Ethics

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Open Science Isn't Always Open to All Scientists

Current efforts to make research more accessible and transparent can reinforce inequality within STEM professions.

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In 2017, the Montreal Neurological Institute and Hospital opened access to all their brain imaging, clinical demographics, and DNA information, becoming the largest open repository of such data in the world. This move may seem baffling in a field as competitive as biomedical research, but the reasoning in their announcement was simple: "We realize that we cannot do everything alone."

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This change is one of the latest in the open-science movement, which has grown from grassroots origins to change our most influential scientific institutions. Indeed, the European Commission and other major funding organizations have now announced plans to require open-access publishing for all funding recipients—a policy that could dramatically alter how thousands of scientists do and share their work.

Open science, a global movement toward openness in scientific research, is fundamentally about accountability and transparency of the scientific enterprise. Rather than keeping data and materials (and ideas) within the confines of academic research labs, open science invites anyone to observe, contribute, and create. Academic researchers are part of a society composed mostly of nonscientists who fund, participate in, benefit from, and in some cases are the subjects of their research. At the heart of the open-science movement is the conviction that research in all fields, from the physical sciences to the humanities, must be performed in dialogue with society—a responsibility that predicates "openness" as the core organizing principle for scientific practices.

Yet historically the culture of science has been a solitary and often secretive endeavor. Driven initially by a lack of connectivity (such as scientists working in isolation in labs), as science became a more mainstream pursuit, "closed" scientific practices continued—through habit, but also because of an increasing sense of competition between scientists, either for scant resources or out of a desire to make a new discovery before a competitor. Because science traditionally has rewarded only scientists who are the first to discover ideas and publish findings, there is resistance to move from "closed" practices that protect the secrecy of ideas to a paradigm that claims that openness and sharing will be rewarded.

Because open science is lionized by its practitioners to be a noble, selfless calling, many of its proponents can be too quick to dismiss this resistance. As practicing scientists and as proponents of open, accountable, accessible science ourselves, we wish to examine this pushback in earnest: Open science is built on the same foundation as science itself, and inherits many systematic barriers that already exist in mainstream science.

Because adopting open practices has far-reaching consequences on what is recognized as good science and what allows a scientific career to progress, we need to reject the reactionary response of assuming that open science is without risks. We hope that understanding barriers we and other early career researchers have experienced can help open-science proponents empathize with the constraints under which many scientists operate and work for solutions that understand the social context science exists within.

Open science could only emerge as a response to transformative technological change and web connectivity. Prior to the advent of the internet, science was performed under relatively

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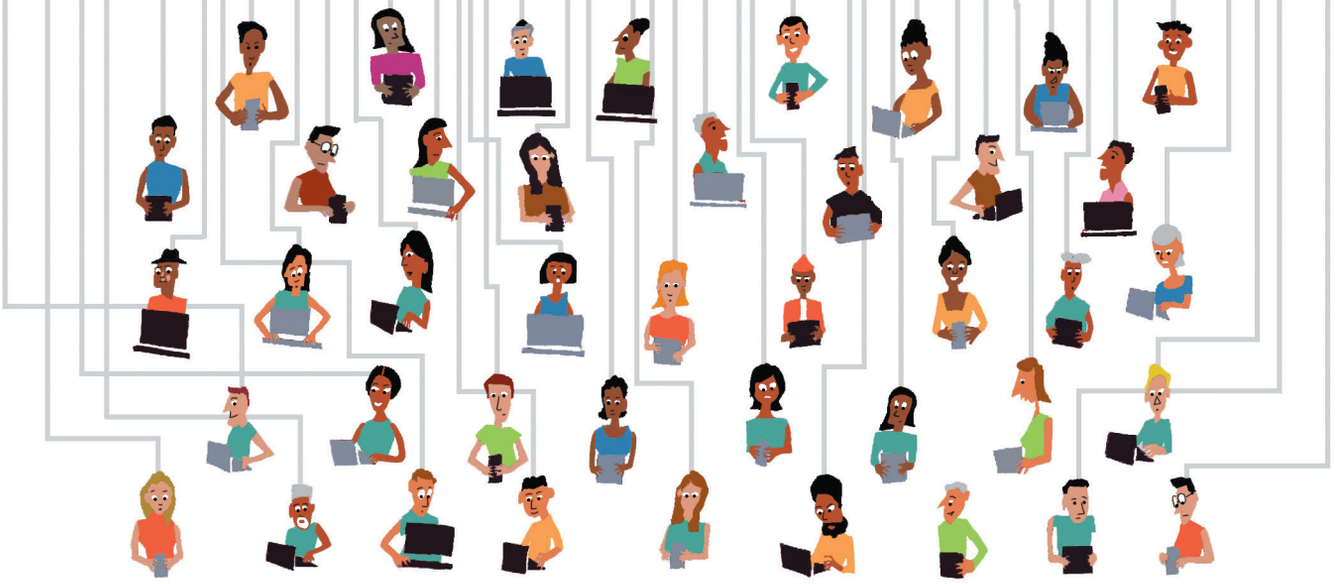
to science information



