Lemke, Steffen; Mehrazar, Maryam; Mazarakis, Athanasios; Peters, Isabella

Conference Paper

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Suggested Citation: Lemke, Steffen; Mehrazar, Maryam; Mazarakis, Athanasios; Peters, Isabella (2018) : Are There Different Types of Online Research Impact?, In: Building & Sustaining an Ethical Future with Emerging Technology. Proceedings of the 81st Annual Meeting, Vancouver, Canada, 10–14 November 2018, ISBN 978-0-578-41425-6, Association for Information Science and Technology (ASIS&T), Silver Spring, Maryland, pp. 282-289

Are There Different Types of Online Research Impact?

Steffen Lemke
ZBW – Leibniz Centre for Economics, Germany.
s.lemke@zbw.eu

Maryam Mehrazar
ZBW – Leibniz Centre for Economics, Germany.
m.mehrazar@zbw.eu

Athanasios Mazarakis
Kiel University, Germany. a.mazarakis@zbw.eu

Isabella Peters
ZBW – Leibniz Centre for Economics, Germany.
i.peters@zbw.eu

ABSTRACT

While web-based indicators for scientific impact – so-called altmetrics – have an increasing uptake as means for research evaluation, many questions regarding their actual meanings remain unanswered. In this article we analyse the data from a survey about researchers' use of 107 online actions that underlie potential altmetrics to discover whether certain types of altmetrics (1) better reflect the judgments of researchers from certain career stages and (2) more reliably capture positive judgments than others. We apply variance analyses to reveal significant differences between the frequencies with which early-stage researchers and professors perform various actions whose occurrences are counted as impact metrics (e.g., downloading, liking, or sharing of scientific publications). The findings imply varying degrees of representation of these groups in respective altmetrics. Moreover, by investigating how commonly various types of actions are used to express positive judgments, we disclose how reliably metrics can be used as proxies for positive impact. Our findings contribute to a more comprehensive understanding of the meaning of different web-based metrics for scholarly impact and provide a basis for evidence-based guidelines on how to use and interpret them.

KEYWORDS

Research evaluation, altmetrics, social media analysis, survey study.

INTRODUCTION

Enabled by the rise of the Internet and social media in particular, the idea of web-based metrics for research impact emerged as a promising means towards a more versatile and fair evaluation of scientific achievements. Frustration about the disproportionate influence of citation counts and citation-based metrics in the assessment of scholarly impact further encouraged researchers to look for alternatives, as for example described in the altmetrics manifesto (Priem, Taraborelli, Groth, & Neylon, 2010) or formulated from the DORA initiative (https://sfdora.org). As web-based platforms had become an integral part of many researchers' everyday work, new options unfolded themselves in the various possibilities to count online engagements with scientific publications, e.g. mentions, shares or downloads. Now, eight years after the coining of the umbrella term *altmetrics* (Priem, Taraborelli, Groth, & Neylon, 2010) to denote those metrics operationalizing the attention scientific products receive online, especially on social media platforms, several grand challenges of handling such metrics remain to be solved (Haustein, 2016).

Much research has been done to find out why people cite, arriving at a multitude of different reasons – a heterogeneity of underlying motivations that complicates the usage of citations as proxies for scientific relevance or quality (Bornmann & Daniel, 2008). When we turn to altmetrics, heterogeneity poses an even greater difficulty, as here it also concerns the tremendous number of existing and emerging platforms that could be used to derive altmetric indicators (Lin & Fenner, 2013). Every single platform potentially imposes its own technical conditions, provides its own set of functionalities and accommodates its own community of users.

