The open research value proposition: How sharing can help researchers succeed

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December 7, 2015

Abstract

Open access, open data, open source, and other open scholarship practices are growing in necessity and popularity, rapidly becoming part of the integral workflow of researchers. However, widespread adoption of many of these practices has not yet been achieved. Understandably, researchers have concerns as to how sharing their work will affect their careers. Some of these concerns stem from a lack of awareness about the career benefits associated with open research. Herein, we review literature on the open citation advantage, media attention for publicly available research, collaborative possibilities, and special funding opportunities to show how open practices can give researchers a competitive advantage.

Contents

1 Introduction

The last decade has seen a dramatic increase in recognition and adoption of policies to increase access to the academic literature (open access) [1, 2], data sharing (open data) [3–5], and code and software sharing (open source) [5]. These open practices can be grouped under the larger umbrella of open science [6], or to be more inclusive, open research. Many ethical, moral, and scientific justifications exist for researchers to be open [7, 8], including the right of taxpayers to access literature arising from publicly-funded research [9] and the importance of code and data sharing for reproducibility [10–12]. However, these arguments may neither be sufficient nor translate into action for all researchers. Some view open research as professionally detrimental and a risk to their careers. Our goal is to show why open practices do not have to be detrimental and can, in fact, aid researchers in their career development.

Herein, we take a researcher-centric approach, with the goal of outlining what we call the ‘open research value proposition’. We discuss how researchers can use open practices to their advantage to gain more citations, media coverage for their research, potential collaborators, job prospects, special research funding, and more. In the process, we debunk common myths surrounding open research, such as poor quality and low impact of open access journals, risks to funding and career advancement, and forfeiture of commercialization opportunities. We have divided the discussion into areas of interest, including publishing, funding, hiring, career advancement, and intellectual property. In sum, we show how practicing open research represents a net positive value for academics.

2 Publishing

2.1 Open publications get more citations

A concern for researchers, especially in the early stages of their career, is building a name for themselves and receiving peer recognition for their work. This is measured in part by article citations. Numerous studies have shown that articles published openly - whether in open access (OA) journals, subscription journals with OA options (hybrid journals), or self-archived in open repositories - tend to receive more citations than articles that are not openly available [13–19].

Eysenbach and colleagues reported that articles published in the *Proceedings of the National Academy of Sciences* (*PNAS*) under their OA option were twice as likely to be cited within 4-10 months and nearly three times as likely 10-16 months after publication than non-OA articles published in the same journal [13]. Hajjem and colleagues studied over 1.3 million articles published in 10 different disciplines over a 12-year period and found that OA articles had a 36-172% increase in citations over non-OA articles [14]. Openly archived articles receive a citation advantage regardless of whether archiving is initiated by the author or mandated by an institution or funder, ruling out the idea that author bias in selecting their best papers to archive causes higher citation rates [15]. A 2014 study of the journal *Nature Communications* found that biological sciences, earth sciences, and physics articles published under an OA option were cited more than non-OA articles [16]. These results were confirmed in 2015 in an independent study, which found that over 77% of openly available articles published in early 2012 had received at least one citation, versus less than 69% of non-OA papers [17]. Importantly, downloads for non-OA articles experienced short spikes briefly after publication, while OA articles saw sustained download activity. Perhaps related, in 2014, *Nature Communications* switched from a hybrid publishing model to fully OA.

Literature reviews have demonstrated that the open citation advantage holds across the majority of studies. Swan and colleagues found 27 studies reporting an advantage and only 4 studies reporting no advantage or a disadvantage of publishing openly, with the percent increase in citations for OA articles ranging from -5-580% [18]. Wagner and colleagues found 39 studies reporting an open citation advantage, with a percent increase ranging from 25-250%, and only 7 studies which found no advantage or attributed it to confounding factors [19]. The Scholarly Publishing and Academic Resources Coalition (SPARC) Europe maintains a database of citation studies (sparceurope.org/oaca/). Of 70 studies registered as of October 2015, 46 (66%) found an OA citation advantage, 17 (24%) found no advantage, and 10% were inconclusive.

