Disparate foundations of scientists' policy positions on contentious biomedical research

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What drives scientists' position taking on matters where empirical answers are unavailable or contradictory? We examined the contentious debate on whether to limit experiments involving the creation of potentially pandemic pathogens. Hundreds of scientists, including Nobel laureates, have signed petitions on the debate, providing unique insights into how scientists take a public stand on important scientific policies. Using 19,257 papers published by participants, we reconstructed their collaboration networks and research specializations. Although we found significant peer associations overall, those opposing "gain-of-function" research are more sensitive to peers than are proponents. Conversely, specializing in fields directly related to gain-of-function research (immunology, virology) predicts public support better than specializing in fields related to potential pathogenic risks (such as public health) predicts opposition. These findings suggest that different social processes might drive support compared with opposition. Supporters are embedded in a tight-knit scholarly community that is likely both more familiar with and trusting of the relevant risk mitigation practices. Opponents, on the other hand, are embedded in a looser federation of widely varying academic specializations with cognate knowledge of disease and epidemics that seems to draw more heavily on peers. Understanding how scientists' social embeddedness shapes the policy actions they take is important for helping sides interpret each other's position accurately, avoiding echo-chamber effects, and protecting the role of scientific expertise in social policy.

science-public relations | opinion formation | biomedical research | topic modeling | collaboration networks

What drives scientists' position taking on matters where empirical answers are unavailable or contradictory? The ongoing contentious debate over "gain-of-function" research (1, 2)—where potentially deadly pathogens are produced in laboratories for study—provides a unique opportunity to examine the social foundations of scientists' public positions on important issues that are fundamentally difficult to answer empirically. In this debate, all parties agree that public safety is the ultimate goal and, as scientists, likely agree on the fundamentals of biology and disease diffusion. Despite this agreement, they strongly disagree on the balance of risks and rewards in doing this research. Assessing risks is difficult because mitigation strategies turn on highly technical and specialized laboratory practices whereas the epidemic potential of a (terrorist or accidental) release could be global. Gauging rewards is similarly elusive, as forestalling research on these sorts of pathogens leaves us unprepared for the next naturally virulent strain. Both action and inaction thus raise a specter of global pandemic. Because possible answers turn fundamentally on unknowable competing risks, empirical research is unlikely to settle the debate; yet—perhaps because the stakes are so high—scientists express deep convictions as they stake public claims on what should be done.

We turned to the social milieu in which scientists are embedded to shed light on why they would publicly announce their support for one position or the other. The social foundation of science rests on a community of scholars sharing ideas and working together (3). Implicit understandings in scholarly communities are shaped by multiple nonempirical factors (4–6), and debates often swing between states of contestation and consensus (7). We can study the workings of such communities by modeling the positions scientists support in the debate as a function of scientists' social networks and scientific specializations. Our results show that choosing to sign one petition over the other is differentially predicted by the scientists' collaborators' positions and their own research focus. Although we found significant peer associations overall, those opposing gain-of-function research seem more sensitive to peers than proponents. Conversely, specializing in fields directly related to gain-of-function research (immunology, virology) predicts public support better than specializing in fields related to potential pathogenic risks (such as public health) predicts opposition. These findings suggest that different social processes likely drive support compared with opposition. Supporters are embedded in a tight-knit scholarly community that is likely familiar with, and trusting of, the relevant risk mitigation practices. Opponents, on the other hand, are embedded in a looser federation of widely varying academic specializations with cognate knowledge of disease and epidemics but perhaps less day-to-day familiarity with laboratory risk procedures and seem to draw more heavily on peers.

Science is frequently called on to settle public debates, particularly over issues that require special substantive knowledge and technical expertise. Science fills this need by drawing on the

Significance

What drives scientists' public support for contentious policy issues? We examined associations between peer exposure and academic specialization on public declarations about research involving potentially pandemic pathogens. Although we found significant peer associations for everyone, they are strongest among the opposition. Conversely, specializing in fields directly related to gain-of-function research predicts support better than specializing in fields related to epidemic risks predicts opposition. These findings suggest that different social processes, rooted in differing social networks and expertise, underlie support or opposition. Identifying the sources of policy support might help parties better understand the different, but legitimate, foundations of each other's positions, providing additional information to inform decision making and thereby help to maintain science's role as an objective arbiter for policy.

