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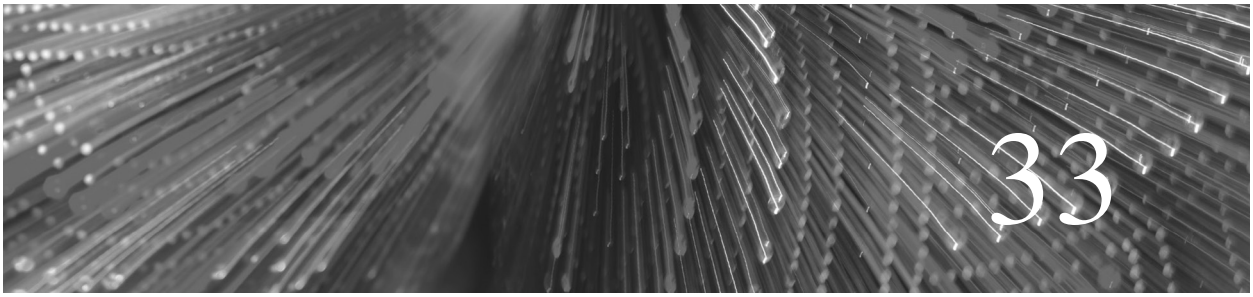

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Scholarly Communication in Social Media

Katrin Weller and Isabella Peters

INTRODUCTION

Lately, blogs have been increasingly used by researchers as tools to reflect upon their latest readings or other everyday workflows, and Maitzen (2012) concludes that academic blogging is a 'forum for developing and testing ideas'. Similarly, Twitter is used by many researchers for live reporting of academic conferences and networking (e.g., Weller, Dröge & Puschmann, 2011) or sharing links to scholarly publications (Eysenbach, 2011). In some disciplines, researchers' activities on social media platforms have covered up to 97% of the relevant scholarly literature, which means that in those cases more articles can be found in the social reference manager Mendeley than in the traditional bibliographic databases, for example Web of Science or Scopus (Li, Thelwall & Guistini, 2012). In fact, more than 60,000 scholarly articles are shared or discussed every week (Adie, 2015).

Therefore, alongside the traditional world of formal papers and official journals, there is a lively parallel universe bustling with new forms of and outlets for scholarly communication – one that needs to be explored for both its potential and its perils. Thus, this chapter provides an overview of how social media platforms are used by academics in different contexts and on the reasons and purposes of researchers in attending to social media. Particularly, we look at platforms that are being used by scholars – this can be common platforms such as Facebook, Twitter, and blogs or specific platforms explicitly aiming at academic audiences, such as Mendeley, Academia.edu and ResearchGate. We will ask about the role these platforms play in academia and outline the positive and negative effects of social media activity on scholarly communication. The chapter demonstrates similarities between traditional forms of scholarly communication – expressed mainly in form of publications and citations – and new ways of communicating through social media. In both cases researchers leave different forms of traces which have the potential to

measure activity and impact and which shape the (digital) identity of a researcher. At the end of this chapter we will take a closer look at the footprints and shadows as traces academics leave while using social media – and explain how this relates to new approaches of measuring academic impact and how the study of these 'altmetrics' contributes to the understanding of scholarly communication in social media.

Basics of Scholarly Communication

Scholarly communication is traditionally based on academic writing that is published and thereby shared with the academic community. Researchers communicate by reading, reflecting on and finally referencing other researchers' publications. The flow of information within the scholarly community can be retraced by studying the citations, which connect different publications: an author who includes a reference to another publication in their work is assumed to have received the information from that original publication. Hence, scholarly communication can be characterized as perpetual loop of publishing and citing of scholarly literature.

By participating in scholarly communication and generating its products researchers create their academic identities. The primary outcomes of academic writing (publications) can be considered as *footprints* (Bar Ilan et al., 2012; Goodier & Czerniewicz, 2015) that the author leaves in the landscape of scholarly knowledge. As a whole they mirror what the researcher does professionally – their scientific contribution – and draw a picture of their expertise. Publications are always linked to the author, who is bringing them into reality. As such the author initiates the publication and influences the appearance of this part of their academic identity. Those self-initiated footprints form the essential foundation for scholarly exchange.

On the other side, it is the citations that show the impact a publication has on other authors (Cronin, 1984). This results in a citation identity of every author (Cronin & Shaw, 2002) reflecting how other researchers perceive their work and, again, ends up in a certain impression of the author. Goodier and Czerniewicz (2015) speak of *shadows* that are initiated by people other than the researcher. Accordingly, this part of the academic identity cannot be controlled by the researcher herself/himself. Interestingly, in scholarly communication, leaving footprints and creating shadows are two sides of the same coin. Since authors publish original material by referencing known literature, they automatically develop shadows of other researchers.

Moreover, citations indicate some sort of topical relation between publications and can thus be used to 'navigate' through masses of publications, for example with special search engines that enable searching for all publications which cite a specific paper, or searching for works that are cited in (or citing) the same set of publications, or by ranking publications based on citations. The ability to retrieve relevant publications is a key for successful scholarly communication. Academics usually have to search for publications on a topic of interest, and to find ways to constantly monitor new publications in a given field to select those that are relevant. While solutions such as subscriptions to journals' table of contents or search alerts can help to monitor the field, the challenge of selecting which publications to read remains. And as publication output grows exponentially (De Solla Price, 1963; Larivière, Haustein & Mongeon, 2015), new strategies for keeping up with new publications and selecting the most relevant in one's field of research are needed to face the challenge of information overload. Peer-based recommendations, for example through social media, may become a welcome support in this effort.

It should also be noted that citations have become a sort of currency in academic life. They are no longer a mere trace of information flows between different researchers and their publications, but have become one of the most frequently used units for creating indicators of scholarly impact (De Bellis, 2009). The effects this may have and the drawbacks and limitations of different citation-based metrics are discussed and studied in the fields of scientometrics and bibliometrics (Cronin & Sugimoto, 2015; Leydesdorff, 1995).

