Social Media, Science Communication and Academic Super Users in the UK

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"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)

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 UK our research suggests that most academics recognised the value and importance of more open science communication and data sharing, but many had concerns about the potential risks. A small group of academics, 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.

Key words: **Collaboration, Communication, Engagement, Intellectual Property, Knowledge, Open Science, Social Media**

Introduction

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 has been traced to the early seventeenth century when science was predominantly a 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 the 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 approach (Davies 2008; Irwin and Wynne 1996; Gregory and Miller 2000; Miller 2001; Priest 2001; Sturgis and Allum 2004; The Royal Society 2012a). However there are increasing opportunities for communicating science and for public engagement in the research process, which could be the basis for tackling challenging research problems.

Traditionally the establishment of knowledge and scientific communication has been through peer reviewed journal article publication (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 can hinder the dissemination of research outputs to wider audiences (Björk

and Solomon 2013; Chan et al. 2011). Moreover, concerns have been raised about bias in the peer review and journal publication process (Nature 2006; OSC 2015).

Social media tools allow cost-free open access to research updates, including before the research findings are formally published in journal articles (Manca and Ranieri 2017). Blogs and social networking sites can include individual academic blogs and those hosted by a faculty or a research community (Graham and Dutton 2014; Tatum and Jankowski 2010).[i] In the case of Open Notebook Science, scientist bloggers record day-to-day laboratory work (RIN 2010). This involves scholarly communication at different stages of the scientists' work and they invite feedback and participation. Some academic bloggers have reported advantages including networking with peers in other institutions and potential collaborators, and keeping up-to-date with new discoveries in the field (Kjellberg 2010). Academic publishers are also using blogs to promote articles published in journals (Stewart et al. 2012). Open peer review initiatives have also been tested, where the wider public are invited to comment on and review academic publications (Acord and Harley 2013).

Academic social networking sites such as Academia.edu and ResearchGate have grown rapidly, with academics sharing their work and being able to track the publications of the academics they follow (Thelwall and Kousha 2014a, 2014 b). Many of these online archives provide real time metrics of access and, as such, academics are contributing to the tracking of their own work. While criticisms have been levelled at some of these archives for exploiting the data generated by academics (Hall 2015), their growth suggests a willingness amongst many academics to share their research freely. However science communication, including aspects of open science such as data sharing and open access publishing raise a number of challenges.

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

Context – Understanding Open Science, Research Communication and Public Engagement

The development of Internet and new tools for communication offer new opportunities for the scientists to engage public in science (Veletsianos 2016). Researchers can inform and engage others in the problem-solving process of constructing knowledge (Tacke 2011). This links with wider developments in relation to campaigns for the public understanding of science and more open government (Levin et al. 2016; The Royal Society 2012b; Watermeyer 2012; Wind-Cowie and Lekhi 2012).[ii]

There is some debate about the definition of open science however broadly it includes open access to: scientific publications research data and meta data, methods, code, software and findings. Open access (OA) publishing can involve different forms of access but it should be timely and be the full text of the publication (Berlin Declaration 2003; Budapest Open Access Initiative 2002). Open science can also include participatory and co-produced research, dynamic communication processes and engagement with ongoing research as part of

what has been termed Science 2.0 (European Commission 2014; Grand et al. 2010; Levin et al. 2016; Nielsen 2012; Suber 2007; Wilbanks 2006).[iii] In co-produced research the public are involved in the problem solving process and contribute to the design and delivery of the research (Fine and Torre 2004). Haklay (2013) describes what is termed extreme citizen science, which is a ground up research practice that takes into account local needs and works with broad networks of people in the knowledge creation process. This can link to forms of citizen mobilisation (Grouix et al. 2017; Purdam 2014).

However, as Scheliga and Friesike (2014) highlight from their qualitative research, there are individual and systematic obstacles to more open science practices and communication. Key issues include: quality assurance and the role of peer review, the protection of intellectual property rights (IPR), including copyright and the commercial value of research, the costs of open access publication and the development of academics' own careers (Peters 2010; Veletsianos 2016). Open Access journals typically charge a fee and authors often need to pay to allow their articles to be published with unlimited access (Willinsky, 2010). For disadvantaged institutions and non-funded researchers, the cost of publication fees brings financial challenges and perhaps risks a two-tier information system. Concerns have also been raised about the reliability of peer review in open access journals. For example Bohannon (2013) found that a deliberately flawed paper was accepted by 157 open-access journals.