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scientific authority bestowed by disinterest and deference to fact (8–10). The nonscientific public, by and large, continues to view science as neutral, unified, and based on a homogenous and clear body of facts (11), although there have been substantial changes in the public perception of science since the 1970s, including signs of politicization (12). For science to retain its position of epistemic authority, scientists must be clear about the foundations of disagreement. Understanding why disagreements over scientific practice emerge helps us better communicate science to the public and, perhaps, helps participants better understand their opponents' positions.

History of the Debate

The debate centers on gain-of-function experiments in which pathogens are endowed with new properties. It was sparked in 2011 by experiments showing how the avian H5N1 influenza virus could be engineered to gain transmissibility among mammals (a function it previously lacked), thus creating an increased risk for spread among humans (13, 14). As the debate unfolded, scientists publicly took sides in opposing camps, with both making plausible claims for protecting public safety against worldwide deadly risks.

Critics of the experiments focused on the risks of an accidental release causing outbreaks as well as the intentional misuse of such research by terrorists. These concerns led to a voluntary moratorium in January 2012 (15, 16) and formalization of additional biosafety regulations, which recommended a minimum standard of biosafety, level 3+, a strict safety protocol (17). Satisfied by these developments, gain-of-function researchers lifted the voluntary moratorium in 2013 (18) and resumed research (19, 20).

Others remained unconvinced that the risks were adequately addressed, and their concerns were heightened by coincidental accidents at the Centers for Diseases Control and Prevention (21) as well as experiments that created a virus similar to the 1918 pandemic influenza virus (22). In July 2014, the Cambridge Working Group (CWG) formed, calling for an extended moratorium and more intensive discussions (23). A few weeks later, opposing scientists formed Scientists for Science (SFS) (24) and emphasized the value of continuing these experiments, arguing that the studies were well regulated and that the existing system of peer review and risk assessment was sufficient.

As key features of the debate, such as the risks and rewards, remained contentious and the rhetoric was heated, observers worried about the obstacles to consensus formation and the long-term consequences of a fractured research community (25). In the months that followed, hundreds of scientists, including several Nobel laureates, signed these competing petitions. In October 2014, the Obama administration announced a research moratorium and asked the National Science Advisory Board for Biosecurity at the National Institutes of Health to develop a federal funding policy recommendation.

Which Side to Take?

We analyzed how scientists' public support for the two positions is differentially related to their peers and research specialty. Social networks are known to channel information and influence beliefs and behavior generally (26–28), and scholars have studied how scientists' social networks shape knowledge production (4) or their patenting behavior (29); yet there is remarkably little research on how scientists influence each other's beliefs and practices on contentious policy activity. As a form of public declaration, petitions of this sort gain value by aggregating the academic prestige and authority of prominent scientists, and it is in the interest of each group to convince members of their community to participate. We thus expected that prominent scientists would engage with their most trusted collaborators, urging them to take a side, which would generate a strong correlation between position-taking amongst close peers.

Scientists spend their lives investigating problems within a relatively narrow field of research. This focus not only defines the explicit knowledge that scientists acquire throughout their careers, but also the implicit knowledge that shapes how they understand fundamental questions, research practices, and standards (30–32). Moreover, people tend to support beliefs that minimize cognitive dissonance and reinforce prior beliefs and knowledge