The open citation advantage holds for more than just articles. A study of 85 cancer clinical trial articles by Piwowar and colleagues found that those who published their data openly experienced a 69% average increase in citations over articles without shared data [20]. These results were confirmed and extended by Piwowar and Vision, who looked at over 10,000 articles published in 2001-2009 [21]. They found an overall 9% increase in citations for studies sharing their data, with increases of up to 48% depending on the subset of articles examined and the year of publication. Similar results have recently been reported for astrophysics data [22]. Studies which openly publish their code are also more likely to be cited than those that do not [23].

2.2 Open publications get more media coverage

One way for researchers to gain visibility is for their publications to be shared on social media and covered by mainstream media outlets. There is evidence that publishing articles openly and sharing data can help researchers get noticed. A study of over 2,000 articles published in *Nature Communications* showed that those published openly received nearly double the number of unique tweeters and Mendeley readers than subscription articles [24, 25]. A similar study of over 1,700 *Nature Communications* articles found that OA articles received 2.5-4.4 times the number of page views as subscription articles, and show maintained growth of article views over a longer period [17]. The same study found that OA articles also garnered more social media attention via Twitter and Facebook than non-OA articles.

Encouraging examples, albeit outliers, exist showing the extent of impact open publishing can have on media attention for researchers. In 2014, Lacovara and colleagues published their new dinosaur discovery in the OA journal *Scientific Reports* [26], shared their data as supplemental information, and posted 3D images to figshare [27]. The article was subsequently covered in over 75 media outlets, including the BBC, National Geographic, the Los Angeles Times, and more. As of October 2015, the 3D images on figshare had been viewed over 29,000 times, scoring in the top 5% of outputs tracked by Altmetric (www.altmetric.com/details/2653335). Similarly, in September of 2015, Berger and colleagues published their discovery of a purportedly new species of ancestral human in the OA journal *eLife* [28], and made scans of the bones openly available through *MorphoSource* [29]. The research was covered by news outlets all over the world, and the lead paper already has 6 citations according to Google Scholar.

There is evidence that news coverage confers a citation advantage. For example, a 1991 controlled study found that articles covered by the New York Times received up to 73% more citations that those not covered [30]. A 2003 study confirmed the results of Phillips et al. [30], reporting higher citation rates for articles covered by the media [31]. We refer readers to a blog post by Matt Shipman, which alerted us to these studies and has a good discussion of their continued relevance, despite their older publication dates [32].

2.3 Visibility and journal impact factor

As Sydney Brenner wrote in 1995, *"...what matters absolutely is the scientific content of a paper and...nothing will substitute for either knowing it or reading it"* [33]. Unfortunately, in a job market flooded with applicants, academic institutions are increasingly relying on proxy metrics, like journal impact factor (IF), to quickly evaluate researchers' work. The IF is a flawed metric that does not indicate scientific quality of individual articles [34–37]. However, until institutions cease using IF in evaluations, researchers will understandably be concerned about the IF of the journals in which they publish. Researchers are also aware of the associated visibility and prestige that often comes from publishing in high-IF journals like *Nature* or *Science*. Importantly, concerns about the visibility and prestige associated with IF do not prevent researchers from publishing openly.

The IFs of indexed OA journals are steadily approaching those of subscription journals [38]. Examples of OA journals in the biological and medical sciences with moderate to high IFs, including some from high-profile publishers such as Nature Publishing Group, Public Library of Science (PLOS), and BioMed Central, are listed in Table 1. In the 2012 Journal Citation Report, over 1,000 (13%) of the journals listed with IFs were OA [39]. Of these OA journals, 39 had IFs over 5.0 and 9 had IFs over 10.0. Some OA journals ranked in the top 10 for their discipline. Although in several fields subscription journal IFs were statistically higher than OA journal IFs, in select fields the difference was small. In multidisciplinary journals, rank normalized IF was higher in OA than subscription journals [39]. Data show that moving to an open publishing model may even help some journals increase their IF [40, 41]. The Cofactor Journal Selector Tool (cofactorscience.com/journal-selector) allows authors to search for OA journals with an IF.