Research in 2010 by Procter et al. (2010a) suggested that that the adoption of Internet tools (Web 2.0) for scholarly communications was limited but likely to grow. More recent research by Quan-Haase et al. (2015), which involved qualitative interviews with academics, found that for some academics in the Humanities Twitter is seen as a critical tool for communication and information sharing within academic networks and beyond. Holmberg and Thelwall (2014) and Manca and Ranieri (2017) have highlighted differences in the extent and type of social media communication by academic discipline. Research by Carrigan (2013) found that in the UK almost 30 sociology departments have a Twitter presence. Research by Nicholas and Rowlands (2011), who surveyed academics, found that many of those who use social media often make use 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 (Grudz et al. 2016). But there are still challenges and limits to this kind of use (Manca and Ranieri 2016)

Research by Al-Aufi and Fulton (2015) has identified that whilst there is a growing use of social media amongst academics for collaboration and for highlighting new research there were still widespread concerns about the protection of intellectual property and a lack of training about how to use the tools effectively. Lupton (2014) and Manca and Ranieri (2016) have also identified academic concerns about privacy and the blurring of boundaries between personal and professional life.

More generally science communication raises questions about how research, which might involve complex methods and technical findings, can be communicated effectively to wider audiences, including to people who may not have background knowledge in the subject area or have the resources including time to keep themselves updated (Hilgartner 1990; Horst 2013; Mogendorff et al. 2012; Priest 2001). Research by Davies (2008) found that a majority of scientists and engineers view the constructions of science communication as one-way and negative.

Communication as one-way transfers of information as 'education' has been

criticised as it fails to take into account of the importance and value of the interaction between the public and scientists (Myers, 2003). Moreover there is a link to the issues of transparency and accountability in the research process and the role that scientists and the public can play in the knowledge generation process, particularly where the research is publicly funded (Hind 2010; Huijer 2003; Nelkin 1967).

Methodology

Firstly, we conducted a series of scoping interviews with academics in the UK. Eight interviews were conducted with a purposive sample of academics who had used social media for scholarly communication and five academics who were not using social media. The interviews focused on the academics' attitudes towards science communication and the use of social media as well as the wider debates about open science. The interviewees were recruited through professional networks.

Secondly, a national online survey was conducted to explore academics' attitudes towards science communication, data sharing and the use of social media in the research development and dissemination process. The sampling frame of the survey was the population of academics in a random sample of 12 UK Russell Group universities. An invitation email with a link to the online survey was sent to over 40,000 academics.

In total 1,829 usable responses were received, of which 46 per cent were female and 54 per cent were male. They were from the following four discipline areas: Medical and Life Sciences (35 per cent), Natural Sciences and Engineering (23 per cent), Social Sciences (27 per cent) and Arts and Humanities (15 per cent). In terms of age: 35 per cent of respondents were aged under 35, 26 per cent were aged 35-44, 21 per cent were aged 45-54 and 18 per cent were aged 55 and over. In terms of research experience: 25 per cent of respondents had 1-5 years experience, 22 per cent had 6-10 years experience, 26 per cent had 11-20 years experience and 27 per cent had over 21 years experience. In terms of their role: 20 per cent of respondents were researchers in training (including PhD candidates and masters students), 39 per cent were lecturers/research fellows or postdoctoral researchers, 16 per cent were senior lecturers or senior researchers and 24 per cent were professors or readers.

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

The sample is broadly representative of the UK academic population in terms demographics and academic discipline (HESA 2015). However the survey does have limitations given the limited response rate. These limitations are considered in the final discussion section below.

Findings

Attitudes Towards Open Access Publishing and Data Sharing

Overall there was a positive attitude amongst academics 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?'.* 93 per cent of academics (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 more detail in the written responses. As one academic commented:

> *'Work is generally publically 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 per cent of academics (649 out of 1,601) stated they had published in an open access journal and a further 31 per cent had plans to publish in an open access journal.

At the same time a number of concerns were expressed about publishing research in open access journals. The concerns included such issues as: 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, Lecturer, Classics).