As altmetrics are increasingly utilized in research evaluation (Haustein, 2016), a differentiated analysis of what different types of altmetrics precisely reflect is indispensable to ensure trustworthiness and fairness in their use (Lin & Fenner, 2013). This becomes especially apparent at a time in which the much-debated problem of fake news makes us painfully aware of one of social media's greatest weaknesses: the unfiltered stream of information on the platforms has to be processed with care, signals should be thoroughly assessed with regard to their origins. Obviously, this also concerns the process of measuring online attention as an indicator for scientific impact. For example, whose attention does a high number of retweets on Twitter reflect, compared to a high number of downloads on ResearchGate? Which level of expertise of the user is typically involved when a publication becomes an altmetric success on Facebook, i.e., shared or liked by many users? And do altmetrics involve a systematic bias towards young researchers,

as is commonly suspected (Priem, 2014)? Originator-related questions like these need to be answered to turn the otherwise overwhelming thicket of altmetrics into transparent and conclusive metrics for scientific impact.

Another difficulty with the interpretation of altmetrics that needs to be addressed is the possibility that a certain action leading to an increase in altmetrics does not necessarily translate to a positive judgment about the object on the receiving end of the action. Just like citations, which can as well be used to criticize, correct or just neutrally comment on the cited publication, social media actions are performed for diverse purposes – even a seemingly one-dimensional action like a Facebook-'Like' (Levordashka, Utz, & Ambros, 2016). Evaluation of research products usually looks for positive interactions with them, so that relevance or quality can be confirmed. The common proxy for quality is: the more means the better – which makes it necessary to examine how reliably different types of metrics actually do reflect positive judgments.

To tackle these issues, we present in this article selected data from a survey conducted in spring 2017, investigating the social media usage of scholars. While researchers' usage of specific social media platforms has already been analyzed by a multitude of both quantitative (Collins, Shiffman, & Rock, 2016; Kramer & Bosman, 2016; Syn & Oh, 2015; Van Noorden, 2014) and qualitative (LaPoe, Carter Olson, & Eckert, 2017; Vainio & Holmberg, 2017) studies, the survey presented in this article sets itself apart from previous studies by inquiring detailed information about degrees of usage of a multitude of individual actions available on social media platforms.

To better understand whose judgments are reflected by which types of altmetrics, we aim to answer the following research question by analyzing the survey data:

RQ1: Which actions related to altmetrics are performed frequently by researchers from which career stages?

Additionally, to get a better understanding of which altmetrics can be regarded as indicators for genuine, positive scientific impact, we also aim to answer the following question:

RQ2: Which actions related to altmetrics are reliably used to express positive sentiments towards their targets?

This article presents findings of a survey that is part of a bigger study on the meaning, reliability and perception of altmetrics (https://metrics-project.net/). Understanding the meaning of altmetrics is a multidimensional task, as that meaning is shaped by both the characteristics of the users performing underlying actions, as well as their concrete motivations for doing so. While the different metrics' inherent positivity is one crucial aspect to consider, further steps are needed to account for the large variety of goals that researchers pursue when interacting with scientific products online. The survey presented here will therefore be succeeded by a round of qualitative interviews and a follow-up survey investigating in more depth on researchers' motivations when performing online actions related to altmetrics.

The relationship between academic experience or career stage and social media usage has been analyzed by previous works with diverging results for different platforms. Regarding *Twitter*, Bowman (2015) found the relationship between academic experience and usage to follow a reversed U-shaped curve, finding that researchers with 7 to 9 years of academic experience are more likely to be active on *Twitter* than those with less or more years of experience. Shema et al. (2012) examined data on research blogs aggregated by the service *ResearchBlogging.org*, concluding that most authors are either graduate students or PhDs, with both groups being about equally represented among the blogs' authorships. Several studies have examined the representation of different researcher career stages on social media by looking at the example of *Mendeley*, finding that junior researchers and doctoral students are the largest user group on the social bookmarking service (Haustein & Larivière, 2014; Jeng et al., 2015; Zahedi, Costas, & Wouters, 2014). These previous findings however do not allow for statements about the actual intensity of activity of users from different career stages on the platforms, e.g., the frequency with which they interact with publications. And – as quickly becomes apparent when looking at the different categorization schemas used in these studies – their results are not directly comparable to achieve a cross-platform overview. Also, so far there has been no broad study comparing the kinds of sentiments that researchers want to express by performing the various actions that lead to increases in potential altmetrics. These are gaps we aim to close with our work.