Table 1: Examples of OA journals with moderate to high impact factors

Publisher	Journal	2014 IF
American Society for Microbiology	mBio	6.8
BioMed Central	BMC Biology	8.0
BioMed Central	BMC Medicine	7.2
BioMed Central	Genome Biology	10.8
BioMed Central	Genome Medicine	5.8
BMJ Publishing Group	The BMJ	17.4
Cell Press/Elsevier	Cell Reports	8.3
eLife Science Publications	eLife	9.3
Nature Publishing Group	Nature Communications	11.5
Nature Publishing Group	Scientific Reports	5.6
Public Library of Science	PLOS Genetics	7.5
Public Library of Science	PLOS Medicine	14.4
Public Library of Science	PLOS ONE	3.2
Public Library of Science	PLOS Pathogens	7.6
Royal Society Publishing	Open Biology	5.8

2.4 Rigorous and transparent peer review

One of the most pervasive myths is that OA journals have poor or non-existent peer review. This leads many to believe that OA journals are low quality and causes researchers to be concerned that publishing in these venues will be considered less prestigious in academic evaluations. To our knowledge, there has not been any controlled study to date comparing peer review in OA versus subscription journals. Studies used by some to argue the weakness of peer review at OA journals, such as the John Bohannon 'sting' paper [42], have been widely criticized in the academic community for poor methodology [43, 44]. In fact, Bohannon himself admitted, *"Some open-access journals that have been criticized for poor quality control provided the most rigorous peer review of all."* He cites *PLOS ONE* as an example, saying it was the only journal to raise ethical concerns with his submitted work.

Subscription journals have not been immune to problems with peer review. In 2014, the publishers Springer and IEEE retracted over 100 published fake articles from several subscription journals [45, 46]. Also in 2014, poor editorial practices at one SAGE journal opened the door to peer review fraud that eventually led 60 articles to be retracted [47, 48]. Problems with peer review thus clearly exist, but these problems are not exclusive to OA journals. Importantly, unlike most subscription journals, some OA journals have open and transparent peer review processes. Journals such as *PeerJ*, *F1000Research*, Royal Society's *Open Science*, BioMed Central's *GigaScience*, all the journals in BMC's medical series, and

MDPI's *Life* offer authors the option to publish the full peer review history alongside their articles and offer reviewers the opportunity to sign their reviews. Studies have shown that open peer review can produce reviews of higher quality, including better substantiated claims and more constructive criticisms, compared to closed review [49, 50]. Over time, we expect that open peer review will help dispel the myth of poor peer review at OA journals, as researchers read reviews and confirm that the process is rigorous. Authors can also use open reviews to demonstrate to academic committees the rigorousness of the peer review process in venues where they publish, and highlight reviewer comments on the importance of their work.

2.5 Publish where you want and archive openly

Some researchers, especially those from certain disciplines, may not see publishing in OA journals as a viable option, and may wish instead to publish in specific subscription journals seen as prestigious in their field. Importantly, there are several ways to share work while still publishing in subscription journals. According to the SHERPA/RoMEO database (www.sherpa.ac.uk/romeo/; accessed October 2015), 78% of indexed publishers allow some form of article archiving, whether preprints, postprints, or both.

2.5.1 Preprints

Authors may provide open access to their papers by posting them as preprints prior to formal peer review and journal publication. Several archival preprint servers exist covering different subject areas, including arXiv (physics, mathematics, computer science, quantitative biology, quantitative finance, statistics), bioRxiv (biology), and PeerJ Preprints (biological and medical sciences). Additional open repositories, such as CogPrints (psychology, neuroscience, linguistics, and other fields related to cognition), figshare (all disciplines), GitHub (all disciplines), and Social Sciences Research Network (cognitive sciences, economics, humanities, law, and more), are not exclusively preprint servers but also serve this function. Importantly, preprints are generally not considered prior publication and hence do not violate the so-called "Ingelfinger rule" [51] against double publication. Many journals allow posting of preprints prior to or during the review process, including *Science*, *Nature*, and *PNAS*, as well as most OA journals. Journal policies regarding preprints can be checked via SHERPA/RoMEO (www.sherpa.ac.uk/romeo/). Of the over 2,166 publishers included in their database, 44% explicitly allow preprint posting.