Traditionally, monographs and journal articles have been the most common publication formats (Harmon & Gross, 2007; Meadows, 1974), though preferences may vary across disciplines and additional formats (e.g., conference papers) have emerged over time. Traditional publication processes rely on professional publishers as outlets. In addition, peer review has widely been adapted as a standard way for quality control of what should be published and what not. Both, the commercial role of publishers and the peer review process, have been subject to public critiques recently. Peer review processes have been criticized for being slow, biased or insufficient to identify flaws in scientific studies. Publishers are being criticized for overcharging access to academic publications and for thus dividing the research community into those who can afford access fees and those who cannot, which has in turn led to the formation of the 'open access' movement, postulating novel modes for financing publishing processes to enable access to the resulting publications free of charge for the reader (apparently already with some effect on scholarly communication as a whole as open access articles appear to attract more citations [Davis & Walters, 2011; Eysenbach, 2006]).

While academics publish at a growing rate and speed, and while dissatisfaction with publishing formats and access, citation counts and peer review is constantly expressed, new developments can be observed which already have a significant influence on scholarly communication.

Effects of Social Media in Scholarly Communication

The activities that make the researcher part of the scholarly communication ecosystem and that form the academic identity of an author consist of countable units, for example the number of publications and citations. These output units are inevitably linked to the elements of the research life-cycle of writing, consuming, understanding, and referencing publications. The publication and referencing structures that have been well established over centuries are increasingly being challenged by new tools and practices in online communication environments. As we will see below, different social media platforms – such as blogs, wikis, and the various types of social networking sites – are having different effects on scholarly communication – in general, we can speak of a positive feedback loop of more output units (e.g., publications acting as footprints as introduced above) generating more units of visibility (i.e., shadows like citations) leading to a better findability (of footprints), as well as increased reputation (of footprints via shadows). As such, social platforms are influencing at least the following seven dimensions of scholarly communication (modified from Peters & Heise, 2014):

1 *The production of published material.* Social media and other collaborative platforms allow for new ways of working together in groups. Although tools for collaborative writing existed before the term social media was made popular (Digital Research Tools, n.d.), new possibilities to work together on a manuscript have come up as the landscape of social media tools grew richer. Researchers may share their drafts and ideas with co-authors through various channels (e.g., via Academia.edu's comments), or may have (near to) real-time conversations while writing collaboratively (e.g., via chat in Google Docs).
2 *The process of searching for information or of monitoring a research field.* Researchers may use their peers (through social media) as indicators for relevant literature and recommendations

of what to read. Researchers may comment on useful literature via Facebook, Twitter or blogs. Academic social networking platforms like Academia.edu or ResearchGate are used to recommend publications. Increasingly, the personal network on the social media platforms is also used to – illegally – obtain articles published behind a paywall (e.g., via Twitter hashtag '#icanhazpdf').

3 *The ways to increase visibility of research results and self-promotion*. As social media platforms are growing into systems that are used to spot relevant publications, they can also be used, in reverse, to broadcast one's own publications. By communicating about academic work through social media it may even become possible to reach other than the core academic audiences (e.g., via hashtags on Twitter, by addressing blogs at a broader public audience, by including references in Wikipedia articles, or by answering FAQs on ResearchGate).

4 *The ways to connect with or to keep in touch with other academics*. Social networking sites such as Facebook are used to establish or maintain relationships with peers and other acquaintances and serve the need for comfortable, informal and fast communication. Given that there are several social network platforms on the market with different purposes and target groups, scholars often choose the platform, their persona and tasks carried out carefully, for example, differentiating between private and professional use on Facebook and LinkedIn (Siegfried, Mazarakis & Peters, 2015). Since most social networking sites allow people to build groups or categorize users via tags or lists, efficient information exchange and dissemination is possible by channeling information to relevant users or filtering out what is of no interest.

5 *The available publication formats and their accessibility*. Blogs, status updates in social networks, wiki articles all serve different purposes of scholarly communication and can be used to publish pieces of information of different sizes, formats and styles. This may also include multimedia formats, for example, videos of a talk on YouTube that supports a written paper. Access to social media contents is typically not restricted through paywalls. But other restrictions may be imposed by the different access settings in social media that may make content only visible to certain groups of users.

6 *The ways to respond to academic publications across a variety of social media channels*. With different publication formats also come different ways to respond to publications. It is possible to respond to a journal article through commenting in tweets, blog posts or other status updates. Sometimes comments are also encouraged ahead of a formal publication as new forms of open peer review.[1] And of course it is also possible to use a tweet to comment on a blog post, to blog about a scholarly talk published on YouTube or to apply other cross-platform types of response (Hall et al., 2016). In this way, citations in social media environments are getting much more complex than in traditional publication formats (Mahrt, Weller & Peters, 2014).

7 *The ways to measure publication output and impact of scholarly work*. As new publication formats and new ways to cite them emerge, it should also be reassessed how scholarly output is being measured and evaluated. The term 'altmetrics' has been coined to refer to new indicators based (among others) on social media data (Priem et al., 2010).

ACADEMIC USES OF SOCIAL MEDIA PLATFORMS

As the *Time* magazine prominently put it in 2006, social media is about 'YOU'.[2] The fundamental property of social media is the ego and the content or activity the person generates on the web (Schmidt, 2009). Usually, a user profile is the entry ticket to the social media platform, allowing only registered users to approach other users and access the available content. Around these profiles the online identity of the person emerges, since the social media platforms track, record and display all user activities performed by the user himself or her contacts. These contacts can either be established via a mutual relationship (e.g., friends on Facebook) or a one-sided relation (e.g., followers on Twitter). Besides setting up a profile and generating original content, social media platforms always also allow for sharing, that is re-distributing or forwarding

(Puschmann & Peters, 2015) content produced by other users of the platform. Both generating and sharing content are characteristic for social media. And both also fit well into the context of scholarly communication, which is about sharing and consuming content as well as about establishing 'profiles' for individual researchers.

The following selection of prototypical social media platforms reflect these characteristics particularly well and therefore will be discussed against the background of their use in academia. The most popular social media platforms are not focusing on a specific target audience. Facebook, YouTube, blogs or Twitter are popular across many different demographic populations (although Facebook was initially created for university students). And of course some of their users are also academics. Many of them may have started using social networks like Facebook for private purposes – before more and more colleagues would connect with them and private and professional communication became increasingly inseparable. While some scholars may simply improvise how they use social media in their daily routines, others turn to specific guidelines for academic usage of social media, such as, for example, the one by Bik and Goldstein (2013). There even exist guidelines for specific platforms targeted at scholars from specific disciplines, like König's (2012) guidelines for historians. Some may try to keep professional communication and private communication separate – either by establishing different accounts within the same platform or by turning to different social media platforms for different purposes – and some may have given up on these efforts after a while.

