Misinformation about science in the public sphere

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In early 2020, the COVID-19 pandemic created an urgent demand, not just for scientific information and advice, but also for policy proposals that helped curb the spread of the virus while minimizing economic and other collateral societal effects. The research response has been unprecedented. After just 1 year, PubMed returns more than 100,000 publications, 10 times as many as for Ebola or Zika, and nearly as many as produced in 200 years of work on influenza.

Some saw the COVID-19 crisis primarily as a crisis of misinformation, following a longer trend of "truth decay" (1): that is, an array of confusing and conflicting messages that question facts, blur the line between fact and opinion, and dismiss formerly respected sources of information as merely political interests pushing a partisan agenda. The World Health Organization went so far as to warn against an "infodemic . . . an overabundance of information—some accurate and some not—that makes it hard for people to find trustworthy sources and reliable guidance when they need it" (2).

But, of course, the informational environment surrounding COVID-19 continues to be highly complex. Since the beginning of the pandemic, science has moved at breakneck speed and under immense public scrutiny. Influential journals published studies only to retract them a short time later. And the scientific community was faced with the dilemma of having to correct misinformation they knew to be false with science that was emerging and would continue to produce new and sometimes contradictory findings in the months to come (3).

The lessons from COVID-19 leave science communication researchers and practitioners in a difficult spot. If we do not improve the scientific literacy undergirding our public and political discourse, how can we make sense of the challenging issues we face? We cannot set policy or make informed decisions as citizens if we do not agree on a common set of facts and trust a common domain of expertise to ground the conversation. At the same time, misinformation and disinformation are multifaceted phenomena. Diagnosing, understanding, and evaluating the problem and its potential solutions is complicated by a host of factors, including a fundamental transformation of our information ecology, widening partisan rifts, human tendencies toward motivated information processing, and even flawed incentives within the scientific system (4). In short, COVID-19 illustrates powerfully why building a practitioner-relevant evidence base for communicating about science and its public impacts is both more urgent and more complicated than ever.

Responding directly to these complexities, this collection of articles reports on a colloquium of the National Academies of Sciences, Engineering, and Medicine titled, "Advancing the science and practice of science communication: Misinformation about science in the public sphere." This event was the fourth and most recent in a series of convenings devoted to the science of science communication (5–7). Beginning in May 2012, the series was designed to survey the state of empirical social science research in science communication and advance the research agenda. The 2019 iteration was designed more broadly, welcoming individuals and organizations engaged in communicating science with a variety of goals and from a variety of vantage points spanning the communities of research and practice. Participants hailed from universities, think tanks, philanthropic foundations, for-profit research organizations, professional societies, journalism and media companies, informal science education entities, health professions practices, nonprofit organizations, and government agencies.

Panels and presentations were organized around four broad principles: 1) the need to tailor efforts toward clearly defined goals for communicating

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This paper results from the Arthur M. Sackler Colloquium of the National Academy of Sciences, "Advancing the Science and Practice of Science Communication: Misinformation About Science in the Public Sphere," held April 3–4, 2019, at the Arnold and Mabel Beckman Center of the National Academies of Sciences and Engineering in Irvine, CA. NAS colloquia began in 1991 and have been published in PNAS since 1995. From February 2001 through May 2019, colloquia were supported by a generous gift from The Dame Jillian and Dr. Arthur M. Sackler Foundation for the Arts, Sciences, & Humanities, in memory of Dame Sackler's husband, Arthur M. Sackler. The complete program and video recordings of most presentations are available on the NAS website at http://www.nasonline.org/misinformation_about_science.

Author contributions: D.A.S., A.J.H., L.N., and C.M.R. wrote the paper.

The authors declare no competing interest.

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Published April 9, 2021.

science; 2) the importance of theory-based and practice-informed hypotheses for evaluating approaches to communicating; 3) the need for (new) metrics when assessing effectiveness; and 4) the importance of partnerships between researchers and practitioners (including science, technology, engineering and mathematics or STEM scientists) for generating needed evidence. This colloquium was designed as a first step toward building such a practitioner-informed research agenda.

Even though the colloquium took place before COVID-19 became one of the most urgent science (communication) issues of our generation, many of the panels and presentations foreshadowed themes that arose as challenges for science communication during the ongoing pandemic. Similarly, many of the contributions to this colloquium issue were prepared during the pandemic and informed by some of the science communication challenges it raised. Overall, five themes emerged within this colloquium issue.