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siloed conditions: Scientific papers were constrained to distribution by academic libraries, it was not practical to share raw data, computational methods could only be performed in specialized facilities, and a person typically needed to be a member of a university community to access science (or scientists). The internet and computing technology removed such constraints on sharing, openness, and collaboration; indeed, we wrote this column collectively from eight institutions in three countries—made possible through these advances in information technology.

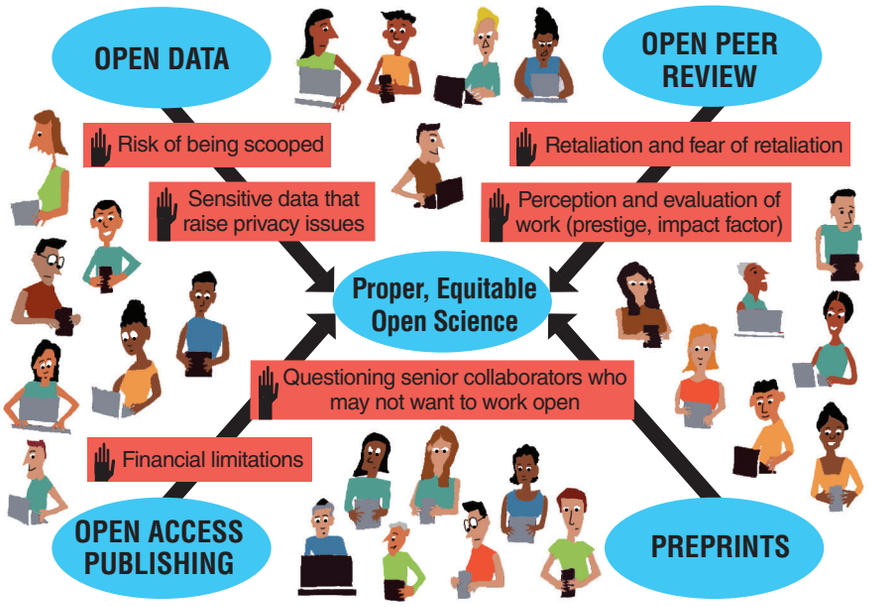
Open science is often seen as a "recent hot topic," although it has been a growing part of our scientific conversation for some time: Self-deposit print servers (also called preprint servers), such as arXiv, have existed since 1991; leading open-access publishers, such as the Public Library of Science, were launched starting in 2001; and all U.K. government funding agencies (known as Research Councils UK or RCUK) introduced open-access policies as early as 2005. The open-science movement has increasingly shaped policy surrounding how science is done, with government funding agencies, private funding bodies, and journals all stipulating that particular aspects of open science be pursued where possible.

Yet because open science can encompass all steps of the scientific process, it is natural that it means different things to different people: One can open the process of data collection, data analysis, computer code, manuscript writing, data publishing, and scholarly publication (to name a few). If you type "open science" into a search engine, you would pull up thousands of hits that do any, all, or none of these things. A side effect of this broad and vague scope, one that has stalled progress in the open-science movement, is that its advocates often become caught up in a detailed checklist of whether a project is "open," based on tallying whether it hits all the aspects of open science discussed above, rather than focusing on the core goal of accountability and transparency.

Open science seeks to make science accessible to everyone, yet projects that are open in one way but not all ways are often derided by the open-science community, without any acknowledgment of the systematic barriers that make open science more accessible to some scientists than others, nor any respect for the steps taken to overcome some of these barriers by scientists who are not necessarily at the most secure point in their career.

Examples abound, including "Open Data Excuse Bingo," an online crowdsourced bingo card mocking the reasons scientists may give for not participating in some aspects of open science, and an online article jokingly subtitled "How to make friends and get them to give you their data." Both examples focus on the perceived benefits of "free data" from others as the value of open science—and the titles are dismissive of legitimate concerns that disproportionately affect a subset of scientists.

