Abstract
The Internet and social media tools have created new opportunities for open science including communicating in more interactive ways and sharing research data. Drawing on evidence from interviews and a survey of academics in the United Kingdom our research suggests that most scholars recognised the value and importance of more open science communication and data sharing, but many had concerns about the potential risks. A small group, who can be termed super users, were frequently communicating updates of their ongoing research. It is clear that there are increasing opportunities for more open science and public engagement but challenges remain.

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Introduction

‘Most of my colleagues make me laugh because they are so clueless ... they think their work is over when they hand the final proofs to the publisher.’ (Male, Professor, Anthropology)

In the so-called age of data, tensions persist in terms of who has access to academic research and data. Open science is founded on the belief that "scientific knowledge of all kinds should be openly shared as early as is practical in the discovery process" (Nielsen, 2011). The idea of open science can be traced to the early seventeenth century when science was predominantly a more secretive process (David, 2008).

Underlying the push towards more open science is a sense of public duty to inform, share and understand (Levin, et al., 2016). The debates about science communication link directly to discussions about the democratisation of knowledge and challenges posed by competing truth claims. Science communication and open science can bring into question the very ideas of the expert and expertise (Bauman, 1987; Benkler and Nissenbaum, 2006; Giddens, 1991; Habermas, 1996).

The so-called deficit model describes how science communication has often been a one-way process focused on educating the public rather than a more dialogue-based engagement (Davies, 2008; Irwin and Wynne, 1996; Gregory and Miller, 1998; Miller, 2001; Priest, 2001; Sturgis and Allum, 2004; Royal Society, 2012a). There are increasing opportunities for communicating science and public engagement in the research process, which in turn could be the basis for tackling challenging problems.

Traditionally the establishment of knowledge and scientific communication has been through peer-reviewed scholarly journals (Lynch, 2009). While such a process has been important in ensuring scientific robustness, subscription-based publishing models and peer-review processes can take considerable time and hinder the dissemination of research to wider audiences (Björk and Solomon, 2013; Chan, et al., 2011). Concerns have been raised about biases in the peer-review and publishing processes (Nature, 2006; Open Science Collaboration, 2015).

Social media tools allow cost-free open access to research in advance of the formal publication of research in traditional, scholarly journals (Manca and Ranieri, 2017). Blogs and social networking sites can include academic blogs and those hosted by a faculty or a research community (Graham and Dutton, 2014; Tatum and Jankowski, 2010) [1]. In the case of Open Notebook Science (for example,
http://onsnetwork.org, scientist bloggers record day-to-day laboratory work (Research Information Network, 2010). This involves scholarly communication at different stages where scientists invite feedback and participation. Some academic bloggers have reported advantages including networking with peers and potential collaborators, keeping up-to-date with new discoveries within a given field (Kjellberg, 2010). Scholarly publishers are also using blogs to promote papers published in certain journals (Stewart, et al., 2012). Open peer review initiatives have been tested, where a broader audience has been involved in the assessment of manuscripts (Acord and Harley, 2013).

Specialized social networking sites, such as Academia.edu (https://www.academia.edu) and ResearchGate (https://www.researchgate.net), have grown rapidly. Academics share their work on these sites and track publications of other scholars in their disciplines (Thelwall and Kousha, 2014a, 2014b). Some of these online archives provide real-time metrics of access, providing scholars with data on the utility of their own work. While criticism has been levelled at some of these archives for exploiting data (Hall, 2015), their growth suggests a willingness to share their research freely. Nevertheless, some forms of scholarly communication, such as data sharing and open access publishing, present present challenges.

We consider the following key research questions in this paper: (i) To what extent do academics support more open science, including sharing research findings and data? (ii) How are scholars using social media to highlight their research work and what concerns do they have? (iii) What are the key factors related to the frequent use of social media to communicate research? (iv) What barriers exist to more open science?

Context: Understanding open science, research communication and public engagement

The Internet and associated tools for communication offer new opportunities for scientists to engage the public (Veletsianos, 2016). Researchers can inform and engage others in the problem-solving processes of constructing knowledge (Tacke, 2010). These developments link with wider efforts to increase public understanding of science as well as encourage a more open government (Levin, et al., 2016; Royal Society, 2012b; Watermeyer, 2012; Wind-Cowie and Lekhi, 2012) [2].