The use of social media platforms is strongly task-driven. Hence, researchers can have profiles on different platforms and use them in a varying intensity (Pscheida et al., 2014; Siegfried, Mazarakis & Peters, 2015). Some initiatives aim at systematically allocating social media tools to the elements and activities of the research life-cycle, reflecting what platform is used for which task (e.g., 101Innovations.wordpress.com). However, truly distinct assignments are difficult to make, mainly due to the broad spectrum of functionalities the social media platforms offer. Literally, most of them successfully serve more than one purpose (Peters & Heise, 2014).

However, as social media platforms evolve over time and their user communities also constantly develop new practices, studies on the adoption of social media platforms in academia (such as the ones by Procter et al., 2010a and 2010b, or Pscheida et al., 2014) can always only capture a certain snapshot at one point of time – and are often also confined to specific subgroups of academics,for example in specific countries or specific disciplines. Among the existing studies, some contain evidence that uptake on social media usage in academia has been rather slow in many cases, while some disciplines appear as early adopters. For example, Procter et al. (2010b: 4044) observed that 'computer science researchers are more likely to be frequent users and those in medicine and veterinary sciences less likely'. Given the case study nature of many findings, generalizability of such research has to be discussed and backed up with more evidence.

Furthermore, determining the value of social media in scholarly communication by using data about active users, or by counting how many academics have user accounts on specific platforms, is problematic in itself. Besides the lack of reliable data in many cases (e.g., when there is no open application programming interface [API] available), it is also of interest who consumes content from social media sites, which in the case of reading blogs or Wikipedia can be done without registering and can be considered much more common than active contributions (Weller et al., 2010). As Allen et al. (2013) point out, social media in academic contexts are more about pushing information (tailored to users' interests) to the public, which distinguishes them from traditional literature databases

where users would usually pull information by active searching. Allen et al. (2013) also conclude that this is how social media increased dissemination of scholarly publications in the health and medical domains. Thus, given the assumingly large share of passive users or lurkers (Nielsen, 2006) on social media platforms, within this chapter we will look at practices rather than at usage statistics.

In particular, we are distinguishing the more text-based platforms that can be considered as pioneers in the earlier years of social media (mainly blogs and Wikipedia) from the later platforms that are more centered around network structures and can combine content-sharing of different media formats (e.g., multi-media formats in Facebook posts). Furthermore, we distinguish platforms that specialize on academic users from those addressing a general audience.

TEXT-BASED SOCIAL MEDIA PLATFORMS AS ADDITIONS TO SCHOLARLY PUBLICATIONS

Blogs have been among the earliest phenomena to be labelled as elements of 'Web 2.0' or the Social Web, and therefore are among the first social media that were believed to challenge traditional (scholarly) communication structures (Nardi et al., 2004). The idea was that blogs could open up new possibilities for sharing scholars' work independently from traditional publishers. Blog posts may look very similar to research articles, as both are text-based and may include figures, tables and references. Blogs offer a platform to write about research, and to reach out to academic and non-academic audiences alike, to cross-reference through the use of hyperlinks, and to receive immediate feedback from the community (Shema, Bar-Ilan & Thelwall, 2015).

Blogs rather seem to complement traditional publications than to aim at replacing them. Being free from constraints in traditional formats, blogs have been used and interpreted in different ways by the academic community. Mewburn and Thomson (2013) suggest that academic bloggers rather write about academic work conditions than about their own research findings, and that they like to give advice or share useful information with their audience. They also report on their workflows in everyday lab-life or latest readings, and use their blogs to informally develop and test ideas (Maitzen, 2012). Halavais (2006) uses several images to illustrate academic uses of blogs: the 'notebook' (a place for work in progress), the 'coffee house' (a place for discussing with [often like-minded] academics), and the 'opinions page' or 'editorial page' (for more general forms of public communication). Walker (2006) distinguishes blog types into 'public intellectuals', 'research logs' and 'pseudonymous blogs about academic life' (and blogs that combine these different genres). Quite interesting is the phenomenon of anonymous/pseudonymous blogging to talk about everyday academic life and the frustrations it may bring.

Overall, it remains hard to define what precisely constitutes an academic blog, or research blogging. In addition, the term 'science blogging' is often used to describe blogs covering scientific topics in general, independent of whether their authors are tenured professors, grad students, high school teachers, interested laymen, or journalists (Mahrt & Puschmann, 2014). Colson (2011) points out that there is a strong interrelation between blogging researchers and science journalists who interact through blogs. Her study also shows that academics may turn to blogging in order to bypass traditional journalism in broadcasting research findings to a broader public, while journalists consider blogs by researchers as useful and trustworthy sources (Colson, 2011). Of course, blogging, as with many other online activities, is not only hard to categorize, it is also evolving over time (Karpf, 2012). Walker (2006) reports how her personal blogging practice

changed – from her first experience as a blogging grad student to being a tenured faculty member – and how blogging in general became more popular.

In some cases, blogs may be used to publish novel research results. Compared to journal articles (where the publication process may take years), blogs have the advantage of a much faster publication process – in fact, they are often instantly available. There are still more indications that blogging is not used for the same purposes as traditional publications. Buschman and Michalek (2013) explain that researchers use blogs to share background information about their work, which may also include approaches that led to negative results. Negative research results are important for the advancement of science, but have recently been less frequently published in traditional publications (Fanelli, 2012). Although new journals have been founded which particularly focus on negative results (e.g., *Journal of Negative Results in Biomedicine*, http://jnrbm.com), they are not universally available for all disciplines. It is therefore positive when blogs help to fill the gap and provide information of this kind. Blogging is also used in addition to traditional papers, for example, to attract more attention to them. Several researchers reported on positive effects of having blogged about their research. Terras (2012) experienced an increased download rate of papers discussed in her blog in comparison with papers that were only published traditionally. Hoang et al. (2015) found that blog articles receive up to 14 times more page views than journal articles on the same topic. Therefore, they conclude that 'dissemination of scientific material on a radiology blog promoted on social media can substantially augment the reach of more traditional publication venues [and] … researchers in radiology should not ignore opportunities for increasing the impact of research findings via social media' (Hoang et al., 2015: 760).

