PERSPECTIVES

SCIENCE COMMUNICATION

The chronic growing pains of communicating science online

Scientists have not yet adapted to new information environments

By **Dominique Brossard**[1,2] *and* **Dietram A. Scheufele**[1,2]

Almost a decade ago, we wrote, "Without applied research on how to best communicate science online, we risk creating a future where the dynamics of online communication systems have a stronger impact on public views about science than the specific research that we as scientists are trying to communicate" (*1*). Since then, the footprint of subscription-based news content has slowly shrunk. Meanwhile, microtargeted information increasingly dominates social media, curated and prioritized algorithmically on the basis of audience demographics, an abundance of digital trace data, and other consumer information. Partly as a result, hyperpolarized public attitudes on issues such as COVID-19 vaccines or climate change emerge and grow in separate echo chambers (*2*). Scientists have been slow to adapt to a shift in power in the science information ecosystem—changes that are not likely to reverse.

The business-as-usual response to this challenge from many parts of the scientific community—especially in science, technology, engineering, and mathematics fields—has been frustrating to those who conduct research on science communication. Many scientists-turned-communicators continue to see online communication environments mostly as tools for resolving information asymmetries between experts and lay audiences (*3*). As a result, they blog, tweet, and post podcasts and videos to promote public understanding and excitement about science. To be fair, this has been driven most recently by a demand from policy-makers and from audiences interested in policy and decision-relevant science during the COVID-19 pandemic.

Unfortunately, social science research suggests that rapidly evolving online information ecologies are likely to be minimally responsive to scientists who upload content—however engaging it may seem—to TikTok or YouTube. In highly contested national and global information environments, the scientific community is just one of many voices competing for attention and public buy-in about a range of issues, from COVID-19 to artificial intelligence to genetic engineering, among other topics. This competition for public attention has produced at least three urgent lessons that the scientific community must face as online information environments rapidly displace traditional, mainstream media.

One challenge is for scientists to break free from informational homophily. Since the early days of the internet, the scientific community has had a very spotty track record of harnessing the full potential of online communication tools to reach beyond an audience that already follows science (*4*) and meaningfully connect with those who disagree with or feel disconnected from science. This includes conservative-minded people on climate change; religious audiences on tissue engineering and embryonic stem cell research; and Black, Indigenous, and people-of-color communities on the current pandemic, for example (*5*).

This is not to say that the scientific community has not become more sophisticated in understanding how different audiences find and make sense of information from online sources (*6*). Nonetheless, even some of the scientific community's more ambitious and resource-intensive efforts to communicate science online, such as science series that have been both streamed online and broadcast on television, were heavily favored by audiences that are likely to be receptive to the messages of scientists already (*7*). And when faced with empirical data showing that they can do better, scientists often argue that "[i]ntangible measures… may matter most" (*8*) and give in to the inherently unscientific temptation to turn to personal anecdotes as a defense against inconvenient empirical data that tell them how to do better.

Scientists' homophilic self-sorting online has another, more subtle siloing effect. Social media platforms have provided a temptation for science journalists, scientists, and other science-affiliated actors to follow and retweet each other in an online environment that looks very different from the rest of society. A survey of 2791 US adult Twitter users by the Pew Research Center in 2018 indicated that those most active on this platform are younger (almost a third of Twitter users are under 30 years old), are more likely to identify as Democrats and have at least a college degree, and have higher incomes than US adults overall (*9*). Most perniciously, this has allowed scientists to live in their own science-centric bubbles on social media platforms, sheltered from often sizeable cross-sections of citizens that feel disconnected from the scientific community. Meanwhile, scientists share each other's tweets and—when their instincts get the worst of them—ridicule audiences that they see as "against us" on issues like climate change or evolution (*3*).

Another challenge for the scientific community is ignoring the allure of social media

[1]Department of Life Sciences Communication, University of Wisconsin–Madison, Madison, WI, USA.
[2]Morgridge Institute for Research, Madison, WI, USA.
Email: dombrossard@gmail.com

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skirmishes. It is debatable whether social media platforms that are designed to monetize outrage and disagreement among users are the most productive channel for convincing skeptical publics that settled science about climate change or vaccines is not up for debate (*10*). Even worse, when scientists do engage, the fast-moving and often almost real-time back-and-forth on social media can change the way they use and represent evidence. Rules of scientific discourse and the systematic, objective, and transparent evaluation of evidence are fundamentally at odds with the realities of debates in most online spaces (*11*) Consequently, scientists are at a distinct disadvantage—especially during everything-goes-type social media clashes—as some of the very few participants in public debates whose professional norms and ethics dictate that they prioritize reliable, cumulative evidence over persuasive power (*12*).