METHODS

To gather information on researchers' usage habits in respect to social media, an online survey consisting of 20 questions was designed and implemented using the online survey software *LimeSurvey* (https://www.limesurvey.org/). The dissemination was started on March 31st 2017 and ended on May 17th 2017. The call for participation was disseminated via a combination of direct personalized mails (containing the recipients' first and surnames), direct non-personalized mails and mailing lists. Personalized mails were sent to about 12,000 economists enlisted in a mailing list administered by the *ZBW Leibniz Information Centre for Economics*; non-personalized mails were sent to about 42,000 addresses of economics- or social sciences-related researchers which had been mined from RePEc and Web of Science. Additionally, about a dozen international mailing lists referring to

either economics, social sciences or corresponding sub-disciplines were also addressed with the call for participation. The emphases put on economists and social scientists during dissemination were by design, as these disciplines hold particular interest for the institutions involved in the study's conduction.

Participants were asked between 13 and 20 questions, depending on their answers over the course of the questionnaire. Most questions revolved around a preselected list of 90 social media services. This list was compiled from three sources: (1) a joint brainstorm session among the authors, which also served the purpose of clarifying the direction to take in the whole process of service preselection; (2) services included in the previous surveys by Kramer & Bosman (2016) and Van Noorden (2014) were considered; (3) Kramer & Bosman (2015) make use of a crowdsourcing approach to collect information on online tools with potential relevance for researchers in an open spreadsheet – we manually scanned the spreadsheet for services we missed before, especially looking out for services with particular relevance for the fields of economics or social sciences. At the end of this preselection process the list was reduced to the 90 services deemed most relevant, to keep the questionnaire reasonably short. The services included in this list reflect a very broad definition of social media – we allowed any kind of web-based platform, which would allow for centrally countable interactions with scientific products and could thus potentially be exploited as a source for altmetrics.

In the survey participants were provided with the list of social media services described above and asked to select those who they use at work. The services a participant selected as "used at work" significantly shaped the remaining course of the questionnaire, as will be seen below.

To answer the first research question, we analyze responses to the survey questions *What is your current role?* (possible answers were *Professor/Associate professor/Assistant professor; Postdoc/Senior Researcher; Research assistant + PhD student; Research assistant; PhD student; Other*) and *How often do you…?* (with the possible answers *Several times a day; About once a day; Several times a week; About once a week; About once a month; Less often; Never*). The group of services a participant previously selected as "used at work" determined for which online actions that participant was asked to answer the latter question – e.g., if a participant stated that she would use *Facebook* and *Twitter* at work, here she would be asked to select the frequencies with which she *writes a post about academic research on Facebook, likes a post about academic research on Facebook, comments on a post about academic research on Facebook, shares a post about academic research on Facebook, writes a tweet about academic research, favors a tweet about academic research, replies to a tweet about academic research,* and *shares a tweet about academic research*. To come up with the survey's list of such actions, the 90 considered services were manually checked for features which could (1) be used to interact with scientific publications and (2) would lead to a measurable number of occurrences that could potentially be exploited as a quantitative metric (e.g., a publication's number of downloads). Frequent types of features were for example 'like'-, 'share'-, 'bookmark'- or 'download'-actions. In total, 107 actions were implemented in the survey this way, between 0 and 5 for each of the 90 included services.

To see whether the metrics behind certain actions better reflect the opinions of established researchers in contrast to beginners, we first assigned the participants to two groups, based on their stated role: (1) professors (consisting of those participants who identified themselves as *Professor/Associate professor/Assistant professor*) and (2) early-stage researchers (consisting of participants who identified themselves as either *Research assistant* and/or *PhD student*). Based on the data about frequencies with which those two groups use the actions the survey asked about, we then performed Welch's t-tests to check for significant differences regarding their mean frequencies. For this we ignored all actions for which less than a total of 150 survey participants provided answers, leaving us with 58 actions to test for. Resulting p-values were adjusted with Tukey's HSD (Lowry, 2008).