It remains an ongoing question to what extent references in Wikipedia might also help to increase the impact and visibility of research publications. Similar to blogs, wikis in general and Wikipedia in particular can be considered as early examples of social media. Wikipedia as a collaboratively created online encyclopedia reflects a form of public understanding of science. It has thus found its very own place within the ecosystem of scholarly communication: Wikipedia articles quote scholarly work and therefore become part of the scholarly communication life-cycle. On the other hand, many academics would not consider Wikipedia as a reliable source that can be quoted. Nielsen (2007) uses the number of Wikipedia references to peer-reviewed articles as a proof for the quality of Wikipedia content. Luyt and Tan (2010) have analyzed the credibility of Wikipedia articles and found numerous statements of Wikipedia articles on history topics lacking any form of valid reference. They still conclude that Wikipedia is valuable, as it offers a gateway to academic knowledge that is otherwise often hidden behind paywalls that prevent access to scholarly publications for a general public and even for many researchers. It is, however, unclear whether Wikipedia articles really help to transfer knowledge from behind academic publishers' paywalls to a broader community. For example, Teplitskyi, Lu and Duede (2015) arrive at the conclusion that there is an effect of open access literature being overrepresented on Wikipedia.

NETWORKING AND CONTENT-SHARING PLATFORMS FOR GENERAL AUDIENCES THAT ARE USED BY ACADEMICS

Blogs and Wikipedia focus primarily on longer texts as their dominant form of content. User profile pages and connections between users are of minor relevance. During the evolution of the social media landscape, networking elements have gained importance and by now there is a vibrant landscape of

various social networking platforms that are utilized by researchers in specific ways. Facebook can be considered the biggest social networking platform worldwide (Statista, 2016), although in some countries different social networks have grown popular instead, such as Vkontakte in Russia or renren, Weibo or WeChat in China. Other social networking platforms, such as Google+ (Henderson, 2012), may include similar features as Facebook, but are less popular in general. LinkedIn is popular among academics in different countries, but has a slightly different set of features as it is mainly targeted as professional usage. Given that in June 2016 Microsoft announced that it had acquired LinkedIn, it remains to be seen how usage numbers and functionalities will develop or merge with existing services.

The high number of users is Facebook's biggest advantage – as with typical network goods, the number of users determines its value for the individual user (Katz & Shapiro, 1985). Thus, Facebook establishes a common ground for connecting with others with little effort. Facebook is highly popular with researchers of different disciplines (Van Noorden, 2014), but little is known about whether researchers are more likely to have a Facebook account than other groups, whether they connect with more people via Facebook, or have more international connections. The facts that researchers tend to travel a lot, often work in international environments, or even move on to different places of residence over the years, suggest that they could particularly benefit from platforms that support connections internationally. It has, however, been shown that use of Facebook often takes place in private settings (Pscheida et al., 2014; Van Noorden, 2014), reflecting that researchers perceive the *audiences* and *affordances* (Norman, 1988) they find on the platform in a specific, yet too narrow, way, preventing them from using it professionally.

In fact, Facebook offers several useful features for academics (Nentwich & König, 2014): it allows group communication and one-to-one communication and supports synchronous as well as asynchronous communication channels. Facebook enables different profile pages for academic institutions (universities, scholarly associations, etc.) and for individuals, offering different functionalities for interaction with followers (of pages) and friends (of users). Posts on Facebook are of flexible length and can contain multimedia features. Another asset is the diversity of user groups with whom researchers can get in touch and with whom they can communicate their work. On the other hand, all this comes at a cost: Facebook is frequently criticized for intransparent privacy settings (e.g., Liu et al., 2011). Furthermore, Facebook's features and options for individual settings are constantly changing, which may require that users constantly spend time and effort on keeping up to date. Another potential drawback can be the fact that students also largely use Facebook, which may challenge traditional authoritative structures. Goodband et al. (2012) report a case of a student group that got in conflict with the broader mathematics community.

Another platform that combines social networking features with personal status updates is Twitter. Several guidelines for scholarly uses of social media have portrayed microblogging with Twitter as useful for diverse academic purposes and contexts (Herwig et al., 2009; Mollett, Moran & Dunleavy, 2011). There are also several studies that investigate the use of Twitter in scholarly communication (an overview can be found in Mahrt, Weller & Peters, 2014), though often focusing on specific case studies. However, surveys with researchers have indicated a rather low uptake of Twitter among academics (e.g., Gu & Widén-Wulff, 2011; Harley et al., 2010; Ponte & Simon; 2011), while there appear to be some disciplinary differences.

Twitter's strength is in specific usage scenarios, such as in being used during academic conferences as a tool for live reporting and

interconnecting (e.g., Letierce et al., 2010; Ross et al., 2011; Weller, Dröge & Puschman, 2011). In this specific context and connected to a conference-specific hashtag, Twitter facilitates exchange not only among existing networks of scholars, but also around shared interests. It enables new contacts in an informal and low-threshold manner. This is supported by the fact that Twitter does not require relationships between users to be reciprocal. Another typical use of Twitter is the sharing of URLs that point to interesting Web content or scholarly publications (Eysenbach, 2011; Priem & Costello, 2010). It thus plays a major role in the study of alternative metrics for measuring scholarly impact, as we will see below.

Other platforms that target a general audience but are also used by academics for professional purposes include, among others, SlideShare, YouTube or GitHub. These three platforms are mainly selected to illustrate the broader spectrum of academic content that is being shared online, including videos, slideshows and programming code. They are, however, not the only examples of tools used for these purposes. On SlideShare researchers may share presentation slides used during conference talks. In principle, it can also be an outlet for teaching material, although a survey by Herath and Hewagamage (2015) indicates that SlideShare is only rarely used for teaching purposes. In general, rather little is known about the academic use of SlideShare or other platforms that enable the sharing of presentation slides. Some more insights are available on the scholarly use of YouTube, which also features videos taken at academic conferences and online lectures. Furthermore, YouTube videos are being cited both in traditional scholarly publications (Kousha, Thelwall & Abdoli, 2012) and in academic tweets (Thelwall et al., 2012). GitHub can be described as an open software repository, where users may share their scripts and code with an interested audience. As such, it is being studied as an example of social coding (Dabbish et al., 2012; Marlow, Dabbish & Herbsleb, 2013), where one may get insights not only into sharing behavior, but also into collaboration in creating new code.