There is some debate over a definition of open science. It broadly includes open access to scientific publications, research data, metadata, methods, code, software and findings. Open access (OA) publishing can involve different forms of access but it occur in a timely fashion and include readily available full text of a given paper (Berlin declaration, 2003; Budapest Open Access Initiative, 2002). Open science can include participatory and co-produced research, dynamic communication processes and engagement with ongoing research, also known as Science 2.0 (European Commission, 2014; Grand, et al., 2010; Levin, et al., 2016; Nielsén, 2012; Suber, 2007; Wilbanks, 2006). In co-produced research the public is involved in problem-solving processes and contributes in a variety of ways (Fine and Torre, 2004). Haklay (2013) described extreme citizen science, a ground-up research practice that takes into account local needs and works with broad networks of individuals in knowledge creation. This research in some cases leads to forms of citizen mobilisation (Groulx, et al., 2017; Purdam, 2014).

Scheliga and Friesike (2014) point out that there are a variety of obstacles to more open science practices and communication. Key issues include quality assurance and the role of peer review; protection of intellectual property rights (IPR), including copyright and the commercialisation of research; costs of open access; and parameters encouraging the development of careers of researchers (Peters, 2010; Veletsianos, 2016). There are some open access journals that charge fees to publish papers with unlimited access (Willinsky, 2010). Unpublished and non-funded researchers, these fees present financial challenges, stimulating the development of a two-tier information system. Concerns have also been raised about the reliability of peer review in some open access journals. For example, Bohannon (2013) found that a deliberately flawed paper was accepted by 157 open access journals.

Procter, et al. (2010) suggested that the adoption of Internet tools for scholarly communication has been limited but likely to grow. Quan-Haase, et al. (2015) found that for some academics in the humanities Twitter was seen as a critical tool for communication and information sharing within scholarly networks. Holmberg and Thelwall (2014) and Manca and Ranieri (2017) highlighted differences in the extent and type of social media communication in certain disciplines. Carrigan (2013) found that in the U.K. almost 30 sociology departments had a Twitter presence. Rowlands, et al. (2011) found that many of those who use social media often take advantage of multiple formats, including blogging and social networking. Evidence also suggests that social media tools are increasingly being used to enhance student learning and engagement (Gruzd, et al., 2016). However there are still challenges and limits to the scholarly use of social media (Manca and Ranieri, 2016).

Al-Aufi and Fulton (2015) noted a growing use of social media amongst researchers for collaboration and to highlight new research, but there were still widespread concerns about the protection of intellectual property and a lack of training on the use of these tools. Lupton (2014) and Manca and Ranieri (2016) also identified academic concerns about privacy and the blurring of boundaries between personal and professional lives.

More generally science communication raises questions about how research, which might involve complex methods and technical findings, could be communicated effectively to wider audiences, such as those lacking sufficient background knowledge in a given subject or missing resources to keep pace with evolving research (Hilgartner, 1990; Horst, 2013; Mogendorff, et al., 2012; Priest, 2001). Davies (2008) found that a majority of scientists and engineers view science communication as one-way and negative.

Communication, as an ‘educational’ one-way transfer of information, has been criticised as failing to take into account the importance and value of interactions between diverse audiences (Myers, 2003). There is a link to broader issues of transparency and accountability and the role that scientists and the public can

http://journals.uic.edu/ojs/index.php/fm/rt/printerFriendly/7866/6560 2/15
Methodology

Firstly, we conducted a series of scoping interviews with academics in the U.K. Eight interviews were conducted with researchers using social media for scholarly communication as well as five scholars not using social media. The interviews focused on attitudes towards science communication and the use of social media as well as wider debates about open science. The interviewees were recruited through professional networks.

Secondly, a national online survey was conducted to explore attitudes towards science communication, data sharing and the use of social media in research development and dissemination. The sampling frame of the survey was a population of academics secured from a random sample of 12 U.K. Russell Group universities. An invitational e-mail message with a link to an online survey was sent to over 40,000 scholars.

In total 1,829 usable responses were received of which 46 percent were female and 54 percent male. They were from the following four discipline areas: medical and life sciences (35 percent); natural sciences and engineering (23 percent); social sciences (27 percent); and arts and humanities (15 percent). In terms of age: 35 percent of respondents were aged under 35 years old; 26 percent were 35–44; 21 percent were 45–54; and 18 percent were 55 and over. In terms of research experience, 25 percent of respondents had 1 to 5 years experience; 22 percent had 6–10 years experience; 26 percent had 11–20 years experience; and 27 percent had over 21 years experience. In terms of their roles, 20 percent of respondents were researchers in training (including Ph.D. candidates and master’s students); 39 percent were lecturers/research fellows or postdoctoral researchers; 16 percent were senior lecturers or senior researchers; and 24 percent were professors or readers.