Preprints can be indexed in Google Scholar and cited in the literature, thus allowing authors to accrue citations while the paper is still in review. In one extreme case, one of the authors of this paper (CTB) published a preprint that has now received over 50 citations in 3 years [52]. Furthermore, this preprint was acknowledged in NIH grant reviews. Depending on the field, preprints can establish scientific priority. In fields such as physics, astronomy, and mathematics, preprints have evolved to become an integral part of the research and publication workflow [53–55]. Researchers have also argued for increased use of preprints in biology [56].

Studies posted as preprints prior to formal publication tend to receive more citations that those published only in traditional journals [55, 57, 58]. For example, a study by Gentil-Beccot and colleagues found that physics preprints posted on arXiv not only accumulated more citations due to their early availability, but continued to benefit from a citation advantage for months to years after publication [55]. The authors conclude,

> *"There is an immense advantage for individual authors, and for the discipline as a whole, in free and immediate circulation of ideas, resulting in a faster scientific discourse."*

Unfortunately, because of the slow adoption of preprints in the biological and medical sciences, few if any studies have been conducted to examine citation advantage conferred by preprints in these fields. However, the rapidly growing number of submissions to the quantitative biology section of arXiv, as well as to dedicated biology preprint servers such as bioRxiv, should make such studies feasible.

2.5.2 Postprints

Authors can also archive articles on open platforms after publication in traditional journals (postprints). SHERPA/RoMEO allows authors to check postprint posting policies of journals from over 2,166 publishers. Of the publishers currently included in the database, 72% allow authors to archive postprints. Some publishers only allow archiving of an author's submitted manuscript, while others allow the final accepted or publisher-formatted version to be posted. Of notable example is *Science*, which allows authors to immediately post the accepted version of their manuscript on their website, and post to larger repositories like PubMed Central six months after publication. The journal *Nature* also allows archiving of the accepted article in open repositories six months after publication.

If the journal in which authors choose to publish does not formally support self-archiving, authors can submit an author addendum that allows them to retain rights to post a copy of their article in an open repository. The Scholarly Publishing and Academic Resources Coalition (SPARC) provides a template addendum, as well as information on author rights (www.sparc.arl.org/resources/authors/addendum). The Scholar's Copyright Addendum Engine helps authors generate a customized addendum that can be sent to publishers (scholars.sciencecommons.org). Not all publishers will accept author addenda, but some are willing to negotiate the terms of their publishing agreements.

2.6 Publish for low-cost or no-cost

Researchers frequently cite high costs, primarily in the form of article processing charges (APCs), as a barrier to publishing in OA journals. While some publishers – subscription as well as OA – do charge steep fees, many others charge nothing at all. In a 2014 study of 1,357 OA journals, 71% did not request any APCs [59]. Eigenfactor.org maintains a list of hundreds of no-fee OA journals across fields (www.eigenfactor.org/openaccess/fullfree.php). Notable examples of OA journals which do not currently[1] charge authors to publish include *eLife*, Royal Society's *Open Science*, and all those published by Open Library of Humanities.

In addition, many OA journals charge minimal fees. At *PeerJ*, for example, a one-time fee of $99 allows an author to publish one article per year for life, subject to peer review. Most Pensoft OA journals charge only €10-20 (∼$11-22 USD) per page, while a select few are free. F1000Research has an APC of $150 for articles up to 1000 words, and $500 for articles between 1000 and 2500 words. SAGE Open charges $395 per article. Ubiquity Press OA journals charge an average APC of $500, with their open data and software journals charging £100 (∼$150 USD). Cogent's OA journals all function on a flexible payment model, with authors paying only what they are able based on their financial resources. Importantly, most OA journals do not charge any additional fees for submission or color figures. These charges as levied by many subscription publishers can easily add up to hundreds, or even thousands, of dollars (e.g. in Elsevier's *Neuron* the first color figure is $1000 while each additional one is $275). Thus, publishing in OA journals need not be any more expensive than publishing in traditional journals, and in some cases, may cost less.