On social media platforms, this can create a temptation for scientists to maximize persuasive appeal and use quotes from prominent scientists or illustrative single-study results as "anecdotal evidence" when trying to correct misleading truth claims. The unscientific nature of using anecdotal data or scientific authority figures is partly driven by 280-character constraints on platforms like Twitter and partly by generations of science communication training programs urging scientists to tell more engaging stories (*13*). Unfortunately, this arms race over the most effective narratives has its risks. Decades of communication research indicate that anecdotal accounts on social media of breakthrough severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infections or severe adverse reactions to COVID-19 vaccines, regardless of how rare both are, will be imprinted in people's memories much more effectively than pages of sound statistical data documenting herd immunity (*14*).

Preprints as a form of anecdotal evidence have exacerbated the problem. This is a version of a scientific paper that has often not been peer-reviewed by a scientific journal. Designed to make science more transparent and maximize the corrective potential of science, preprints have emerged as a major driver of episodic, single-study media coverage of science. Especially during the COVID-19 pandemic, conversations surrounding individual non–peer-reviewed preprints has made it difficult to extract meaningful signals about reliable, cumulative scientific evidence from the noise of sometimes short-lived findings reported in a preprint. At first glance, a hyperlink to a preprint article (typically posted on an online archive) might seem like good-enough evidence to support a scientist's Tweet calling for people to wear masks, for example. But winning these short-term Twitter battles using questionable "evidence" that itself might turn out to be wrong is likely to do irreparable long-term damage to the public's perception of science as a reliable way of understanding the world.

Arguably, the greatest challenge that scientists must address as a community stems from a fundamental change in how scientific information gets shared, amplified, and received in online environments. With the emergence of virtually unlimited storage space, rapidly growing computational capacity, and increasingly sophisticated artificial intelligence, the societal balance of power for scientific information has shifted away from legacy media, government agencies, and the scientific community. Now, social media platforms are the central gatekeeper of information and communication about science. The scientific community has been slow to react.

Recent concerns about misinformation are a good illustration of the scientific community's outdated thinking in this space (*15*). Especially during the COVID-19 pandemic, scientists misconstrued misinformation as a new problem, in terms of both nature and scope, even though empirical evidence for these assumptions is thin, at best (*10*). This has distracted scientists from a much bigger and more urgent problem for science: What evidence reaches which parts of the audience is increasingly up to automated algorithms curated by social media platforms rather than scientists, journalists, or users of the platforms themselves.

Algorithms that select and tailor content based on an audience member's social context, personal preferences, and a host of digital trace data increasingly determine what scientific information an individual is likely to receive in Google searches, Facebook feeds, and Netflix recommendations (*10*). For audiences that engage less with credible science content, artificial intelligence, if left unchecked, might eventually slow the stream of reliable information about COVID-19 to a trickle, drowning it out by a surplus of online noise.

At present, there is little that science can do to escape this dilemma. The same profit-driven algorithmic tools that bring science-friendly and curious followers to scientists' Twitter feeds and YouTube channels will increasingly disconnect scientists from the audiences that they need to connect with most urgently. Moving forward, conquering this challenge will require partnerships among the scientific community, social media platforms, and democratic institutions. Scientific logic and access to information are two of the main foundations of enlightened democracies. Distortions to any part of this delicate relationship will inevitably lead to the downfall of the whole system. This also means that it is far too late for Band-Aid solutions. Of course, the scientific community can try to increase scientific literacy among the electorate (*11*). Training scientists to better communicate their science can continue. And scientists can become more savvy at gaming Facebook's or Google's algorithms when communicating science, using tools of digital marketing, for instance, to enhance the reach or effectiveness of their communication.

But these responses address the symptoms rather than the underlying problem. The cause is a tectonic shift in the balance of power in science information ecologies. Social media platforms and their underlying algorithms are designed to outperform the ability of science audiences to sift through rapidly growing information streams and to capitalize on their emotional and cognitive weaknesses in doing so (*10*). No one should be surprised when this happens. When world chess champion Garry Kasparov lost to Big Blue, a supercomputer solely designed by IBM to beat him, no one called for better training for the next generation of chess players, for developing strategies to outsmart supercomputers at chess, or for blaming Kasparov for not understanding what the machine was up to (*10*). Everyone realized that this was a new age for chess and for computing with no turning back of the clock. The same understanding is now here for scientists. It's a new age for informing public debates with facts and evidence, and some realities have changed for good. ■

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