Descriptive statistical analysis, factor analysis and regression modelling were conducted. Factor analysis allows the identification of underlying attitudes or behaviours by examining associations between responses to multiple survey questions. Logistic regression methods allowed the modelling of binary dependent variables (Sanders and Brynin, 1998) and the identification of key factors associated with the likelihood of being a super user from 11 survey questions. Thematic analysis was used to identify key issues emerging from written comments to open response questions. All the responses were anonymised.

The sample is broadly representative of the U.K. scholarly population in terms of demographics and academic disciplines (Higher Education Statistics Agency, 2015). However there are limitations to the survey, given its limited response rate. These limitations are considered later in this paper.

Findings

Attitudes towards open access publishing and data sharing

Overall there was a positive attitude amongst scholars towards publishing research in open access formats. Academics were asked: ‘How important do you think it is, in general, to make research articles freely accessible online to everyone?’. Ninety-three percent (1,606 out of 1,722) stated that they felt it was very, or fairly, important to make research articles freely accessible to everyone. We can explore this notion in more detail in written responses. For example, one comment noted that:

‘Work is generally publicly funded, so the public should be able to access it! Plus researchers in developing countries may not have the funds to pay subscriptions.’ (Female, Research Fellow, Public Health and Primary Care)

In terms of what happens in practice, respondents were asked: ‘Have you published an article in a journal that is open access?’ Of those who had published research articles, 41 percent (649 out of 1,601) stated they had published in an open access journal and a further 31 percent had plans to publish in an open access journal.

At the same time a number of concerns were expressed about publishing in open access journals. The concerns included copyright, quality assurance and the fees that might be charged to authors. One lecturer raised a concern about the potential problems of the author–payment model for open access journals:

‘In principle yes, I prefer open access journals, but the system of author payment is very dangerous; it will discourage and possibly exclude young/independent scholars, or those working at impoverished institutions.’ (Female, Research Fellow, Public Health and Primary Care)

There were also concerns about quality control and peer review in open access journals.

‘I do not believe that open access journals are of as good quality in terms of peer reviewing and therefore do not rate them highly.’ (Male, Senior Lecturer, Applied Health Professions, Dentistry, Nursing and Pharmacy)
The wider issue of open access and questions about the extent to which people without background subject knowledge can understand technical material was also raised.

"While in principle open access is a good idea I believe there are some potential issues/hazards in the way that research is interpreted and used by a non-academic audience." (Female, Research Fellow, Business and Management Studies)

Another academic commented on possible risks:

'Anyone in a position (with the required expertise) to understand my research would have institutional access to it. Laypersons would not understand the work.' (Male, Reader, Biological Sciences)

We now examine attitudes to making research data available for re-use. Academics were asked: 'How important do you think it is, in general, to make research data available online for reuse?' Again there was a high level of support, with 86 percent (1,459 out of 1,695) stating that it was very or fairly important to make research data available online for re-use. As one scholar commented:

'If the research is funded by public funds, then the data should be accessible for the public.' (Female, Lecturer, Civil and Construction Engineering)

Moreover, there was a link made to issues of efficiency and research transparency.

'It should stop duplication of research and transparency ensures honesty and quality.' (Male, Senior Lecturer, Psychology, Psychiatry and Neuroscience)

Another researcher pointed out the significance of access to data, for:

'the validation of research findings by the community; pump-priming ideas from other scientists and giving value for money from tax-funded research.' (Male, Senior Lecturer, Clinical Medicine)

In terms of data sharing in practice, respondents were asked: 'Have you deposited your own primary research data in an online repository that can be reused by other researchers?' Not all academics use primary research data; 24 percent of those who had produced data (360 out of 1,481) stated that they had deposited their own research data in an online repository where it could be re-used by others.

A number of concerns were also expressed about open data, including resources needed to create usable data sets.

'Of course it depends on the kind of data. It could require quite a lot of extra work to make the data clear and easy to access without ambiguity.' (Male, Research Assistant, Aeronautical, Mechanical, Chemical and Manufacturing Engineering)

Another academic highlighted risks of misinterpretation:

'The use of any data without data collectors' insight has a great risk for misinterpretation.' (Female, Senior Lecturer, Clinical Medicine)

Concerns were also expressed about copyright, ethics and confidentiality.