Researchers can also be found communicating in various online forums. Another case of particular interest is reddit. This platform includes several sections (subreddits) that are dedicated to current scientific findings and recent scholarly publications as well as academic life and career choices (e.g., www.reddit.com/r/academia or www.reddit.com/r/Professors/). There are even subreddits that call out cases of misinterpretations of scientific findings (e.g., www.reddit.com/r/badscience). With all this, reddit combines features of blogs and bookmarking systems with a broader networked community and thus has a significant potential for advancing scholarly communication. However, not much insight is available on the actual role reddit is currently playing in academia.

SPECIFIC SOCIAL MEDIA PLATFORMS FOR ACADEMIC AUDIENCES

In addition to the popular general platforms, some social media platforms are specifically addressing academics as their target audience. Few of them even focus on specific disciplines, for example, http://hypotheses.org, a blog aggregator for the humanities and the social sciences. But more popular are those that address the academic community as a whole, like Academia.edu, Mendeley and ResearchGate.

All of the latter include some principles of social bookmarking. The idea of social bookmarking platforms (Henning & Reichelt, 2008) is relatively simple yet powerful: they enable their users to create bookmarks for web contents which they want to retrieve later. Often they include functionalities of social tagging so that users assign content-descriptive keywords ('tags') to their bookmarks for adding structure and enhancing

retrieval options (Peters, 2009). Social bookmarking platforms started as tools for generally saving all sorts of links on the Web, for example, through platforms like CiteULike or Delicious. They were soon also taken up by users who wanted to share and keep track of scholarly literature on the Web, which lead to specialized bookmarking systems for this type of resources and turned platforms into social reference managers. Platforms like Bibsonomy (Zoller et al., 2016) or Zotero include functionalities such as, for example, directly importing bibliographic metadata via identifiers (e.g., DOI or ISBN numbers).

Moreover, Academia.edu, ResearchGate and Mendeley have used functionalities of social networking platforms and combined them with bookmarking principles in order to attract an academic user community. Users can set up profile pages with information on their affiliations and other biographical details as well as research interests and expertise. They may then also connect with other researchers (e.g., also by browsing for topics or affiliations), and follow their updates. In this way, one may, for example, be informed about new publications from specific researchers. Publication lists are becoming part of the user profiles too. And usually, researchers are enabled to also upload manuscripts directly. This leads to another core feature of these platforms: they may count in-platform citations of publications as well as numbers of article views, downloads and of course bookmarks. They also use these counts to promote platform services through addressing the academics' vanity fair, that is the tendency of academics to constantly compare themselves and their works against those of their peers - which is increasingly criticized (Murray, 2014).

There are more critical voices, especially concerning the increasingly commercial nature of these platforms. Academia.edu is criticized for using the .edu domain without being an educational institution. And since Mendeley was bought by Elsevier in 2013, this has also raised many concerns for future developments and led to calls for boycotting the reference management system (although almost no effect can be seen in the user numbers[3]). Others criticize these platforms for their lack of transparency and for locking in user data. For example, ResearchGate's underlying metrics are intransparent and influenced by spam (Kraker & Lex, 2015). Single approaches exist for making the underlying user data transparent and open. Mendeley, for example, offers an open application programming interface (API) that allows users to download their contribution, whereas ResearchGate and Academia.edu do not offer this option. To overcome this problematic situation, William Gunn from Mendeley, in a comment to Matthews (2016), advises us to 'embrace the idea of a [sic.] ecosystem of applications, each interoperating with the other to provide a flexible range of functions that fit the diverse needs of various scholarly fields rather than one monolithic site which aims to be all for everyone'. It should be noted, however, that similar practices and methods to ensure exclusivity have been known in scholarly communication for years – most prominently those fought about in the 'Elsevier boycott'[4] – and they are not immanent challenges of social media use.

Despite some limitations in accessibility, the overall existence of different usage statistics also makes these platforms interesting in the exploration of novel metrics to measure scholarly impact – as we will also discuss below. Indeed, from research in this field we learn that these academic bookmarking/networking platforms have achieved notable coverage of scholarly literature. In selected samples from different scholarly domains, Mendeley includes more than 80% (and up to 97%) of published research papers (Haustein et al., 2013: Haustein, Larivière et al., 2014; Li, Thelwall & Giustini, 2012; Priem et al., 2012). Although coverage of publications appears broad on social media platforms, there may be specific omissions and biases (especially regarding the disciplines and types of articles covered). Given

that articles shared on social networking platforms like ResearchGate are subject to the platforms' terms and services, those publishing approaches can also not be compared to institutional repositories and true open access initiatives for several reasons, such as that they do not support long-term availability of the data or allow for text mining.

Also, some researchers explicitly avoid using these platforms for these reasons or consider profiles only as a 'me too-presence' (Nentwich & König, 2014: 113) to signal readiness to network. This leads to the next question on the validity of usage data. Do registered researchers actively use the platforms at all? Little is still known about who is active. In terms of number of profiles, 'ResearchGate is more than twice as popular as Academia.edu. Usage of ResearchGate particularly outweighs that of Academia.edu in China and Japan, in the sciences and among the most senior researchers. Overall, 61 per cent of respondents who have published at least one paper use ResearchGate, while 28 per cent use Academia.edu, and just 0.2 per cent apparently use Mendeley' (Matthews, 2016). Studies like these are just the first step towards understanding how social media influence the perceived impact and relevance of a researcher or their individual digital identity. Much more work is needed to fully assess the impact of social media on scholarly communication and researchers' careers.