There are many valid reasons not to participate in an all-or-nothing approach to open science. Factors such



Different open-science activities present various financial and social barriers to scientists. To address these barriers meaningfully, they must first be recognized by the open-science community. Doing so would further the true goal of open science: transparent and accessible science for all.

as a scientist's career stage, employment stability, financial circumstances, country of origin or residence, and cultural context (including their race, gender identity, and ethnicity) may all create barriers to specific aspects of open science. Power imbalances support some barriers, because of the risk of retaliation across power hierarchies; our concern about being "called out" for not meeting the arbitrary milestone of being "open enough" is one reason we worked together in a large group on this article to share our anonymized experiences.

In addition to advocating for making data, papers, and other parts of science more open, we advocate for recognizing the structural barriers that individual scientists may face and not penalizing individuals for failing to tick all the "necessary" boxes for a project to be considered open. Such calling out of scientists through all-or-nothing criteria reduces the accessibility of science and may reify existing inequalities within this profession.

Accessibility for All Scientists

To truly achieve open science's transformative vision, it must be universally accessible, so that all people have access to the dialogue of science. *Accessible* in this context means usable by all, with particular emphasis on communities often not served by scientific products. This emphasis includes people with sensory disabilities who may use access technology, such as blind and low-vision scientists using screen readers; people in rural or poorer regions with no or slow internet; and people without the means to pay for scientific publications. An accessible open science would serve everyone.

It is an unfortunate irony that open-science practices are not equally accessible to all scientists.

This kind of accessibility can be vital for those who need these scientific findings. For example, family members of people with rare illnesses may not be able to afford to go through a paywall and read scientific studies that may help them access care and resources for their loved one.

It is thus an unfortunate irony that open-science practices are not equally accessible to all scientists. We often lament the paywalls that make research inaccessible to the reader, but we often do not lament the paywalls, in the form of specific barriers to openness, that prevent many scientists from sharing their work in the first place. Accessibility does not happen by accident, but requires us to intentionally evaluate our work, practices, and organizations to ensure that they are accessible. This evaluation is a constant iterative process—and not a one-off decision—to question whether our new praxis has retained the existing structural inequalities of the one before it.

The barriers that make open science unequally accessible fall under two categories: financial and social. The financial barriers are often impassible for some scientists, especially those who are earlier in their career, lack job security (as is common among scientists doing consecutive-term positions such as postdocs), or are at institutions that lack the financial resources to pay for these fees (such as many smaller or public institutions without big endowments). Although there are mechanisms to alleviate some publication costs, such as fee waivers and institutional pots of money to pay fees, disparities still exist, including for researchers from some developing nations, researchers at teaching institutions, or early career scientists in general.

Social barriers are more nuanced and not as easily quantified. For example, the fear of retaliation from making fair but critical comments on a senior colleague's paper and then signing one's name as part of open review, though well justified, makes it less likely for scientists in an underprivileged position to engage in the practice. Open-access journals and papers are also not (yet?) viewed to have as much prestige or influence as traditional high-impact-factor journals by many senior scientists with power over the career paths of junior scientists, and early career researchers like us may fear that publishing in them will indicate that our work is of lesser quality. These difficult-to-measure barriers are not only as real as more easily measured barriers, such as not having the financial resources to pay for open-access publication, but can be more difficult to address because they rely on scientists' perceptions of their own field.

Most barriers to open science are made to appear larger by the signaling that exists around publishing entirely in fully open-access venues. As open science becomes a more widely accepted practice, an increasing emphasis on the use of "gold open-access" publishing (as defined by the Sherpa/Romeo

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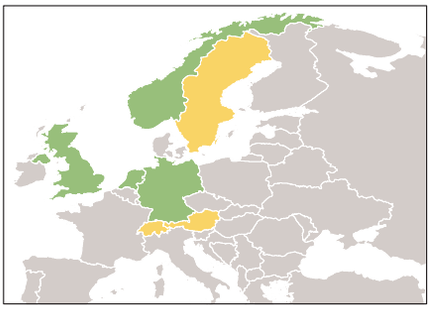
database) has manifested, where additional charges are paid to make a paper open. Many governments and funding bodies have embraced pledges to promote and reward such gold-open-access publishing. This acceptance means that those with adequate financial resources, which are disproportionately associated with certain countries or institutions (but also career stages, and there is the gender gap in research funding to consider), are more able to signal their compliance. Those with fewer resources appear to circumvent the rules—not by choice, but by lack thereof.