'A lot of my primary research data is copyright protected, e.g., photocopies of newspaper articles and government papers so I couldn’t make it available this way even if I wanted to.' (Male, Lecturer, Communication, Cultural and Media Studies)

One lecturer in sociology noted:

'I work with qualitative data, where issues of confidentiality and anonymity are paramount ... Placing data in online repositories open for all would feel too risky ... with regards to protecting research participants’ anonymity.' (Female, Senior Lecturer, Sociology)

Concerns were also raised about intellectual property and competition with other researchers.

'I am not sure that all data needs to be available to everyone immediately because of issues with competition.' (Female, Lecturer, Biological Sciences)

Highlighting concerns about the protection of research, another scholar remarked:

'I think researchers should freely share research data with those colleagues who email and ask personally. I will share the data and we will produce a paper together. I resent, however, spending the time and effort ... for someone else to swoop in and just use the end product.' (Female, Research Fellow, Sociology)
Use of social media for highlighting research

The use of three social media tools were considered in the survey: blogs, Twitter and sites such as Facebook and ResearchGate. These social media tools are quite different in the services that they provide. Blogs usually have no word limit and so researchers can write a summary of their published papers. Social networking sites, such as Academia.edu and ResearchGate, allow users to upload entire papers.

A number of participants posted their links in Twitter and Facebook accounts to their blogs to publicise their posts. As such, it was important to capture multiple uses of these tools.

The survey found that the vast majority had never posted updates of ongoing research on blogs (84 percent, 1,407 out of 1,668); Twitter (84 percent, 1,401 out of 1,673); or social networking sites (81 percent, 1,360 out of 1,671). Overall 70 percent (1,167 out of 1,677) had never posted updates of ongoing research on any social media sites.

Table 1: Publishing ongoing research updates on blogs, Twitter and other social networking sites.

<table>
<thead>
<tr>
<th>How often do you do any of the following in your research work?</th>
<th>Always</th>
<th>Often</th>
<th>Sometimes</th>
<th>Never</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Publish research updates on blogs</td>
<td>N %</td>
<td>N %</td>
<td>N %</td>
<td>N %</td>
<td>N %</td>
</tr>
<tr>
<td>17 1 40 2 204 12</td>
<td>1,407 84 1,668</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Publish research updates on Twitter</td>
<td>25 1 65 4 182 11</td>
<td>1,401 84 1,673</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Publish research updates on other social network sites</td>
<td>10 1 46 3 255 15</td>
<td>1,360 81 1,671</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Publish research updates on at least one of the above</td>
<td>32 2 107 6 371 22</td>
<td>1,167 70 1,677</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

However, there were a small number who either ‘always’ or ‘often’ (8 percent, 139 out of 1,677) published updates of ongoing research using at least one of these social media tools. We return to consider this high frequency user group, or ‘super users’, in more detail below.

We now examine attitudes towards the potential benefits and negative consequences of using social media in their research. As Table 2 highlights, academics were asked to what extent they agreed or disagreed with different statements regarding using social media in their work. The single choice answers for 11 items ranged from ‘strongly agree’ to ‘strongly disagree’ on a five-point scale.

Table 2: The potential positive and negative consequences of using social media in research work.

<table>
<thead>
<tr>
<th>To what extent do you agree or disagree with the following statements?</th>
<th>Strongly agree</th>
<th>Agree</th>
<th>Neither disagree nor agree</th>
<th>Disagree</th>
<th>Strongly disagree</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>N %</td>
<td>N %</td>
<td>N %</td>
<td>N %</td>
<td>N %</td>
<td>N %</td>
<td>N %</td>
</tr>
<tr>
<td>Communicating research on social media benefits the public</td>
<td>152 9</td>
<td>733 45</td>
<td>45565 35</td>
<td>152 9 25</td>
<td>2 1627</td>
<td></td>
</tr>
<tr>
<td>Communicating research on social media accelerates scientific discovery</td>
<td>83 5</td>
<td>396 24</td>
<td>24806 50</td>
<td>294 18 47</td>
<td>3 1626</td>
<td></td>
</tr>
<tr>
<td>Using social media promotes my professional profile</td>
<td>148 9</td>
<td>575 35</td>
<td>35584 36</td>
<td>242 15 76</td>
<td>5 1625</td>
<td></td>
</tr>
<tr>
<td>Using social media helps me find collaboration opportunities</td>
<td>118 7</td>
<td>524 32</td>
<td>32643 40</td>
<td>273 17 69</td>
<td>4 1627</td>
<td></td>
</tr>
<tr>
<td>Using social</td>
<td>104 6</td>
<td>387 24</td>
<td>24747 46</td>
<td>290 18 89</td>
<td>6 1617</td>
<td></td>
</tr>
</tbody>
</table>
In relation to the potential benefits for the public good, over half (54 percent, 885 out of 1,627) agreed that communicating research on social media would benefit the public. Twenty-nine percent (479 out of 1,626) agreed that communicating research on social media would accelerate scientific discovery. Forty-four percent (723 out of 1,625) agreed that using social media would promote their professional profiles. Thirty-nine percent (642 out of 1,627) agreed that using social media would help them find opportunities for collaboration and 30 percent (491 out of 1,617) agreed that using social media would benefit their careers. Thirty-one percent (499 out of 1,631) agreed that blogging or tweeting about their publications would increase citations. Only 14 percent (234 out of 1,624) agreed that using social media increased their chances of securing funding.