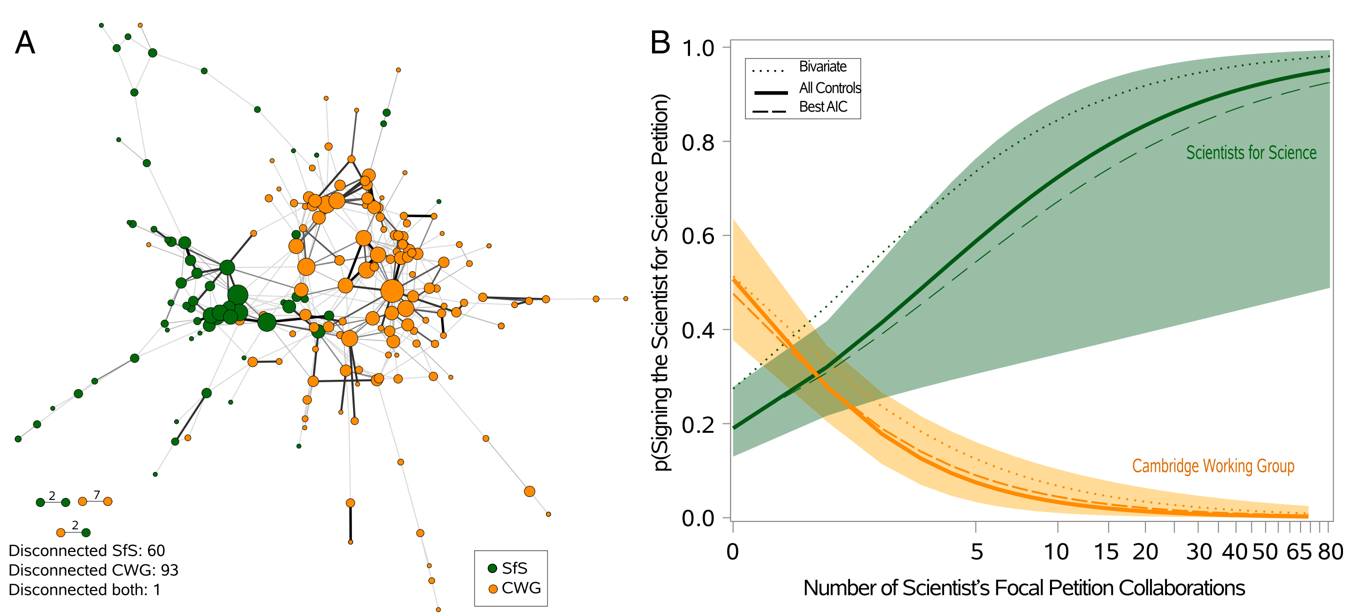

Fig. 1. Collaboration and position on gain-of-function research. (*A*) Scientists' collaboration network. Nodes are petition signers, and edges are collaborations; layout via Fruchterman–Reingold, which tends to place scientists near collaborators; node size is proportionate to the total number of collaborators; $n = 378$. (*B*) Predicted probabilities of signing the SFS petition by number of collaborators who signed either the SFS (green) or CWG (orange) petition. Probabilities are based on logistic regression models (*SI Appendix*, Table S3); the shaded area represents the 95% CI for the "all controls" model (*SI Appendix*, Model 6 in Table S3), which adjusts for specialization, publication volume, and demographic characteristics; $n = 378$.