Answering the second research question, we analyzed the responses for the survey question *When you are performing the following actions, in how many cases does that indicate a positive stance on the respective target?* (possible answers: *In all cases, In most cases, In few cases, Never*). Participants were asked to answer this question for all actions they use at least occasionally according to their responses given before. For the analysis we again focused on actions for which we got data from at least 150 participants, in this case leaving us with 42 actions. These actions were then allocated to one out of seven groups each, depending on their consequences: 'writing', with 7 actions leading to an original piece of text by the active user; 'commenting', with 4 actions leading to an original piece of text by the active user that directly refers to an already existing item; 'downloading', with 14 actions that lead to a file download with the active user as recipient; 'sharing', with 5 actions that forward an existing item to the active user's contacts on the respective platform; 'bookmarking', with 3 actions that lead to the addition of a reference of the selected item to the active user's personal library on the respective platform; 'liking', with 5 actions that refer to an existing item, increase a visible score attached to it and add the active user to an associated user list; 'Other', with 4 actions that don't fit in the previous groups.

For all 42 actions we calculated the individual shares of users stating they would use the respective action exclusively to express positive sentiments among all users who provided an answer concerning the respective action. We then analyzed the resulting

shares graphically. Examining which actions are most constantly performed to express positive sentiments towards their targets, we get evidence which altmetrics can reliably be used to measure an article's positive impact in its research community.

RESULTS AND DISCUSSION

In this section we present results of the analysis of the two pivotal questions asked in our survey. The analysis of the first question sheds light on the intensity of social media usage among researchers in different career stages, the analysis of the second question on the sentiments researchers express via affordances of social media and other web-based platforms.

Respondent Demographics

We received input from a total of 3,427 participants, i.e. a response rate of ~6% (n ≈ 54,000). Of those participants 2,659 (78%) had gone through the complete questionnaire. The median time spent in the survey was 9 minutes 3 seconds. Participants were from 84 countries, the majority being from *Germany* (51%), followed by the *United States of America* (10%), the *United Kingdom* and *Italy* (both 5%). Most participants stated to be from the age bracket *30-39 years* (32%), followed by the age brackets *40-49 years* (17%) and *20-29 years* (12%), the mean age was 40 years. Discipline-wise the sample was dominated by participants stating *Economics* as their primary field of research (60%), followed by *Social Sciences* (23%) and *Other* (7%). *Engineering/Technology*, *Life Sciences*, *Arts/Humanities*, *Law*, *Medicine* and *Physical Sciences* all received less than 4%.

Asking for the participants' current role revealed that most identified as belonging to the group *Professor/Associate professor/Assistant professor* (44%). Remaining categories were *Research assistant + PhD student* (20%), *Postdoc/Senior Researcher* (19%), *PhD Student* (9%), *Other* (5%) and *Research assistant* (3%).

The sample's considerable biases towards German participants as well as towards economists and social scientists can be explained by the choice of distribution channels explained in the Methods section. The discipline-wise emphases are a consequence of the topical focus of the project in which this study was carried out. The biases towards German participants and professors were very likely caused by the aforementioned mailing list with 12,000 entries administered by the ZBW, which contained email addresses of researchers from German-speaking countries working at institutions related to economics, business studies and closely related fields.

RQ1: Comparison of Frequent Actions by Career Stages

To reveal how the degree of representation of researchers from different levels of professional experience within specific metrics varies, we analyzed the mean frequencies with which *early-stage researchers* in contrast to *professors* use 58 social media actions by applying Welch tests. To be able to calculate mean scores for the ordinal scaled frequencies, we applied the following mapping from answer options to numerical values: *Never* = 0, *Less often [than once a month]* = 1, *About once a month* = 2, *About once a week* = 3, *Several times a week* = 4, *About once a day* = 5 and *Several times a day* = 6.