In relation to the possible negative consequences of using social media in their research, over half (58 percent, 949 out of 1,625) agreed that research published on social media could not be trusted because of concerns about a lack of peer review. Forty-four percent (722 out of 1,625) felt that communicating research on social media might result in plagiarism and 30 percent (492 out of 1,625) agreed that communicating research on social media could result in the loss of good ideas.

It is important to explore these concerns in more detail in the written responses of scholars. The issues raised included quality assurance, intellectual property rights, lack of time and resources and the prioritising of the peer review process.

'Because social media is non-reviewed, a push towards enhancing this as a means of science communication will hugely increase the amount of poor science on the Internet. There has to be quality control, and self-publishing via social media has no means of quality control.' (Male, Professor in Biological Science)

Another academic raised concerns over trust, reliability and the lack of time:

'Amongst senior academic medics real collaborative contacts are made during meetings and departmental visits. If your data is not publishable in a peer reviewed journal there is something wrong with your work. Nobody has time for chatting and tweeting, or trusts an unknown virtual colleague or his data. And what would it serve anyway?' (Female, Senior Lecturer, Clinical Medicine)

The issue of the importance of highly regarded publications was also emphasized. One lecturer in business studies explained:

'While some people are quite involved with social media in my circles, I don’t think it matters in the absence of producing those elite publications.' (Female, Lecturer, Business and Management Studies)

One scholar pointed to concerns about intellectual property in relation to publishing ongoing research:

'Twitter makes it very easy for people to see someone else’s insights and then pass them off as their own, either on Twitter or in their own academic research. How does one prove plagiarism of ideas without making reference to a publication?' (Female, Ph.D. Student, Sociology)
These views are related to the tension between communicating research on social media and securing more formal academic recognition. We return to this later in this paper.

Comparing across academic disciplines, age, gender and experience

As shown in Table 3, academics in the social sciences as well as in the arts and humanities were most likely to report research using social media. Scholars in the medical and life sciences and natural sciences and engineering were the least likely to do so. Seventy-seven percent of researchers in the medical and life sciences had never posted research updates using social media. Younger academics and those with little experience were more likely to publish research on blogs, Twitter and social networking sites.

Overall out of 1,677 responses 139 (8 percent) ‘always’ or ‘often’ posted research updates on social media. While this is a small group they are clearly highly engaged with social media to highlight their research. We consider these academics as ‘super users’.

The comments in the open-ended survey questions pointed out the benefits of using social media tools including raising the profile of their research, building their networks, engaging in dialogue with other researchers and linking with policy-makers as well as practitioners. One scholar stated:

‘... and on social media, most of my colleagues make me laugh because they are so clueless ... they think their work is over when they hand the final proofs to the publisher when, in fact, that’s when the real work begins: do you think I got those 8,000 citations from being an academic genius? No, from relentless online promotion (though of course you have to have a product of a good-enough quality for promotion to work). And second, clueless about social media: they think it’s some dumb thing for their kids. Long may they remain clueless — makes it easier for me to raise my profile compared to them!’ (Male, Professor, Anthropology)

Academics also pointed out the importance of their social media activity in terms of building research links, a wider profile and career progression.

‘Social media “indirectly” impacts on my promotion and career advancement as this is the main way I heard about funding, conferences and publication opportunities ... A case study wouldn’t have happened if I hadn’t stumbled across a tweet about it, I got 5k in funding, made a few connections, might even get a cheeky publication out of it.’ (Male, Lecturer, Social Science)

One senior scholar stated that he blogged about important breakthroughs to keep stakeholders engaged in a study:

‘My research team blogs updates about the study to keep agencies and potential beneficiaries engaged in the study throughout. I blog on my personal blog about ongoing research for the same purpose. The updates

Table 3: Publishing ongoing research on blogs, Twitter and other social networking sites by academic discipline, gender, age and experience.