CHALLENGES AND DRAWBACKS OF USING SOCIAL MEDIA IN ACADEMIA

We have now seen that social media platforms offer a variety of opportunities for researchers to connect and engage and that, overall, their functionalities well meet the goals of scholarly communication. However, to complete the picture of scholarly communication with social media we must also consider the drawbacks and challenges that every tool entails. First, the appearance of social media platforms in academic environments may lead to new tasks and efforts that may challenge researchers personally. The increased availability and amount of products of scholarly communication can lead to an information overload that leaves the consumers of research results with all the effort of searching and compiling information. Moreover, since in social media environments traditional indicators and institutions commonly guaranteeing a certain quality standard of the research product may not work any more, the entire process of quality assurance (e.g., peer review) and relevance assessment is loaded on to the consumer side. Here, education and tools need to be developed to assist researchers and other stakeholders in wading through the flood of information. On the other side, it might be problematic and time-consuming for researchers to engage in social media-based scholarly communication in order to maintain their profiles on social networking sites and keep every representation of their digital image up to date. Some researchers may decide just to focus on single platforms and will not register on other platforms. On the other hand, this means that one single platform will rarely be able to provide a complete picture of researchers in one field.

Second, there are other reasons why researchers may decide to not use specific platforms. It should not be underestimated that most of the social media platforms used for scholarly communication are, although free for use, private companies still searching for business models and revenue. This means that content put on their platforms is subject to the company's terms and services – sometimes allowing the company forms of manipulation, re-use, and ownership. Moreover, since the platform providers usually control appearance, functionalities and algorithms of their services, they also massively influence how (as well as if and what) scholarly content is presented and consumed. Matthews (2016) reports that researchers fear 'tunnel vision' if only popular and mainstream articles are

displayed and only a narrow view of the landscape of scholarly publications is provided. Although social media-based platforms are able to increase accessibility to scientific content, openness is interpreted differently by the providers.

Finally, social media use may be approached differently by different researchers. Some may be more successful in drawing attention to their own activities. This can lead to a 'rich gets richer' phenomenon, where those who already have succeeded in gaining attention for their social media profiles will continue to do so, while others will struggle to ever reach a similar level. Also, researchers with a higher academic age and/or longer lists of publications may have an advantage over beginners, since it is easier to find them or their contributions on the social media platforms. This has been confirmed by earlier research: senior scholars appear to attract more page views on Academia.edu (Thelwall & Kousha, 2014), and have a higher perceived impact (Li & Gillet, 2013). As mentioned before, this effect is amplified by the algorithms underlying the social media platforms that often provide more visibility for researchers and contributions that have already gained a lot of attention in the past.

Considering this, it is most crucial that we improve our understanding of attention economics in scholarly social media use. A first step towards this can be achieved by critically investigating social media usage related to academia. Currently, such efforts can mainly be found as parts of a broader community that aims at developing novel indicators for measuring scholarly communication through novel data (not only) from social media.

ASSESSING SCHOLARLY COMMUNICATION WITH SOCIAL MEDIA METRICS

We have seen how different social media platforms can be used in academia and that social media complement platforms of scholarly communication since they offer authors even more possibilities to present themselves, publish content, exchange arguments and to set up an online academic identity. As such, they enable researchers to leave new types of footprints that can be exploited in scholarly communication, for example, user profiles, posts, tweets. The next question is whether there are ways to measure how the platforms are actually affecting scholarly communication. Defining what counts as acts of scholarly communication in platforms such as Twitter, Facebook or Wikipedia is not always trivial. In social media environments scholarly conversation and exchange of arguments evolve around profiles, footprints, and shadows of all contributors to the research life-cycle. In the following, we will consider scholarly communication in social media as reflected through three dimensions: (1) the dimension of actively leaving footprints in social media; (2) the dimension of passively casting shadows which are reflected through the activities of others; and (3) the dimension of creating a digital identity that is composed of the previous two dimensions.

Footprints, Shadows and Digital identities

Every researcher leaves their footprints through numerous activities. In traditional scholarly communication, the act of leaving footprints is relatively clear to define – and typically happens very consciously: a researcher actively publishes a paper or a book, gives a talk at a conference, provides a list of references with a publication, edits a collection, etc. All these acts can be traced back to the researcher and thus shape his or her identity as an actor in the respective scholarly community. A more complicated case is participation in blind review processes, where actions of one researcher – writing a review – leave footprints, but cannot normally be traced back to the person

directly. However, reviewing also shapes the presented identity of a researcher if membership on reviewer boards or program committees is included in the CV. All of these footprints can be counted – and most of them are increasingly being counted in order to measure scholarly activity (e.g., to justify spending of tax money for research, etc.).

Researchers also cast their shadows, an act that is more passive because it cannot be influenced – shadows emerge where others react to one's own activities. In traditional scholarly publication, this usually happens through citations. If my own work is being cited in another scholar's paper, a shadow of my work has been created. There are thus two sides on how to view a single researcher within the system of scholarly communication: based on the profile he/she has created himself/herself or based on how others see her/him reflected through citations and other types of shadows (which can, for example, be book reviews or mass media articles referring to scholarly work). Again, most of this can be and is being counted. In terms of citations, counting is to some degree automated on platforms like Google Scholar, Scopus or Web of Science; in other cases, researchers may have an interest to count themselves how often they are mentioned in reviews or mass media. This is because the respective numbers are also increasingly being viewed as a part of an academic identity; they are believed to illustrate how influential a researcher is. Of course, focusing on aggregated counts as indicators of activity and influence, and therefore as true reflections of an academic identity, can be criticized, especially if numbers are viewed out of context (e.g., disciplinary context) (see the Leiden Manifesto: Hicks et al., 2015).

In the digital world, new types of footprints and shadows emerge, not all of them happening equally consciously and not all of them in a countable format (yet). A researcher who actively publishes a blog post, posts a comment on Facebook, or publishes a tweet is leaving a footprint. A researcher who downloads the pdf file of an article, likes a Facebook post, retweets a tweet, or links to a blog post is also leaving footprints in social media. Shadows of researchers' activities can consequently appear in the form of received likes, retweets, pingbacks, or mentions on Wikipedia, as well as in download statistics, Mendeley readership and other forms of reactions to traditional publications that are represented in social media platforms. Again, footprints and shadows contribute to the perceived identity of a scholar. The digital identity of a researcher with all the facets is based on footprints and shadows that are visible online – and only on those that are visible online, that is presentations or publications and activities that are not tracked and publicly published online do not shape the *digital* identity of a researcher.