For OA journals that do charge APCs, fee waivers are often available. Policies vary by publisher, but frequently include automatic full waivers for authors from low-income countries, and partial waivers for those in lower-middle-income countries. Researchers in any country can also request a partial or full waiver if they do not have sufficient resources. Some publishers, such as BioMed Central, F1000Research, Hindawi, and PeerJ, have membership programs through which institutions pay part or all of the APC for affiliated authors. Some institutions also have discretionary funds for OA publication fees. Increasingly, funders are providing OA publishing funds, or allowing researchers to write these funds into their grants. PLOS maintains a searchable list of both institutions and funders that support OA publication costs, organized by country (www.plos.org/publications/publication-fees/open-access-funds/).

If none of the above options work, researchers can make their work available without paying fees by self-archiving preprints or postprints. As discussed in section 2.5, most subscription journals allow authors to openly archive some version of their manuscript, either immediately or following an embargo period. Archiving is free on a variety of platforms, including arXiv, bioRxiv, figshare, institutional repositories, or personal websites. Self-

[1] Both *eLife* and *Open Science* have said they will likely charge an APC in the future, though no dates for the change in fees have been publicly announced.

archiving can thus be an extremely cost-effective method of making one's research openly available.

3 Funding

3.1 Funder mandates on article and data sharing

For academics in many fields, securing funding is essential to career development and success of their research program. Increasingly, funders are not only preferring but mandating open research. The United States National Institutes of Health (NIH) has been a leader in this respect. In 2008, the NIH implemented a public access policy, requiring that all articles arising from NIH-funded projects be deposited in the National Library of Medicine's open repository PubMed Central within one year of publication. NIH also currently requires that projects receiving $500K or more per year in direct costs include a data management plan that specifies how researchers will share their data. In 2016, NIH's data sharing policy will be extended to all grants, regardless of funding level. The policy reads in part,

> *"NIH expects the timely release and sharing of data to be no later than the acceptance for publication of the main findings from the final dataset."* [60]

Since 2011, the United States National Science Foundation (NSF) has also had sharing policies in place stating,

> *"Investigators are expected to share with other researchers...the primary data, samples, physical collections and other supporting materials created or gathered in the course of work under NSF grants."* [61]

All NSF investigators are required to submit a data management plan, specifying data availability. In 2015, in response to the White House Office of Science and Technology (OTSP) Memo on *Increasing Access to the Results of Federally Funded Scientific Research* [62], the NSF announced their new public access initiative. Starting in January of 2016, NSF will require articles from funded projects to be deposited in an open repository within one year of publication. Other U.S. government agencies, such as the Centers for Disease Control and Prevention (CDC), the Department of Defense (DoD), and the Food and Drug Administration (FDA), have announced similar plans to implement article and data sharing requirements in response to the OSTP memo. A crowd-sourced effort has collected information on these agency policies [63] and continues to be updated (bit.ly/FedOASummary).

Researchers can check article and data sharing policies of specific funders through SHERPA/JULIET (www.sherpa.ac.uk/juliet/). As of October 2015, a search for U.S. funders retrieves 14 public and private funders requiring open publishing or archiving of articles, including the Bill and Melinda Gates Foundation, NASA, and the World Bank. In the U.K., over 70 funders have article sharing policies, including the Wellcome Trust and all seven councils comprising Research Councils UK. Internationally, the number of open access policies has been steadily increasing over the last decade (see roarmap.eprints.org/ for data). A smaller but growing number of funders have data archiving requirements. Thus, researchers funded by a wide variety of sources will soon be not just encouraged but required to engage in open practices to receive and retain funding. Those already engaging in these practices will likely have a competitive advantage.