<table>
<thead>
<tr>
<th>Publish ongoing research updates on blogs, Twitter and other social networking sites</th>
<th>Always N</th>
<th>%</th>
<th>Often N</th>
<th>%</th>
<th>Sometimes N</th>
<th>%</th>
<th>Never N</th>
<th>%</th>
<th>Total N</th>
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<td><strong>Discipline</strong></td>
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<tr>
<td>Medical &amp; life sciences</td>
<td>4</td>
<td>21</td>
<td>109</td>
<td>4</td>
<td>452</td>
<td>77</td>
<td>586</td>
<td></td>
<td></td>
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<tr>
<td>Natural sciences &amp; engineering</td>
<td>6</td>
<td>20</td>
<td>76</td>
<td>5</td>
<td>281</td>
<td>73</td>
<td>383</td>
<td></td>
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<tr>
<td>Social sciences</td>
<td>14</td>
<td>41</td>
<td>114</td>
<td>9</td>
<td>277</td>
<td>62</td>
<td>446</td>
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<tr>
<td>Arts &amp; humanities</td>
<td>7</td>
<td>25</td>
<td>71</td>
<td>28</td>
<td>153</td>
<td>60</td>
<td>256</td>
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<td><strong>Gender</strong></td>
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<td>Female</td>
<td>15</td>
<td>54</td>
<td>167</td>
<td>22</td>
<td>523</td>
<td>69</td>
<td>759</td>
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<td>Male</td>
<td>17</td>
<td>53</td>
<td>199</td>
<td>22</td>
<td>635</td>
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<td>904</td>
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<td><strong>Age</strong></td>
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<td>Under 35</td>
<td>13</td>
<td>50</td>
<td>130</td>
<td>23</td>
<td>364</td>
<td>65</td>
<td>557</td>
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<td>35–44</td>
<td>36</td>
<td>36</td>
<td>116</td>
<td>26</td>
<td>274</td>
<td>63</td>
<td>438</td>
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<td>45–54</td>
<td>6</td>
<td>16</td>
<td>79</td>
<td>21</td>
<td>272</td>
<td>73</td>
<td>373</td>
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<tr>
<td>55 and over</td>
<td>1</td>
<td>5</td>
<td>42</td>
<td>14</td>
<td>252</td>
<td>84</td>
<td>300</td>
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<td><strong>Academic experience</strong></td>
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<tr>
<td>1–5 years</td>
<td>10</td>
<td>27</td>
<td>85</td>
<td>22</td>
<td>267</td>
<td>69</td>
<td>389</td>
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<td>6–10 years</td>
<td>9</td>
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<td>64</td>
<td>377</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11–20 years</td>
<td>9</td>
<td>41</td>
<td>108</td>
<td>25</td>
<td>278</td>
<td>64</td>
<td>436</td>
<td></td>
<td></td>
</tr>
<tr>
<td>21 years or more</td>
<td>3</td>
<td>9</td>
<td>78</td>
<td>17</td>
<td>370</td>
<td>80</td>
<td>460</td>
<td></td>
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</tr>
</tbody>
</table>

http://journals.uic.edu/ojs/index.php/fm/rt/printerFriendly/7866/6560
are usually milestones reached or preliminary observations from the data.’ (Male, Reader, Social Work and Social Policy)

Another academic indicated that research was followed by a broader readership, engaging media around the world:

‘We’ve also had journalists pick up on information we’ve posted. Someone from the xxx called me after I wrote a blog post on a certain topic, and the xxx a month or so ago. So clearly we have a strong international list of subscribers.’ (Male, Professor, Politics)

At the same time some were concerned about publishing updates of ongoing research. As one researcher stated:

‘You need to distinguish between communicating published research and communicating research in progress. Huge difference. Communicating completed research is outreach, communicating ongoing research is giving the game away.’ (Male, Senior Researcher, Chemistry)

Academic super users

We conducted logistic regression modelling to identify factors associated with being a super user. The outcome variable indicated whether scholars were super users (coded as 1), defined as having always or often posted ongoing research updates on blogs, Twitter or other social networking sites. Those academics who ‘never’ or ‘sometimes’ performed these activities were coded as 0.

Independent variables included age; gender; academic discipline; digital device access (laptop, smartphone or tablet computer); whether they had social media training; whether they had been encouraged by their institution or by their colleagues; views on the importance of dissemination of research findings to different audiences; and attitudes towards the benefits and risks of using social media for research.