The first relates to uncertainties in what we know and do not know about misinformation infodemics. To what degree are misinformation and disinformation more frequent or ubiquitous in their occurrence (such as during the ongoing pandemic) than they have been in the past? And what do social scientific literatures tell us about interventions and their likelihood of success? Cacciatore's overview (8) identifies areas of consensus across different strands of literature about the extent to which misinformation might pose a problem in various issue domains. He also examines the state of the social scientific evidence base underlying proposed solutions. Understanding the changing landscape of misinformation will also require an increasingly sophisticated grasp of the information ecologies in which data—accurate or not—gets produced, disseminated, and consumed. Watts, Rothchild, and Mobius (9) posit that previous approaches to mapping the problem of misinformation have taken too narrow a view. Instead, they argue for a much broader take on the issue, encompassing biased and misleading—but not necessarily inaccurate—information that might be produced or amplified by mainstream news organizations.

Of course, COVID-19 also laid bare uncertainties of science itself, the second theme to emerge from the colloquium. During the COVID-19 pandemic, science on the virus, therapies, and vaccines moved at breakneck speed and under immense public scrutiny. Missteps, as a result, were not only predictable but also unavoidable in an environment in which scientists tried to correct information that they knew to be wrong with science that itself was still uncertain and, in some cases, even had to be retracted (3). West and Bergstrom (10) see this as part of a much larger problem related to factors that might impede the scientific community's ability to produce reliable and accurate sources of information, ranging from hype and hyperbole to publication bias and citation misdirection, predatory publishing, and filter bubbles.

The third theme from the colloquium that reverberated throughout the COVID-19 pandemic was the search for effective interventions to combat the spread and uptake of misinformation. Research on corrective interventions has produced mixed results at best, with some meta-analyses showing a continued influence of misinformation even in the face of correction (11). Nyhan (12) takes a deep dive into this problem, examining why short-term corrections, even if they are shown to be effective in laboratory settings, might have a short half-life in real-world competitive message environments. In other words, fact-based interventions might be rendered useless in the long run by identity-motivated biased reasoning and information processing.

As a result, a number of papers in this colloquium issue touch on a fourth theme, suggesting a rethinking of the problem and potential solutions. Dahlstrom (13) examines the role of storytelling in the communication of scientific information. While narrative is viewed warily by some within the scientific community as a distortion of science that promotes misinformation, the technique can counter misinformation in certain contexts by linking scientific truths to human experience through the assignment of meaning and value to reality. Reyna (14) proposes a gist-based framework for understanding how scientific messages are more likely to be remembered and shared through social media, while misinformation is resisted. Effective interventions, based on her model, rely less on mental representations of the memorized facts of a message and more on its gist, which reflects audience knowledge and experience, induces emotions, and connects to social values. This idea is echoed by Yeo and McKasy (15), who provide an overview of the roles of emotion and humor in the formation of science attitudes and related behaviors. Directly addressing the motivational drivers behind the spread and acceptance of misinformation, Yeo and McKasy also discuss how humor and emotions can help with explaining and potentially overriding audiences' inability or lack of motivation to recognize and challenge misinformation.

Howell and Brossard (16) highlight the fifth and final theme, returning to the idea of truth decay, especially during the COVID-19 pandemic: What does it mean for citizens to be scientifically literate in a world where authoritative and well-vetted scientific information sources compete with an onslaught of disinformation and misinformation in fragmented and often partisan information environments? Synthesizing across literatures in information science, communication, and education, among others, Howell and Brossard highlight civic science literacy, cognitive science literacy, and—maybe most importantly—digital media science literacy as key indicators when assessing the effectiveness of interventions against misinformation.

Howell and Brossard (16), along with other contributors to this colloquium issue, flag the pernicious effects of deeply rooted social inequities. This includes having access to information, being able to evaluate its quality, and having the motivation or capacity to extract relevant meaning for one's life. Many existing efforts in science communication favor more affluent or already information-privileged audiences, while failing hard-to-reach or, more aptly, hardly reached audiences (17). COVID-19 is just one of countless scientific issues with disproportionate impacts on populations based on intersections of socioeconomic status, gender, race, ethnicity, and related social determinants of health. Moving forward, the field of science communication needs to rely even more systematically on evidence-based strategies to meaningfully connect with audiences that are likely to be most vulnerable, not only to this particular virus and its effects, but also to a science communication environment that does not serve them as well as it should.

The misinformation crisis exemplified and intensified by the COVID-19 pandemic lays a gauntlet at the door of all science communicators. Scholars, experts, educators, activists, organizers, public servants, and philanthropists share an obligation to engage in "difficult, broad-based negotiation of moral, financial, and other societal trade-offs alongside a collective investigation of scientific potential" (18). In the end, it is our hope that this colloquium issue will stimulate deeper explorations of the causes and cures for misinformation, conducted in closer collaborations among researchers and practitioners.

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