3.2 Special funding for open research

3.2.1 Fellowships, prizes, and travel grants

A number of organizations offer fellowships and travel grants for researchers to receive training and develop open projects. Other organizations offer prizes to those promoting open practices. While we realize some of the following funds may be transitory, they serve as examples of the types of awards for which researchers can qualify when they share they work. There has been an increase in such funds in recent years, and we expect this trend to continue.

1. **Shuttleworth Foundation Fellowship Program**: includes funding for researchers and entrepreneurs working openly in a variety of fields and on diverse problems (shuttleworthfoundation.org/fellows/)

    > *"we are looking for social innovators who are open at heart…The only true way is not a project plan but a champion"*

2. **Mozilla Fellowship for Science**: targeted at researchers interested in open data and open source (www.mozillascience.org/fellows)

    > *"…fellows will receive training and support from Mozilla to hone their skills around open source and data sharing. They will also craft code, curriculum and other learning resources that help their local communities learn open data practices"*

3. **Leamer-Rosenthal Prizes for Open Social Science**: rewards social scientists whose research and/or educational practices encourage transparency and reproducibility through sharing of data and methods; separate prizes for early-career researchers and established faculty (www.bitss.org/prizes/leamer-rosenthal-prizes/)

    > *"Transparency is integral to the validity of social science research – especially when this research informs policy and affects the lives of millions around the world"*

4. **OpenCon Travel Scholarship**: provides funds for students and early-career researchers to attend OpenCon, and receive education in open practices as well as advocacy training (www.opencon2015.org)

> *"Empowering the next generation to advance open access, open education, and open data"*

3.2.2 Research and development grants

1. **Shuttleworth Foundation Fellowship Program**: in addition to providing funding for fellows, Shuttleworth also provides project funding through the fellowship mechanism (shuttleworthfoundation.org/fellows/)

> *"Our number one ask is that openness be at the core of your idea and/or its implementation. Openness is not an add on. It is a fundamental approach to both participation and intellectual property"*

2. **Open Science Prize**: collaborative effort by the Wellcome Trust, NIH, and Howard Hughes Medical Institute to fund open work (www.opensciencepize.org/)

> *"The Prize provides funding to encourage and support the prototyping and development of services, tools or platforms that enable open content...to be discovered, accessed and re-used in ways that will advance discovery and spark innovation."*

4 Career advancement

4.1 Finding collaborators and mentors through sharing

As the world's scientific knowledge grows and the problems we must solve become more complex and multifaceted, no one academic can know or do it all. Researchers must be increasingly willing to establish interdisciplinary collaborations to advance their projects. However, identifying and connecting with potential collaborators is not trivial. To our knowledge, they have been no formal studies on how open practices affect collaborative projects. However, a few anecdotal examples, though not conclusive, serve to illustrate how sharing articles, code, data, and more can attract potential collaborators and mentors.

An excellent example was communicated to us by Dorothy Bishop, a professor at Oxford University. In 2011, after not finding a journal home for her methodological paper, she posted the full article to her blog [64]. She was subsequently contacted by researcher Maximilien Chaumon from the Berlin School of Mind and Brain, who expanded on Bishop's methods and developed a plug-in. Chaumon drafted a manuscript on the work, to which Bishop contributed, and they published the work this year in *Journal of Neuroscience Methods* [65].

In September 2015, academics involved with the newly-established Advancing Research Communication & Scholarship (ARCS) conference and the open access publishing platform The Winnower co-organized a competition to showcase and reward researchers' open scholarship success stories [66].

One notable example from the series was written by Juan Pablo Alperin, a professor at Simon Frasier University [67]. In his prior work for a medical journal, Alperin used the open source software Open Journal Systems (OJS) from the Public Knowledge Project (PKP) (pkp.sfu.ca/ojs/). While developing software for the journal, he built on OJS and contributed plug-ins back to PKP. When he was ready to leave his job at the journal, he contacted PKP director John Willinsky and offered to finish up some plug-ins that were in development if they could give him a short contract. Willinsky agreed, and said he also needed someone to run open access/OJS workshops in Latin America as part of a research project. Alperin accepted the job and spent several years traveling around Latin America giving workshops and conducting a survey on behalf of PKP, subsequently analyzing and writing up the results. He went on to do a PhD at Stanford under Willinsky's direction. As Alperin describes, his contributions to an open source project were thus responsible for launching his academic career.