As outlined in the earlier methodology section, factor analysis was conducted to identify the key components of the 11 question items in the survey. Overall 68 percent of the variance in these 11 items was attributable to three latent factors, identified as: (i) social media use benefits the public good; (ii) individual career benefits; and (iii) risks of using social media. Table 4 illustrates logistic regression analysis of the likelihood of being a super user.

Table 4: The likelihood of being a super user.
Note: N=1,366. Significance level of OR *p<.05; **p<.01; ***p<.001
The betas (B) are the coefficients for the logistic regression. The odds ratios (OR) are the exponential of the Bs. If it is greater than 1 the OR indicates that as the independent variable increases so does the likelihood of being a super user. The standard errors (SE) provide information on how accurate the B coefficient is likely to be given the sample size.

<table>
<thead>
<tr>
<th></th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>S. E.</td>
<td>OR</td>
</tr>
<tr>
<td>Demographic variables</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender (reference — Female)</td>
<td>0.24</td>
<td>0.20</td>
<td>1.27</td>
</tr>
<tr>
<td>Discipline [Sciences (0); Humanities (1)]</td>
<td>1.00***</td>
<td>0.20</td>
<td>2.71</td>
</tr>
<tr>
<td>Age (reference — under 35)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>35–44</td>
<td>0.13</td>
<td>0.22</td>
<td>1.14</td>
</tr>
<tr>
<td>45–54</td>
<td>-0.83**</td>
<td>0.31</td>
<td>0.44</td>
</tr>
<tr>
<td>55 and over</td>
<td>-1.80***</td>
<td>0.48</td>
<td>0.17</td>
</tr>
<tr>
<td>Access to equipment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Use of laptop (reference — no)</td>
<td>0.02</td>
<td>0.52</td>
<td>1.02</td>
</tr>
<tr>
<td>Use of smartphone (reference — no)</td>
<td>0.73*</td>
<td>0.29</td>
<td>2.07</td>
</tr>
<tr>
<td>Use of tablet (reference — no)</td>
<td>0.74***</td>
<td>0.22</td>
<td>2.09</td>
</tr>
<tr>
<td>Context</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Have received social media training (reference — no)</td>
<td>0.75***</td>
<td>0.26</td>
<td>2.11</td>
</tr>
<tr>
<td>Been encouraged by</td>
<td>0.15</td>
<td>0.23</td>
<td>1.17</td>
</tr>
</tbody>
</table>
Overall being a younger academic, a scholar in the humanities compared to a researcher in medical and life sciences or natural sciences and engineering, having access to a tablet computer or smart phone, having received some training and peer recommendations were all positively associated with the likelihood of being a super user. The importance of peer recommendations suggests a strong social network influence over the likelihood of using social media in research.

Perhaps, not surprisingly, those academics who agreed that communicating research on social media benefits the public were more likely to be super users. Those who agreed that the use of social media for their research benefited their academic careers were also destined to be super users. Those who were more concerned about the potential risks of using social media for research, such as concerns over intellectual property rights, were less interested in sharing their research on social media.

The findings highlight the importance of a range of factors governing the likelihood of a scholar being a super user.

### Discussion

Our findings suggest that while many academics recognise the importance, and for some, the public duty of open science communication, the use of some of tools is still limited. There were substantial differences in attitudes and behaviour across academic disciplines and also in terms of age and experience. A training and skills gap appears to be part of the problem. The findings highlight the importance of context as well as administrative and peer support and peer pressure influencing the use of Internet-based communication tools, supporting earlier work by Carrigan (2016), Cruz and Jamias (2013) and Kieslinger (2015).

Citation rates are increasingly important to scholars. There is some evidence of increased citations from work that has been highlighted on social media as well as for research published in openly accessible.
journals and repositories (Niyazov et al., 2016; Shema et al., 2014). Indeed, evidence suggests that research published in open access formats is increasingly likely to be referenced on public Web sites such as Wikipedia (Dude, 2015). The potential benefits to the public can be significant and also as a result of dissemination to practitioners. Yet at an institutional level, peer reviewed publications remain the key criterion of assessment. Even so, it is likely that the number of academics using social media in their research will continue to increase. Some British scholars cited their numbers of Twitter followers in their 2014 Research Excellence Framework (REF) impact statements (REF, 2014). The REF determines the allocation of much government funding for higher education in the U.K.

We identified a small group who frequently used social media for their research that we termed as super users. This builds on Kieslinger’s (2015) notion of the ‘heavy user’ where the use of social media is integral to professional lives. In our research super users frequently communicated updates of their research using social media. They appeared to be based in the humanities and social sciences and were younger than their colleagues. Their use of social media contributes to the construction of their profiles in addition to sharing information and developing networks.