There were also concerns about quality control and peer review for open access journals. As one academic stated:

> *'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. As one academic commented:

> *'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 the possible risks of misunderstanding:

> *'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 academic 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 amongst academics, with 86 per cent (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 academic 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, the link was made to the issues of efficiency and research transparency. As one academic commented:

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

Another academic commented on how the availability of research data was important 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?'* Of course not all academics use primary research data and this needs to be taken into account – 24 per cent of academics who had produced primary data (360 out of 1,481) stated that they had deposited their own primary research data in an online repository that can be re-used by other researchers.

A number of concerns were also expressed about this aspect of open data. These included the resources needed to create usable data sets. As one academic commented:

> *'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 the risks of misinterpretation, commenting:

> *'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 respondent confidentiality. As one academic commented:

> *'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 commented:

> *'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 the competition with other researchers. One academic commented:

'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 their research, another academic commented:

'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).

We now consider the use of social media by academics during the research process.

Use of Social Media for Highlighting Ongoing Research

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

A number of participants from the scoping interviews of this research highlighted how they would link their Twitter and Facebook accounts to their blogs to publicise their blog posts. As such, it was important to capture the multiple uses of these tools by some academics in the survey.

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

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

How often do you do any of the following in your research work?	Always		Often		Sometimes		Never		Total
	N	%	N	%	N	%	N	%	
Publish research updates on blogs	17	1%	40	2%	204	12%	1407	84%	1668
Publish research updates on Twitter	25	1%	65	4%	182	11%	1401	84%	1673
Publish research updates on other social network sites	10	1%	46	3%	255	15%	1360	81%	1671
Publish research updates on at least one of the above	32	2%	107	6%	371	22%	1167	70%	1677

However, there were a small number of academics who either 'always' or 'often' (8 per cent, 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 what can be termed the 'super users', in more detail below.

We now examine academics' attitudes towards the potential benefits and negative consequences of using social media in their research work. As Table 2 highlights, academics were asked to what extent they agreed or disagreed with different statements regarding using social media in their research 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

To what extent do you agree or disagree with the following statements?	Strongly agree		Agree		Neither disagree nor agree		Disagree		Strongly disagree		Total
	N	%	N	%	N	%	N	%	N	%	
Communicating research on social media benefits the public	152	9%	733	45%	565	35%	152	9%	25	2%	1627
Communicating research on social media accelerates scientific discovery	83	5%	396	24%	806	50%	294	18%	47	3%	1626
Using social media promotes my professional profile	148	9%	575	35%	584	36%	242	15%	76	5%	1625
Using social media helps me find collaboration opportunities	118	7%	524	32%	643	40%	273	17%	69	4%	1627
Using social media benefits my career	104	6%	387	24%	747	46%	290	18%	89	6%	1617
Blogging or tweeting about my publication will increase citations	65	4%	434	27%	798	49%	273	17%	61	4%	1631
Using social media increases my chances of getting funding	43	3%	191	12%	757	47%	499	31%	134	8%	1624
Research published on social media cannot be trusted	282	17%	667	41%	484	30%	165	10%	27	2%	1625
Communicating research on social media may result in plagiarism	92	6%	630	39%	633	39%	242	15%	28	2%	1625
Communicating research on social media risks my ideas being stolen	69	4%	423	26%	708	44%	376	23%	49	3%	1625

In relation to the potential benefits for the public good, over half of all academics (54 per cent, 885 out of 1,627) agreed that communicating research on social media would benefit the public. 29 per cent (479 out of 1,626) of academics agreed that communicating research on social media would accelerate scientific discovery. 44 per cent (723 out of 1,625) of academics agreed that using social media would promote their professional profiles. 39 per cent (642 out of 1,627) of academics agreed that using social media would help them find collaboration opportunities and 30 per cent (491 out of 1,617) agreed that using social media would benefit their careers. 31 per cent (499 out of 1,631) of academics agreed that blogging or tweeting about their publications would increase their citations.

However only 14 per cent (234 out of 1,624) academics agreed that using social media increased their chances of getting funding.

In relation to the possible negative consequences of using social media in their research work, over half of the academics (58 per cent, 949 out of 1,625) agreed that research published on social media could not be trusted because of concerns about peer review. 44 per cent of academics (722 out of 1,625) felt that communicating research on social media might result in plagiarism and 30 per cent of academics (492 out of 1,625) agreed that communicating research on social media could result in the risk of good ideas being stolen.

