could be that Social Sciences and Humanities consume more literature than other research areas because the critical analysis of texts is a fundamental part of the Humanities (Mayhew, 1954). The third component (citations/saves) displays that General publications have the highest scores, while Health and Social Sciences present the lowest averages. The same as the first component, General papers are published in multidisciplinary journals with high impact (JIF, SJR), improving the number of citation that these articles receive. Surprisingly, the low performance of Medicine was already noticed by Vaughan et al. (2017) and Hassan et al. (2017), who also found low citations for Medicine articles in comparison to Natural and Physical Sciences. According to saves or readers, Zahedi et al. (2017) also found that Biomedicine articles have lower mean readership score than Social Sciences and Humanities. Bornmann and Haunschild (2016), applying a Mendeley normalized count, also observed that Biomedicine and Health Sciences papers have the lowest proportion of top-10% readers. Overall, PCA has made possible to identify different groups of altmetrics and to distinguish differences between disciplines according to their altmetric performance.

Conclusions

For the first time, data from Altmetric, PlumX, Scopus and CED were integrated and analyzed, providing the broadest view of the altmetric impact. This study demonstrates that this integration process is not only possible but it should be a standard to obtain a complete and reliable picture of the alternative metrics. Researchers interested in developing altmetric studies have to consider that the altmetric impact is reflected in multiple sources (altmetric providers, publishers platforms, search engines, etc.) and therefore they should design methods that capture this information from different providers. What is more, this fact pushes scholars to be critical of the altmetric sources because they employ different ways to calculate their metrics.

PCA has also shown that these metrics can be grouped according to their internal relationships and performance. Three groups were identified: Social media metrics, which include indicators from online and generalist social networks (tweets, Facebook and Google+ mentions) and news media (blogs, news); usage metrics include indicators about the use of publications, such as views, downloads and link outs; and finally, a third group of metrics related to scientific impact (Scopus and Wikipedia citations) and bookmarking of publications (CiteULike saves, Mendeley readers). These results suggest that altmetrics do not have a unique meaning and they measure a wide range of actions not always related to the scientific impact. Due to these results, altmetrics should be grouped by their meaning (i.e. social mention, usage, and scientific impact), showing a multidimensional view on the different type of impacts each publication receives, and avoiding the use of all-in-one metrics (i.e. Altmetric Score, RG Score).

Other important result, thanks to the PCA, has been the detection of disciplinary differences between research areas. According to the three observed components, we have perceived that articles included in General category have more social media (first component) and scientific impact (third component) than other research areas, whereas Social Science articles have better averages in usage metrics. These differences should be considered when altmetrics are compared across disciplines because articles from specific disciplines could be systematically more mentioned, used or cited than others. This fact could have some implications for the allocation of resources and the selection and promotion of personnel.

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