Many researchers in our survey had concerns about communication and aspects of open science including a lack of clarity regarding formal policies for open science; risks over intellectual property in relation to other researchers and commercial organisations; ethical issues raised by the reuse of data; quality assurance of peer review; and challenges and potential risks of communicating research to audiences without subject-specific and technical expertise. Sharing research ahead of formal publication could put at risk a given researcher’s claims over findings as well as academic credit (Robinson-García et al., 2016). Indeed, the sharing of data could limit a researcher’s future use of that data for their own research and as the basis of future grant applications. For some, a lack of time and resources were additional issues. There were also ethical issues related to security and sensitive information (Butler, 2012).

Some academics elect to use social media to promote their own research. Others communicate with a closed community while some practitioners of open science may choose not to use social media directly. In some case, specialized tools may be utilized for sharing data. However it is clear that social media provides new opportunities for more open and two-way science communication. In turn, it can be a valuable part of the research process. Social media can contribute to the development of collaborative problem solving and lead to a more informed public. In this regard, it is notable that Head et al. (2017) highlighted the popularity of blogs amongst college graduates even if primarily for personal issues. Talbot (2017) noted the growing importance of scholarly blogs contributing to the decision-making processes of policy-makers.

Restrictions on access thanks to pay walls and other barriers pose difficulties for the wider dissemination of research, even when those studies were publicly funded. Research councils in the U.K. require that all publicly funded research data and metadata should be openly available and reusable in a timely manner (Research Councils UK, 2015). Some journal publishers, such as PLOS ONE (2013), require authors to make data, used in published papers, publicly available. However, this initiative has generated considerable debate amongst scholars over intellectual property rights and those resources needed to prepare data and document how it can be used (Yarkoni, 2014). It is notable that the AllTrials campaign (http://www.alltrials.net) has been focused on the registration of clinical trials as well as recording methods and summary results.

Open access publishing in particular can raise some challenges in terms of costs to individual researchers and research institutions. As such, open access publishing may in part be re-positioning the barrier, in some cases, from the reader to the author. In addition, online open access archives have faced challenges. For example, some publishers have forced sites, like Academia.edu (https://www.academia.edu), to remove certain papers because of claims of copyright infringement (Howard, 2013). In some instances, reviewing and analyzing research data can be overwhelming for some journal editors and reviewers (Acord and Harley, 2013). It is clear that peer review is key to scientific research, but there are new and more open ways for communicating research. There needs to be a greater recognition of the value of more accessible communication channels. In the U.K., the Higher Education Funding Council for England (HEFCE) has required that publications must be available in open access repositories to be eligible for future funding (HEFCE, 2015).

The challenges of communicating research directly to wider audiences remain. In our research some researchers were sceptical of more open communication. Research descriptions and findings can contain highly complex concepts and technical language; there are risks in oversimplification.

Limitations

This study is one of the largest of its kind to date and adds considerably to an existing evidence base, but there are limitations. As outlined earlier, the scoping interviews to develop the survey were based on a purposive sample. The main survey analysis is based on a large number of responses across a number of universities in the U.K., but those scholars who responded may be more likely to be using social media. As such, we need caution in interpreting the results described in this paper. We may be overestimating the level of social media use amongst researchers. Whilst the overall response rate was low, the respondents were broadly representative of the British academic population in terms of key demographics and discipline areas (Higher Education Statistics Agency, 2015).

Conclusions

There are opportunities for a more creative dialogue-based relationship between scientists and the public, which would help overcome knowledge gaps and transform the deficit model of conducting and communicating science (Godin and Gingras, 2000; Gregory and Miller, 1998; Levin et al., 2016; Perrault, 2014). Research will continue to increase. Some British scholars cited their numbers of Twitter followers in their 2014 Research Excellence Framework (REF) impact statements (REF, 2014). The REF determines the allocation of much government funding for higher education in the U.K.
2013; Sturgis and Allum, 2004). As Grand, et al. (2012) argue, practicing science in the open can help build trust and contribute to a more engaged, informed and critical culture.

Multiple formats and channels need to be utilised as part of an integrated communication process. Research findings should be accessible beyond a specific discipline and its network of researchers.

Given changes in academic research funding as well as the evolution of new tools for communication and data sharing, there are clearly opportunities and incentives for more dynamic science communication and public engagement. However, many challenges need to be resolved at a variety of levels.

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Notes

1. See, for example, www.scienceblogs.com or www.researchblogging.org.


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