It is important to explore these concerns in more detail in the written responses of the academics. The issues raised included: quality assurance, intellectual property rights, lack of time and resources and the prioritising of peer review publication. As one academic commented:

> *'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 the issues of 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 highlighted. 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 academic pointed to concerns about intellectual property in relation to publishing ongoing research. They stated:

> *'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, PhD 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 in our discussion below.

Comparing Across Academic Disciplines, Age, Gender and Experience

As shown in Table 3, academics in the Social Sciences and Arts and Humanities were the most likely to report using social media to publish research updates. Those academics from the Medical and Life Sciences and Natural Sciences and Engineering were the least likely to do so. 77 (452 out of 586) per cent of

academics in Medical and Life Sciences had never posted research updates using social media. Younger academics and those with fewer years' experience of being an academic were more likely to be publishing research updates on blogs, Twitter and social networking sites.

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

Publish ongoing research updates on blogs, Twitter and other social network sites	Always		Often		Sometimes		Never		Total
	N	%	N	%	N	%	N	%	
Discipline									
Medical & Life Sciences	4	1%	21	4%	109	19%	452	77%	586
Natural Sciences & Engineering	6	2%	20	5%	76	20%	281	73%	383
Social Sciences	14	3%	41	9%	114	26%	277	62%	446
Arts & Humanities	7	3%	25	10%	71	28%	153	60%	256
Gender									
Female	15	2%	54	7%	167	22%	523	69%	759
Male	17	2%	53	6%	199	22%	635	70%	904
Age									
Under 35	13	2%	50	9%	130	23%	364	65%	557
35-44	36	3%	36	8%	116	26%	274	63%	438
45-54	6	2%	16	4%	79	21%	272	73%	373
55 and over	1	0%	5	2%	42	14%	252	84%	300
Academic experience									
1-5 years	10	3%	27	7%	85	22%	267	69%	389
6-10 years	9	2%	27	7%	99	26%	242	64%	377
11-20 years	9	2%	41	9%	108	25%	278	64%	436
21 years or more	3	1%	9	2%	78	17%	370	80%	460

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

The comments provided by academics to the open-ended survey questions also highlighted the benefits of using social media communication tools including: raising the profile of their research, building their networks, engaging in dialogue with other academics, creating research impact and linking with policy makers and practitioners. One academic commented:

> *'…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 highlighted the importance of their social media activity in terms of building research links, their wider profile and career progression. As one academic stated:

> *'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 academic stated that he blogged about important breakthroughs to keep stakeholders engaged in the 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 are usually milestones reached or preliminary observations from the data.'* (Male, Reader, Social Work and Social Policy).

Another academic highlighted the link to communicating their research more widely and engaging the 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 academics highlighted concerns about publishing updates of ongoing research. As one researcher commented:

> *'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).

We now consider the small group of academics who are frequent users of social media in their research work in more detail.

Academic Super Users

We conducted logistic regression modelling to identify the factors associated with being an academic super user. The outcome variable indicates whether the academics 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' did this were coded as 0.

The independent variables include: age, gender, academic discipline, digital device access (laptop, smart phone 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 methodology section above, factor analysis was conducted to identify the key components of the 11 question items asked in the survey. Overall 68% of the variance in these eleven items was attributable to three latent factors, which were identified as: (i) social media use benefits the public good, (ii) individual career benefits, and (iii) risks of using social media. Table 4 shows the results from the logistic regression analysis of the likelihood of being a super user.

Table 4. The likelihood of being a super user[1]