Assuming a significance level of 5%, for 27 actions significant differences in regard to the frequency with which the two groups on average use them were found. Table 1 shows the 15 actions that are used significantly more frequently by early-stage researchers than by professors. n_e/n_p shows the number of early-stage researchers/professors that stated a usage frequency regarding the respective action, m_e/m_p shows the mean frequency with which the respective group uses the respective action, p is the significance value of the according Welch test (adjusted with Tukey's HSD). Table 2 shows the 12 actions that are used significantly more frequently by professors than by early-stage researchers accordingly.

The probably most striking peculiarity in these results is the high number of 'download' actions seen in Table 1. In fact, we found significant differences for eleven out of thirteen 'download' actions we tested, in all cases with higher means for the early-stage researchers. A similar observation can be made for 'bookmarking' actions, where all three tested actions revealed higher means for early-stage researchers than for professors. Among the twelve actions that professors use significantly more frequently are seven actions that imply the writing of some original text. Of the remaining actions in Table 2, three are about sharing academic resources, two about liking. Also remarkable is that eight of the twelve actions from Table 2 refer to either *Facebook* or *Twitter*.

Action	Platform	n_e	n_p	m_e	m_p	p
download an article	Academia.edu	182	353	2.34	1.74	0.001
download an article	arXiv	63	101	2.98	2.12	0.001
download an article	EconStor	203	146	2.95	2.41	0.001
download an article	JSTOR	560	816	3.42	2.84	0.001
download an article	MPRA	50	155	2.96	2.22	0.001
download an article	PubMed C.	88	147	3.19	2.25	0.001
download an article	RePEc	155	492	3.20	2.50	0.001
download an article	ResearchGate	529	711	2.56	2.12	0.001
download an article	SSRN	219	505	2.70	2.10	0.001
download a repository	GitHub	159	130	1.98	1.63	0.016
download a sample	EBSCO	360	469	2.68	1.98	0.001
export/save a sample	EBSCO	357	457	1.93	1.35	0.001
save a bookmark	Citavi	302	94	2.94	2.06	0.001
save a bookmark	JSTOR	542	785	1.22	0.79	0.001
save a bookmark	Mendeley	159	205	2.43	1.55	0.001

Table 1. Actions used more frequently by early-stage researchers.

Given the availability of only quantitative data on the usage frequencies and significant differences we can only hypothesize about the underlying reasons for these results. The findings for early-stage researchers suggest a comparatively higher usage of services that are helpful during the practical stage of scientific work, in most cases by either providing access to literature or by assisting in managing it. This seems plausible as early-stage researchers might typically be able to spent more time with the realization of research than professors, who in turn often might be more occupied with diverse other tasks like administration or teaching. The observation that professors more frequently perform several actions involving writing might be explained by the availability of personal networks: as professors will on average have built more extensive professional networks than most early-stage researchers, they'll also have a wider potential audience to reach on social networks like *Facebook* and *Twitter*. This would both lead to more opportunities to engage in running scientific discussions as well as make posting written contributions more meaningful in general. Another reason for early-stage researchers' lower use of such actions might be a comparatively lower self-confidence to actively participate in scientific discussions online. Of course different interpretations are possible, all of which need to be backed up with in-depth research.

Action	Platform	n_e	n_p	m_e	m_p	p
cite academic research	Wikipedia	571	771	0.49	0.67	0.002
comment on a post[1]	Facebook	216	287	1.50	2.08	0.001
favor a tweet[1]	Twitter	123	283	2.41	2.86	0.032
like a post[1]	Facebook	219	289	2.62	2.94	0.046
reply to a tweet[1]	Twitter	123	280	1.64	2.09	0.012
retweet a tweet[1]	Twitter	124	283	2.23	2.81	0.004
send a tweet[1]	Twitter	135	297	2.03	2.78	0.001
share a post[1]	Facebook	218	289	1.65	2.19	0.001
share a video[1]	Youtube	279	452	0.44	0.73	0.001
write a post[1]	Facebook	228	308	1.33	1.89	0.001
write a post[1]	LinkedIn	227	465	0.58	0.80	0.009
write a post[1]	Wordpress	119	210	0.82	1.14	0.009

[1]about academic research

Table 2. Actions used more frequently by professors.