Another essay in the series was written by researcher Kevin Moerman [68]. During his first postdoc at the Academic Medical Centre in Amsterdam, Moerman started informally sharing MATLAB codes he had written. Sharing and keeping track of versions quickly became difficult, so he eventually posted the codes on GitHub. He assigned a citable DOI to the codes and created a website for the toolbox he now calls GIBBON (www.gibboncode.org). He shared the codes internationally, leading to collaborations with institutions such as Trinity College Dublin and MIT. He hosted free workshops on the toolbox to attract more users. His collaborations with Trinity College and MIT have since grown, leading to the supervision of PhD students, publications, and a job offer to join MIT as a postdoc this November. The GIBBON toolbox currently has over 50 downloads per month, and users continue to contact Moerman with questions, often leading to further collaborations.

At the close of the competition in October, 13 stories had been submitted by researchers, recounting a variety of successes. Bastian Greshake described how he became the "Mark Zuckerberg of open source genetics" by launching a platform for sharing genetic data [69]. Amber Thomas wrote about how her passion for making science accessible led her to launch a company dedicated to helping scientists explain their work in simple terms [70]. Shreejoy Tripathy explained how open science helped him "fall back in love with neuroscience", and led to speaking invitations and collaborative projects [71]. All the essays are openly available through The Winnower (thewinnower.com/keywords/arcs2015).

4.2 Institutional support of open research

There is still a lot of progress to be made in improving how we evaluate academics. However, there are indications that institutions are gradually moving away from flawed journal-level metrics and towards article-level and alternative metrics that recognize open practices in hiring, promotion, and tenure decisions.

In 2013, the American Society for Cell Biology, along with a group of diverse stakeholders in academia, released the San Francisco Declaration on Research Assessment (SF-DORA) (www.ascb.org/dora/). The declaration outlines *"the need to eliminate the use of journal-based metrics, such as Journal Impact Factors, in funding, appointment, and promotion considerations"* and *"assess research on its own merits"*. Additional recommendations for institutions include recognizing data and software as valuable research products. As of October 2015, over 12,000 individuals and nearly 600 institutions have signed SF-DORA in support of the recommendations.

Several institutions have passed resolutions explicitly recognizing open practices in promotion and tenure evaluations. In 2010, the Virginia Commonwealth University Faculty Senate passed a resolution stating,

> *"VCU Promotion and tenure committees should recognize that publication and editorial effort in open access, peer-reviewed journals or re-publication of peer-reviewed articles in an open access repository offers added value and greater public good than scholarship made only available in expensive journal publications"* [72].

In 2012, academics and administrators at the University of North Texas published the Denton Declaration: An Open Data Manifesto stating,

> *"The academy should adapt existing frameworks for tenure and promotion, and merit-based incentives to account for alternative forms of publication and research output including data papers, public data sets, and digital products. Value inheres in data as a standalone research output"* [73]

The declaration has been signed by academics from all over the world.

In 2014, Harvard's School of Engineering and Applied Sciences launched a pilot program to encourage faculty to archive their articles in the university's open repository as part of the promotion and tenure process [74].

5 Intellectual property

5.1 Retain your author rights and control reuse

Contrary to popular belief, practicing open research does not mean forfeiting intellectual property rights over one's work. In fact, authors publishing in OA journals may retain more rights than those publishing in subscription journals, which often require authors to sign over their copyright. OA articles are typically published under Creative Commons licenses, which function within the legal framework of copyright law. Under the licenses, authors retain copyright but grant specific reuse rights to users. All CC licenses (with the exception of the public domain license, CC0) require attribution, which allows authors to receive credit for their work and accumulate citations. Licensors can specify that attribution include not just the name of the author(s) but also links back to the original work. If terms of the license are violated by a user, the licensor can take legal action. There are several legal precedents upholding CC licenses, including: (1) Adam Curry v. Audax Publishing [75, 76]; (2) Sociedad General de Autores y Editores (SGAE) v. Ricardo Andrés Utrera Fernández [77, 78]; and (3) Gerlach v. Deutsche Volksunion (DVU) [79]. Thus, through open licensing, researchers retain control over how their work is read, shared, and used by others.