		Model 1			Model 2			Model 3		
		B	S. E.	OR	B	S. E.	OR	B	S. E.	OR
Demographic Variables	Gender (reference - Female)	0.24	0.20	1.27	0.25	0.21	1.29	0.42	0.23	1.52
	Discipline (Sciences (0); Humanities (1))	1.00***	0.20	2.71	0.99***	0.21	2.70	0.87***	0.23	2.39
	Age (reference - under 35)									
	35-44	0.13	0.22	1.14	0.12	0.23	1.13	0.22	0.25	1.25
	45-54	-0.83**	0.31	0.44	-0.80*	0.32	0.45	-0.36	0.35	0.70
	55 and over	-1.80***	0.48	0.17	-1.63***	0.49	0.20	-0.88	0.52	0.42
Access to equipment	Use of laptop (reference - no)				0.02	0.52	1.02	0.18	0.58	1.20
	Use of smart phone (reference - no)				0.73*	0.29	2.07	0.41	0.33	1.50
	Use of tablet (reference - no)				0.74***	0.22	2.09	0.87***	0.24	2.38
Context	Have received social media training (reference - no)				0.75***	0.26	2.11	0.45	0.29	1.56
	Been encouraged by institution to use social media (reference - no)				0.15	0.23	1.17	-0.05	0.25	0.95
	Colleagues have recommended use of social media (reference - no)				0.83***	0.23	2.30	0.49*	0.25	1.64
Attitudes towards use of social media for dissemination	Importance of communicating research to public (reference – not important)				0.59*	0.24	1.81	0.38	0.26	1.46
	Factor 1 - Positive view that social media use benefits public good and contributes to scientific discovery (negative to positive)							0.62***	0.12	1.87
	Factor 2 - Positive view that social media benefits own career							1.01***	0.14	2.76
	Factor 3 - Use of social media does not pose risks, e.g. to the protection of intellectual property rights							0.47***	0.11	1.59
	Constant	-2.72		0.07	-4.73	0.63	0.01	-5.15	0.72	0.01
	Nagelkerke R Square	0.09			0.20			0.35		

N=1366. Significance level of OR *p<.05 **p<.01 ***p<.001.

Overall being a younger academic, an academic in Humanities compared to an academic in Medical and Life Sciences or Natural Sciences and Engineering,

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[1] 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.

having access to a tablet computer or smart phone, having received some training and peer recommendation were all positively associated with the likelihood of being a super user. The importance of peer recommendation suggests a strong social network influence on an academics' likelihood of using social media in their research work.

Perhaps, not surprisingly, those academics who agreed that communicating research on social media benefits the public, including as part of the process of scientific discovery, were more likely to be super users. Those who agreed that the use of social media for their research work benefited their academic careers were more likely to be super users. Those who were more concerned about the potential risks of using social media for research, including intellectual property rights, were less likely to share their research updates on social media.

The findings highlight the importance of a range of factors in relation to the likelihood of an academic being a super user.

Discussion

In the age of data and competing truth claims our findings suggest that while many academics recognise the importance, and for some the public duty, of more open science communication, the use of some of the available tools is still limited. There were substantial differences in attitudes and behaviour across academic disciplines and also in terms of academics' age and experience. A training and skills gap is part of this. Supporting research by Carrigan (2016), Cruz and Jamias (2013) and Kieslinger (2015) the findings highlight the importance of context and administrative and peer support and also peer pressure for the uptake of Internet based communication tools.

Research citation rates are increasingly important to academics' profiles and assessment of impact and there is evidence of increased citation rates for research that has been highlighted on social media and for research published in open access journals and repositories (Niyazov et al. 2016; Shema et al. 2014). Moreover, evidence suggests that research published in open access formats is increasingly likely to be referenced on public websites such as Wikipedia (Duede 2015). The potential benefits to the public can be both direct in terms of the advancement of knowledge and indirect as a result of the dissemination to practitioners. At an institutional level, peer review publications remain the key criterion of assessment of success. Even so it is likely that the number of academics using social media in their research will continue to increase. Some UK academics cited the number of Twitter followers they had in their 2014 Research Excellence Framework (REF) Impact Statements (REF 2014). The REF determines the allocation of much of the government funding for higher education in the UK.

We identified a small group of academics who were frequently using social media for their research and who can be termed super users. This builds on Kieslinger's (2015) notion of the 'heavy user' where the use of social media tools is integral to the academic's working life. In our research the super users we identified frequently communicated updates of their ongoing research using social media. They tended to be based in the Humanities and the Social Sciences and to be younger. Their use of social media tools contributes to building their profile, sharing information and developing their networks.

However, many academics in our survey had concerns about communication and aspects of open science including: a lack of clarity about the formal policies for open science, the risks to the protection of their intellectual property in

relation to other researchers and commercial organisations, the ethical issues raised by the reuse of their data, the quality assurance of peer review and the challenges and potential risks of communicating research to audiences who do not have subject-specific and technical expertise. Sharing research ahead of final publication could put at risk the researcher's claims to the findings. Concerns may also relate to academic credit (Robinson-Garcia et al. 2016). Moreover, the sharing of data could limit an academic's future use of the data for their own research and as the basis of future grant applications. For some academics a lack of time and resources was an issue. Ethical issues including security are also factor, such as in relation to sensitive information, including public health research (Butler 2012).