RQ2: Positive Sentiments Behind Social Media Actions

Exploring the ways users shape specific metrics is a multi-dimensional problem: while looking at the frequency with which certain user groups perform an action gives us insights on their probable influence on the respective metric's shape, another aspect are the users' prevalent motivations – *why* they perform certain actions. While a follow-up survey will be specifically dedicated to that aspect, we at this point want to hint at patterns related to user motivations that the past survey could reveal.

Figure 1 shows the shares of users of actions that use the respective action exclusively to express positive judgments. Every data point corresponds to one of the 42 actions for which at least 150 survey participants gave a response. The three points from the group *bookmarking* for example refer to the actions *save a bookmark on Citavi, save a bookmark on Mendeley,* and *save a bookmark on JSTOR*.

Comparing the ranges of the action groups suggests noticeable differences between the latter: for like-actions from different platforms we get shares between 32.8% and 40.6% of their users who exclusively use them to express positive judgments, suggesting Likes are a comparatively reliable proxy for praise. On the other end of the spectrum are comments – only between 13.7% and 16.9% of their users state that they only ever comment to express positive stances. Bookmarks follow Likes as another indicator with mostly fairly high shares of users only bookmarking targets they take a positive stance on, while the range of shares for writing-actions is the second lowest aside from comments. Sharing- and downloading-actions mostly lie in the midfield, with a few outliers to the top service-wise.

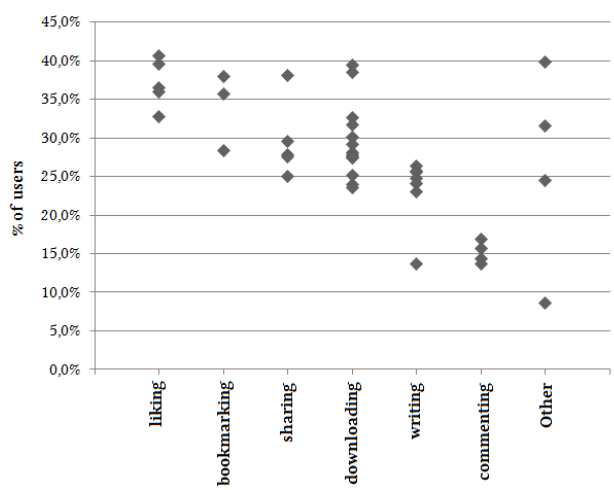

Figure 1. Share of users of an action who exclusively perform it to express a positive stance towards its target.

In addition to the described general tendencies observable for types of actions, through outliers like these the results provide another facet of interesting insights, as they indicate that similar actions might be commonly used for different reasons on different platforms. The outlier down among writing-actions for example refers to the action 'review academic research on Amazon', suggesting that *Amazon* is a platform used by more of its users to write critically about research, compared to the other platforms represented in that action group (*Facebook*, *Twitter*, *LinkedIn*, *Wikipedia*, *SSRN* and blogs).

CONCLUSIONS

The results of our survey indicated significant differences regarding the usage frequencies of researchers from different career stages in regard to actions whose consequences can be measured as altmetrics. This implies imbalanced degrees of representation of these user groups in respective altmetrics – for example publications' download counts on many platforms will more likely reflect judgments by early-stage researchers, counting mentions of a scientific article on *Facebook* or *Twitter* might lead to a better reflection of that article's impact among more experienced researchers.

The participants' responses to the survey question about how commonly they use different online actions to express positive judgments indicated that web-based impact metrics should be differentiated by the type of action behind them, not only by the source they are from – regarding their intended meaning, e.g., Likes on two distinct platforms seem in most cases to be more similar to each other than Likes and comments on the same platform. Also, our graphical analysis hinted at a rough 'ranking order' of different action types' likelihoods to represent positive judgments, with Likes being the most consistent and comments being the least consistent proxy for endorsement. Moreover, aggregations on action type-level – which some prominent providers for altmetric data already customarily do, such as PlumX – should still be done with care, as our analysis revealed a few strong outliers in several action groups.