6 Discussion

6.1 Open questions about open research

While published studies assessing the benefits of open research have increased in recent years, they are many more studies waiting to be done. Some of these studies would involve simply expanding on our knowledge in given areas. For example, while there is published evidence of the citation advantage conferred by sharing data and code, we are aware of only three studies on the former and just one on the latter. The studies on open data citation advantage by Piwowar and colleagues [20, 21] looked at cancer and gene microarray data. Does the citation advantage hold for other types of data? Do data sharing practices (e.g. format and organization of the data) affect whether data sets are cited or reused? Are data more likely to be cited if shared in a general or subject-specific repository? Additional studies of the citation advantage and visibility of open research products in various fields would be beneficial.

Other questions have yet to be asked in formal studies. For example, while open advocates often cite reproducibility as one of the benefits of data or code sharing, we are not aware of any studies systematically looking at whether studies with shared data or code are more reproducible than studies in the same field without available data. A recent study organized by the Center for Open Science and led by one of the current authors (BN) attempted to replicate 100 findings in the psychological sciences [80]. While only 36% of those replications had significant results, it was the sharing of information, protocols, and data between authors of the original studies and the replication teams that allowed experiments to be reproduced faithfully. Further analysis of the openly available data (osf.io/ezcuj/wiki/home/) from the replication studies may allow researchers to discover why the results were not the same in several cases. This reproducibility project marks an important milestone in the quantitative study of the reproducibility problem and the possible ways in which open science can help. However, more research across multiple fields is needed.

In the section on openness and collaborative research opportunities, we presented only anecdotal evidence since we could find no published data on the subject. While it would be hard to quantify and compare across researchers the number of collaborative opportunities directly arising from open practices versus not, one could examine whether open collaborative projects such as OpenWorm (www.openworm.org/) or Open Source Malaria (opensourcemalaria.org/) have higher citation counts or reproducibility than similar closed projects.

6.2 Openness as a continuum of practices

While there are clear definitions and best practices for open access [81], open data [82, 83], and open source [84], we as advocates must be careful not to take an 'all-or-nothing' approach. We should recognize that not all researchers are comfortable with the same level of sharing and appreciate the variety of ways researchers can be open with their work. Openness can be thus defined by a continuum of practices, starting perhaps at the most basic level with openly self-archiving manuscripts and reaching perhaps the highest level with openly sharing research protocols and data in real time.

As researchers share their work and see the benefits, they will likely become increasingly comfortable with sharing and willing to experiment with new open practices. Encouraging these incremental steps should therefore lead to a gradual culture change from closed to open research. Training of researchers early in their careers is fundamental. We recommend that all graduate programs require students to take a course on scientific publishing. In addition to basic writing methodologies and proper citation practices, such a course could include information on author rights and open access publishing. Institutions and funders running grant workshops should incorporate skills training on how to self-archive articles and data to meet mandate requirements. Importantly, education and training must be integrated as much as possible into regular curricular and workshop activities - e.g. data sharing as part of training on meeting grant requirements, rather than a separate course - so as not to increase the time burden on researchers.

7 Summary

The evidence that openly sharing articles, code, and data is beneficial for researchers is strong and building. Each year, more studies are published showing the open citation advantage; more funders announce policies encouraging, mandating, or specifically financing open research; and more employers are recognizing open practices in academic evaluations. In addition, a growing number of tools are making the process of sharing research outputs easier, faster, and more cost-effective. In his 2012 book *Open Access* [7], Peter Suber summed it up best:

> *"[OA] increases a work's visibility, retrievability, audience, usage, and citations, which all convert to career building. For publishing scholars, it would be a bargain even if it were costly, difficult, and time-consuming. But...it's not costly, not difficult, and not time-consuming."* (pg. 16)

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