It is not unheard of for open-access fees to be paid out of a scientist's personal funds, instead of a grant or an institution's funding sources. Using thousands of dollars from one's salary for those fees is not accessible to everyone. But the need to conform to an emerging practice, through gold-open-access publishing, can create social pressure to do just that. There is a cruel irony to the situation, as it is not rare to hear members of the search committee dismiss an application for a faculty position for having too many papers in open-access journals. The same practice can hurt or boost one's career for reasons that have nothing to do with science.

Open-science proponents often argue that preprints, or archiving a copy of an article in a university repository, achieve the same goals as gold-open-access publishing—even though many scientists operate out of smaller institutions that cannot maintain repositories, or they may not be at a university at all. However, such practices are not valued the same (preprints do not meet most funding bodies' open-access requirements), are not available or widely used in all scientific fields, and do not send the same virtue signal to the wider community.

Open-access publishing remains a morally grounded and worthwhile endeavor. But barriers preventing some scientists from pursuing it should not be wielded as a way to deny their further participation in science, including receiving grant funding or being considered for jobs.

Social barriers highlight the pressures that alter the cost-benefit ratio between researchers at different career stages and with different lived experiences. For example, if an early career scientist participates completely in open-science practices, their publications will land in journals with lower impact factors or that are perceived to be of lower quality because they are open access. This publication record can make these scientists less competitive when job hunting. Debates over the value of journal impact factor notwithstanding, young scientists are still evaluated based on the same principles of their predecessors (large numbers of "high-impact" publications).



example countries who require open access & give APC* block grant to institutions: United Kingdom, Germany, Netherlands, Norway

pros
- money is provided
- money is committed to open science provision
- evidence of high uptake of open science with these policies' implementation

cons
- favors large research
- preprint services such as arXiv not accepted as compliant

** article processing charge*

example countries where open-access APCs* can be taken out of grant research costs: Switzerland, Sweden, Austria

pros
- money is provided
- no requirements at institutional level

cons
- tension between use of money for open science and other research activities
- preferences about money use will be affected by power hierarchy
- preprint services such as arXiv not accepted as compliant

** open-access article processing charge*

The earliest policies regarding open science have been passed in European countries. How grant funding is allotted for paying open-access article processing charges each has pros and cons. On the international funding stage, the Bill and Melinda Gates Foundation requires all research be made immediately available without any embargo period (which is realistically only achieved through gold open access). (Data from RCUK, 2015, Review of the implementation of the RCUK policy on Open Access, https://www.ukri.org/files/legacy/documents/openaccessreport-pdf.)

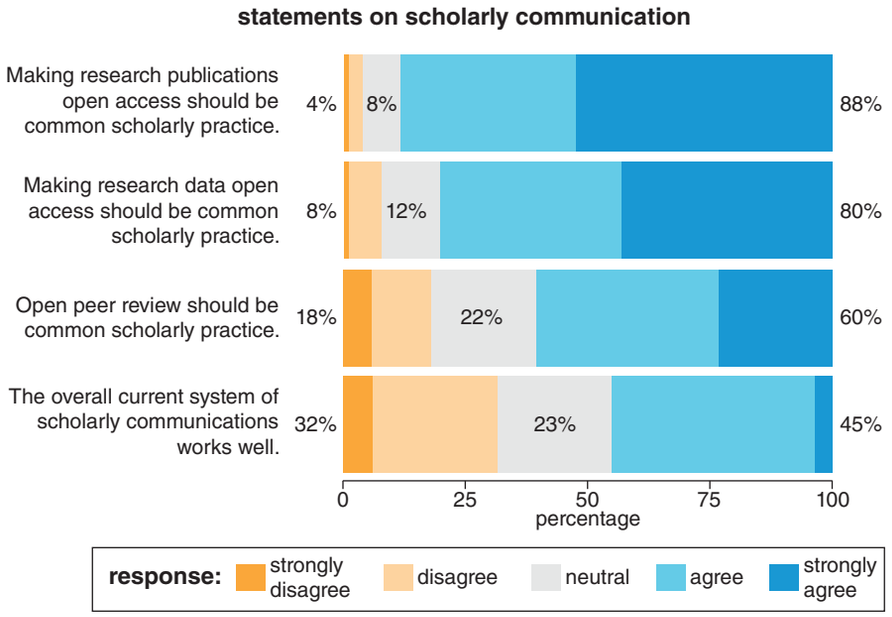
Creating open science has required the development of new tools and products. For example, scientists may need to write new statistical analysis packages and can make these available for other researchers, in addition to the traditional product of a scientific journal article. Yet open tools, code, or data sets are often not valued the same as "normal" academic products, and therefore those who spend their limited time and resources on these products suffer a cost in how they are evaluated for current and future jobs. Moreover, this kind of openness requires a large time investment, above and beyond what has been demanded by traditional, "closed" research. Bias against viewing the infrastructure of open science as valuable or legitimate productivity disincentivizes early career and contingent scientists from participating because they are under enormous pressure to "publish or perish."