In summary, this case study on scholarly social media use provides evidence that closely observing the circumstances among which different kinds of altmetrics arise is necessary to get to an informed picture of what they express. It also shows that such differentiation should not stop at the level of sources, but should go even deeper to the level of action types or even individual actions.

Our approach can only serve as a first glimpse at what users' motives for specific actions tell us about how to handle the metrics resulting of such activities, so further work will go into testing hypotheses made based on this article with solid statistical evidence. Also, future analysis of the survey data will incorporate an additional dimension by linking the participants' responses about their motives to perform certain actions with their stated individual frequencies of usage, thus accounting for the fact that on social media very few users are responsible for a large share of activities (Nielsen, 2006).

A limitation of this study lies in its sample, which was heavily biased towards economists and social scientists. Similar to how disciplines' differ regarding prevailing citation norms (van Raan, 2003), they might also behave differently regarding their usage of the social media-related actions analyzed in this study. And although it might be a reasonable assumption that the lion's share of online interactions with scientific products is performed by researchers, the influence of non-academic users on altmetrics should be considered in future studies as well.

Moreover, the survey results presented in this article only reveal a snapshot of the participating researchers' social media usage – safe predictions about that usage's future development cannot be made on this basis. To allow for such predictions a worthwhile approach might be to repeatedly survey the same group of researchers over a longer period of time. This could reveal whether certain participants continue to use particular services they started using early, regardless of changes to their career stage. However, our hypotheses for such a study would be in accordance with the results discussed above: for example, although someone who as a PhD student started to use the social bookmarking tool *Mendeley* might be more likely to also use it in later career stages, the frequency with which that researcher saves bookmarks on *Mendeley* would probably decrease due to accompanying changes regarding the researcher's tasks.

A general shortcoming of surveys like ours is their dependence on the participants' perceptions and memories, which are of uncertain reliability. A more reliable approach to investigate on individuals' usage habits would be to analyze log data from the platforms on which relevant actions take place. This approach however comes with its own challenges: for example the identification of respective active users' demographics, the possibly missing inter-platform comparability of log data due to differences between the ways they are recorded as well as – in the first place – the general difficulty to get access to log data for many platforms.

Also, there are other approaches which might be valuable complements to the survey-based approach taken by this study. Network analysis can provide additional insights regarding the influence of certain user types on the rise of specific metrics by revealing which nodes play particularly prominent roles during the dissemination of information through online communities (see e.g., Brown, Broderick, & Lee (2007)). Qualitative analyses of the circumstances under which interactions (e.g., comments or Likes) take place might result in similar results as for citation analysis (see for example Catalini, Lacetera, & Oettl (2015); Cavalcanti, Prudêncio, Pradhan, Shah, & Pietrobon (2011)). Although qualitative approaches like these might not be feasible to perform for a number of actions as high as in this study at once, for a selection of platforms sentiment analysis could be used

to confirm this study's findings regarding the shares of writing- and commenting-actions that are performed to express positive judgments.

The results presented in this article provide input to research and development on the Web, for example by informing ranking or personalization algorithms that utilize social media and usage data in similar contexts. Moreover, our results could serve as a starting point for the development of well-informed guidelines for a more differentiated handling of altmetrics.

Suppliers of altmetric data for purposes of research evaluation are very aware that the online activities they measure do not equal scholarly praise, but are merely indicators for attention (Altmetric.com, 2015). Still, if we are striving to release altmetrics' full potential to lead to a more comprehensive, transparent and fairer appreciation of scientific work, systematic analyses of precisely what actions happening on social media platforms and the web in general mean are a necessary endeavor.

ACKNOWLEDGEMENTS

This work is part of the DFG-funded research project **metrics* (project number: 314727790). Further information on the project and the survey mentioned above can be found on https://metrics-project.net/.

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81st Annual Meeting of the Association for Information Science & Technology | Vancouver, Canada | 10 – 14 November 2018