Of course some academics may use social media to promote their own research and for communication within a closed community and some practitioners of open science may choose not to use social media directly themselves. Moreover, they may use specialised tools for sharing data. However it is clear social media tools provide new opportunities for more open and two-way science communication. Such communication can be a valuable part of the research process; it can contribute to the development of collaborative problem solving and lead to a more informed public as they find new ways to engage with scientists and scientific research. It is notable that Head et al. (2017) have highlighted the popularity of reading blogs amongst college graduates even if primarily for personal issues. Moreover Talbot (2017) whilst recognising the growing importance of peer reviewed journal articles has pointed to the growing use by policymakers of evidence from academic blogs.

Restrictions on access to research findings that are published behind pay walls and data pose barriers to the wider dissemination of research findings even when the research has been publicly funded. Research councils in the UK require that all publicly funded research data and metadata should be made openly available and reusable in a timely manner (RCUK 2015). Journal publishers such as PLOS One require authors to make data used in published articles publicly available (PLOS 2013). However, this initiative has generated considerable debate amongst academics concerning intellectual property rights and the resources required to prepare data and document how it can be used (Yarkoni 2014). It is notable that the All Trails campaign is focused on the registration of all past and present clinical trials and the recording of the methods and summary results.[iv]

Open access publishing in particular can also raise some challenges in terms of the costs to individual researchers and research institutions. As such, open access publishing may in part be re-positioning the barrier to open science from the reader not being able to access published material to the author not being able to afford to publish. In addition, online open access archives have faced challenges; for example, some publishers have forced organisations like Academia.edu to remove certain academic articles because of claims of copyright infringement (Howard 2013). Moreover, the checking and publication of the research data can be overwhelming for journal editors and reviewers (Acord and Harley 2013). It is clear that peer review is the key anchor for scientific research, but there are new and more open ways for communicating research and there needs to be a greater recognition of the value of this. In the UK the Higher Education Funding Council for England (HEFCE) from 2016 required that publications must be available through open access repositories to be eligible for the next REF (HEFCE 2015).

The challenges of communicating research directly to wider audiences remain and in our research some academics were sceptical of more open science

communication. Research descriptions and findings can contain highly complex concepts and technical language and there are risks of oversimplification and misunderstanding.

Limitations

This study is one of the largest of its kind to date and adds considerably to the existing evidence base, however it does have limitations. 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 UK, but those academics who responded may be more likely to be using social media tools. As such we need some caution when interpreting the results and we may also be overestimating the level of social media use amongst academics. Whilst the overall response rate was low the respondents are broadly representative of the UK academic population in terms of key demographics and discipline area (HESA 2015). Moreover

Conclusions

There are opportunities for a more creative, dialogue-based relationship between scientists and the public, which would help overcome the knowledge gap and transform the deficit model of conducting and communicating science (Godin and Gingras 2000; Gregory and Miller 2000; Levin et al. 2016; Perrault 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.

There is clearly a link between the different channels for communicating research, with one reinforcing the other, and as a consequence multiple formats and channels need to be utilised as part of an integrated communication process, perhaps with journal article publication as the anchor. It is also important that research findings should be accessible beyond a specific research network or discipline.

Given the ongoing changes in academic research funding, including the recognition of the importance of open access publishing, and the evolution of new tools for communication and data sharing there are clearly opportunities and incentives for more dynamic science communication and public engagement and collaboration, but challenges remain.

Acknowledgments

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[i] See, for example, www.scienceblogs.com or www.researchblooging.org

[ii] See, for example in the UK, http://data.gov.uk/ and also the Open Data Institute www.theodi.org/. Also see the International Council for Science - Open Data Accord https://www.icsu.org/current/news/open-data-in-a-big-data-world-accord-passes-120-endorsements

[iii] See for example, the Open Science Grid http://www.opensciencegrid.org/; arXiv http://arxiv.org/; ENCODE www.genome.gov/10005107; GitHub https://github.com and the Directory of Open Access Journals http://doaj.org/.

[iv] For more information see http://www.alltrials.net/find-out-more/all-trials/