Bias against early career scientists can further extend to other open-science practices, especially open peer review and open writing, such as preprints. Signing one's name to a manuscript review opens up the possibility for the credibility of the reviewer to be questioned, perhaps based on career stage or the prestige of the institution where they received their degrees, and to become a metric against which the authors can rebut criticisms, as opposed to the author having to address the review comments at face value.

Thus, arguments defending open-science practices, such as preprints and signed peer reviews, as universal goods without potential to reinforce existing inequalities in science ignore these important disparities. Further, and more disappointing, forcing transparency in practices that have traditionally operated in a "black box" may exacerbate inherent biases against women and people of color, especially women of color. These underrepresented groups have been shown to benefit greatly from double-masked review processes (where the names of the author and the reviewers are known only to the editor) as a way to reduce active and unconscious bias.

Open peer review assumes that everyone accepts criticism in a friendly way and that there is no such thing as

Barbara Aulicino



A cross-disciplinary survey of more than 3,000 scientists showed widespread support for open science, as illustrated in the graph above, but also revealed concerns about practices such as open peer review. (From Ross-Hellauer et al., 2017.)

bias, which is demonstrably untrue. As of yet, no satisfactory solution to pairing double-masked review with products such as preprints or research proposals exists. In this sense, actions in the name of progress (open review) may inadvertently push our field backward (through retaliation to some reviewers), especially for those who are already most embattled.

Power imbalance can play a large role in an individual's ability to convince their research group to use open-science practices and as a result may cause them to not engage in these practices until they have stable employment or are in a senior position. Doing open science requires all members of a team to be on board with working openly. For students and other early career scientists who are trying to work openly, this reality can mean pushing back against established members of a team and possibly suffering the consequences thereof. For senior members of a team, this situation can mean early career folks are forced to work openly, and later have hiring committees who look down on open-access publications penalize them.

Dogmatic adherence to or avoidance of open-access journals can prevent early career scientists from finding the best audience for their science, which depending on the work can be a broad suite of people from high-level policy makers to those suffering from medical conditions and their loved ones. Making data openly available is often seen as high risk because of the possibility of someone publishing analyses with your data before you can. Even though the risk is small, according to a 2016 study by Simon Robin Evans, a small risk particularly affects members of the scientific community with fewer resources (including scientists outside of major research universities, a group that is disproportionately people of color, women, and people with disabilities) when making intermediate research products (data sets, preprints, code) public, because their jobs allocate less time for research and so their risk of having their work published without them is higher.

Barriers preventing some scientists from pursuing open science should not be wielded as a way to deny their further participation.

The anxiety of constantly keeping up with a shifting field of tools can make participating in open science intimidating, especially because we talk about it as a binary: Either you are open and can check all the boxes, or you are deemed not open. This absolutism means we sacrifice good open work, because we want perfectly open work. This standard can prevent those who might be able to work in a partially open way from wanting to engage, because they will be "open-splained" to death for every choice they make, even as they overcome obstacles and do great open science.

Although open-science advocates claim that this movement will cure many problems that exist within science, in practice it can reinforce the existing biases and inequalities commonly found in academia in the ways we lay out in this article. Open science by itself cannot fix all the problems that its proponents claim it will solve, because the problems of bias and inequality are inherent in our broader culture. Many proponents, especially those within academia, act as if scientists are somehow removed from the cultures that have shaped us all and that we are somehow "above" things such as implicit bias, ego, and pettiness—as if our training in removing bias from our research somehow trains us to ignore it within ourselves.

Open science is a push in the right direction for increasing the repeatability and accountability in science. However, "all-or-nothing" approaches are not the answer. We should welcome any and all steps that scientists take to make science more open and work to remove the structural barriers that currently slow or prevent adoption by all scientists.

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