All this leads to new important questions: As researchers' identities do no longer build on footprints and shadows of purely traditional forms of scholarly communication, do we need new ways to measure and quantify digital forms of footprints and shadows? And to which degree are both dimensions, digital and traditional, similar or different in what they represent?

Metrics to quantify scholarly communication have long been subject to critiques. Researchers concerned with scholarly metrics have acknowledged several drawbacks and limitations, among others, that citations need time to accumulate, that they do not reflect the motivation of the citation, that they only reflect impact on other *authors* instead of all *readers* of the publication, and that citation behavior varies between disciplines (MacRoberts & MacRoberts, 1989; see also Haustein & Larivière, 2014). Consequently, with scholarly communication reaching the Internet, approaches for also measuring these activities were explored. Early approaches have been labeled 'webometrics' (Thelwall, 2008) in reference to the earlier terms 'bibliometrics' and 'scientometrics'. Webometric approaches for calculating metrics are mainly based on Web links or download numbers.

In 2010, the term 'altmetrics' was introduced when Jason Priem, Dario Taraborelli,

Paul Groth and Cameron Neylon (2010) published their Altmetrics Manifesto (Priem et al., 2010), after Priem first suggested the name altmetrics in a tweet. The authors of the manifesto report different motivations for their call for new metrics: they describe altmetrics as a possible tool to guide researchers through the huge amount of potentially relevant information on the Web (acknowledging that 'no one can read everything', Priem et al. [2010], highlight the role of social media as pointers to interesting literature), and envision that evaluation of researchers may in the future also consider output and influence in social media environments. Altmetrics are still not or only very rarely used officially in evaluation processes such as funding or hiring decisions, but some in the altmetrics community have been advocating for this idea (Galligan & Dyas-Correia 2013; Lapinski, Piwowar & Priem, 2013; Piwowar, 2013b).[5] Not all researchers, believe that social media activities will be considered in evaluative contexts in the future (Procter et al., 2010a), and there is no knowledge about how many would want social media to be included in evaluation processes. Even more crucial may be the fact that it is hardly known what types of activities and influence of scholarly communication would actually be measured through data from social media and altmetrics based upon them – a problem that is also inspiring different broader initiatives to better understand altmetrics. One of the most notable developments in this field is the NISO Alternative Assessment Metrics (Altmetrics) Initiative[6] by the National Information Standards Organization (NISO).

WHAT DO SOCIAL MEDIA METRICS MEASURE – AND HOW?

Since the publication of the Altmetrics Manifesto (Priem et al., 2010), and even before this, quite a significant number of studies have focused on measuring different scholarly footprints and shadows through social media data with the aim to better understand why and how researchers make use of different social media platforms. Overall, it is assumed that altmetrics will measure different phenomena than traditional metrics for scholarly communication. Social media are expected to respond to scholarly publications much quicker than traditional citations, which means that 'many online tools and environments surface evidence of impact relatively early in the research cycle, exposing essential but traditionally invisible precursors like reading, bookmarking, saving, annotating, discussing, and recommending articles' (Haustein et al., 2013: 2). Consequently, social media metrics can be obtained quicker than traditional citations; they are 'available immediately after publication – and even before publication in the case of preprints – and offer a more rapid assessment of impact' (Thelwall et al., 2013). Piwowar (2013a: 9) sees four advantages of altmetrics/social media metrics in that they: (1) provide 'a more nuanced understanding of impact', (2) provide 'more timely data', (3) include the consideration of alternative and 'web-native scholarly products like datasets, software, blog posts, videos and more', and (4) serve as 'indications of impacts on diverse audiences'. While Piwowar (2013a) speaks of nuances for measuring impact, this also poses additional challenges, as long as little is known about the different nuances and their meanings. Similarly, Lapinski Piwowar and Priem (2013: 292–293) discuss different 'impact flavors' as 'a product featured in mainstream media stories, blogged about, and downloaded by the public, for instance, has a very different flavor of impact than one heavily saved and discussed by scholars' (Lapinski et al., 2013: 292–293). But what is the 'flavor' of a retweet, a blog post, or a Wikipedia reference? What are the motivations behind these different social media activities? To what degree do they represent a commitment comparable to a citation in a published article? A lot of the

current research in altmetrics attempts to assess the quality and scope of altmetrics indicators, with case studies comparing metrics across platforms (either alternative or traditional) or across specific disciplines.

Answering questions on how social media metrics relate to traditional forms of scholarly communication, altmetrics research faces the same challenges as all social media studies: with these media evolving quickly and users changing their practices at the same time, one is studying a moving target (Karpf, 2012). Altmetrics studies also face similar technical challenges as social media research in general: data have to be obtained from social media platforms, for example, via the application programming interface (API), which is often restricted by the companies behind the platforms (Gaffney & Puschmann, 2014). Also, many third-party tools that allow for data collection from social media act as black boxes: it is hard to understand how data have been collected and prepared and to assess whether a tool is reliable and the data are complete or representative (Haustein, Peters et al., 2014). Stakeholders involved in altmetrics (Weller, 2015) have assembled some specialized tools, sometimes based on the involvement of big publishers such as Elsevier (who bought Mendeley in 2013). Liu and Adie (2013b: 153) have summed up the current state of the art as follows: 'All of the tools are in their early stages of growth. Altmetrics measures are not standardized and have not been systematically validated; there has been no clear consensus on which data sources are most important to measure; and technical limitations currently prevent the tracking of certain sources, such as multimedia files'.

So, currently, different approaches to measure scholarly communication are being explored, different indicators are being combined and different tools are being developed. At the same time, research in altmetrics is conducted to better understand the relations between user behavior, tools and new indicators. Before we take a look at some examples of this kind of research, it may be useful to take a step back and – on a meta-perspective – distinguish different levels of assessing user activities in social media through altmetrics. In particular, we can distinguish the following approaches (modified from Weller, 2015):

- *Article-level metrics.* This summarizes approaches to measure the impact of traditional scholarly articles through the shadows they cast in social media platforms, especially by aggregating all types of citation for a specific publication (such as, for example, traditional citations plus mentions on Twitter).
- *Metrics based on alternative forms of interactions.* Some shadows resemble traditional citations less, but reflect other forms of engaging with a publication (e.g., readership statistics, likes or bookmarks). Again, these can be aggregated with other metrics on the article-level.
- *Metrics for new output formats.* A next step is not only to measure the impact of traditional publications, but to consider all kinds of footprints, including a researcher's output in social media platforms, such as blog posts or academic YouTube videos, or software commits (e.g., Github and Depsy [see http://depsy.org]).
- *Aggregated metrics for researchers.* If all kinds of footprints and shadows are combined for one researcher, the aggregated metrics can also be used to inform us about their digital identity.

For the key question of whether social media mentions predict subsequent traditional citation rates (or whether they at least correlate to some degree with traditional citation metrics), the most comprehensive study has been conducted by Thelwall et al. (2013), who looked at eleven different social media resources. They concluded that the metrics collected from different sources were not able to predict subsequent citations. We thus have to assume that social media metrics represent different phenomena of scholarly communication than traditional metrics, although in this mostly case-based area of research, slightly varying values may be found for some platforms or for specific disciplines. For example, for Mendeley, several

studies found a moderate to significant correlation of readership and counts of traditional citation (Haustein et al., 2013; Li et al., 2012; Priem et al., 2012; Zahedi et al., 2014).

In another example, Zahedi et al. (2014) compared article-level altmetrics aggregated for journals across disciplines and showed how journals from different disciplines are represented to a very different extent on Mendeley, Wikipedia, Twitter, and Delicious. Holmberg and Thelwall (2014) compare Twitter usage across 10 different scholarly disciplines. And, as mentioned above, social media have to be considered as a moving target – the field of social media metrics is still developing, as Haustein, Peters et al. (2014) demonstrated: in 2012 around 20% of biomedical papers were mentioned in at least one tweet on Twitter, twice as many as in 2011.

On the other hand, research indicates that social media activities do have a potential to really influence scholarly communication. For example, tweeting about a scholarly paper increases its download statistics (Shuai, Pepe & Bollen, 2012) – which could mean that social media are rather linked to readership than to citations and that researchers do indeed use their peers' social media activities as recommendations for useful literature. One needs to be careful with very popular content on social media, though. Haustein, Peters et al. (2014) show that papers with unusually funny titles are much more popular on Twitter (e.g., 'Penile fracture seems more likely during sex under stressful situations').

This case is a reminder that altmetics research has not yet fully revealed what social media metrics are measuring exactly – scholarly impact or other forms of interestingness, popularity, or buzz. Another crucial step in order to shed light on this situation will be to get a more complete picture of who is using different social media platforms: Who is using Twitter, Facebook, YouTube, Mendeley and co.? Are users of different academic disciplines represented equally across platforms? What are the user demographics and how do they develop? How well are we able to capture data from different platforms with the tools we have? How can we compare conceptually different units of user interaction, for example, retweets versus likes?

CONCLUSION

In the last decade, new formats and means of publishing, communication and exchange have evolved. These tools and publications, driven by developments in the social media market in particular, have brought a plethora of options that have fundamentally changed the way researchers engage in scholarly discourse and that have proposed, among others, the following benefits for scholarly communication:

- They offer new venues for all elements of scholarly communication.
- They provide more timely and direct conversations and feedback.
- They enable faster and more efficient access and exchange of scholarly information.
- They increase availability of scholarly information.
- They increase visibility of researchers and their scientific contribution.
- This results in a positive feedback loop of visibility and reputation of research products and researchers.
- They enable quick feedback on the relevance of scholarly products via altmetrics.

Social media-based scholarly communication has resulted in diverse products concerned with research outcomes (e.g., blogs or tweets) which in specific cases are much better publication formats for research findings (e.g., videos of scientific experiments). It has also enabled showcasing as well as the acknowledgement of all types of research output (e.g., data papers on GitHub). Moreover, this development has offered a multitude of alternatives for reacting to those publications (e.g., via likes or retweets, which then also become elements of the

scholarly discourse). Social media now offer researchers endless possibilities to express themselves and to develop scholarly identities that are truly digital. Research showed that scholars make conscious decisions when choosing social media for scholarly communication, that they differentiate between tools that address a general public (e.g., Facebook) or peers (e.g., Academia.edu), and that they are well aware of what platforms serve which purposes and what footprints they leave.

Tracing shadows that other scholars create in traditional, web and social media environments may not have moved into the center of most researchers' attention so far. But it will gain importance given that forms of reaction to scholarly content and engagement with publics on the Social Web have been proposed as complementary ways of measuring impact of research (Priem et al., 2010). Besides traditional forms of publication and scholarly communication, which surely will keep their space in the ecosystem of publishing and referencing because of their long-earned reputation, social media-based products have gained in popularity and are seen as one of the driving forces behind Science 2.0 and Open Science (European Commission, 2016). It is believed that access to research results and other outcomes of the research life-cycle, as provided by social media platforms and other tools (preferably in an as open as possible way), is of immense benefit for science as a whole and will accelerate innovation and progress (European Commission, 2016).

Social media have put new players in the field of scholarly communication, consequently making it more difficult for traditional providers of scholarly content to get their shares of the market, but also making the publication landscape more complicated and opaque for researchers and consumers of scholarly content. Given the success of social media-based communication practices and their still-increasing uptake among researchers, the scholarly community as well as society have to fundamentally rethink how science is performed, presented and assessed. In the end, the community has to decide on which publishing modes are valued the most and should persist, and which processes should be revised.

Notes

1 For example during this workshop: http://ascw.know-center.tugraz.at
2 Time Magazine Person of the Year 2006: https://en.wikipedia.org/wiki/You_(Time_Person_of_the_Year)
3 http://tech.eu/features/762/mendeley-elsevier
4 http://thecostofknowledge.com/
5 One example for the use of altmetrics in evaluation can be found here: http://guides.mclibrary.duke.edu/c.php?g=217135&p=1434259
6 NISO Alternative Assessment Metrics (Altmetrics) Initiative: www.niso.org/topics/tl/altmetrics_initiative/

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