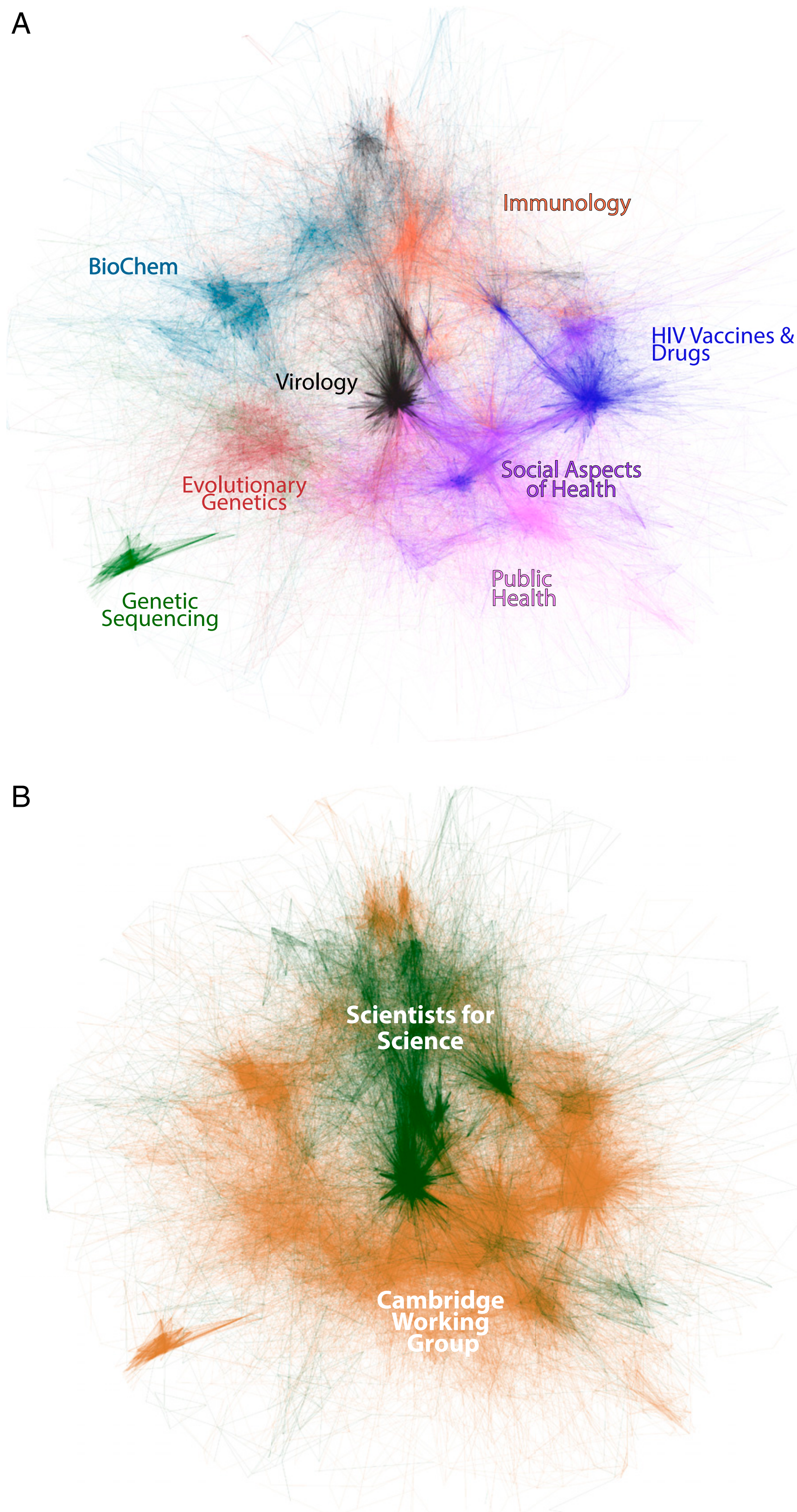

Fig. 2. Correspondence between research topics and position on gain-of-function research. Map of the largest component of scientists' paper-to-paper coterm network: edges link papers (n = 19,257) weighted by their cosine similarity (see the *SI Appendix* for details); layout is via Fruchterman–Reingold, which places similar papers near one another; layout positions are constant in both *A* and *B*. (*A*) Edges colored by papers' highest loading topic (eight colors, corresponding labels positioned near the center of topic clusters). (*B*) Edges colored by the authors' camp (green, SFS; orange, CWG).

(33, 34). Accordingly, we hypothesized that scientists' past research specialties predict which petition they sign. Although scientists with vested interests in gain-of-function research were clearly expected to support its continuation and funding, the vast majority of participants in the debate have no direct interest in such research and thus no simple pecuniary interest. To the extent that specialization captures how scientists understand the fundamental process of science, consistent specialty effects are therefore best seen as indicators for what sort of problems that they perceive as being central to the debate.

Although people generally weigh advice and beliefs of others less than their own in forming opinions (35, 36), such egocentric discounting is higher the greater a person's task-relevant expertise and knowledge (37, 38). We therefore expected peer associations with position taking to be stronger among scientists from fields lacking direct expertise in gain-of-function experimentation and tacit understandings of related scientific practices than among scientists from fields directly related to such research.

Data and Methods

We matched the 378 names from the SFS and CWG petitions with 19,257 publications indexed in Medline or Web of Science. We used the bibliographic information from these publications to reconstruct collaboration networks and to identify research specialties by means of topic models. We then modeled which petition a scientist signs as a function of past collaborators and research specialties, controlling for the total number of collaborators, publications, degree of specialization, gender, highest academic degree, time since degree was obtained, and country of residence and degree. For further details, see the *SI Appendix*.

Results

Fig. 1 reveals the associations between scientists' collaborations and the petition they sign. Fig. 1*A* maps collaboration among the scientists and reveals a clear association of collaboration and camp membership. Fig. 1*B* summarizes the effects of statistical models and confirms that the peer association is generally stronger and more consistent across models for CWG than for SFS (*SI Appendix*, Table S3). Even though we consider only collaborations that predate the debate, it is formally impossible with cross-sectional models to fully identify causal peer effects; however, within the scope that we can test (see the *SI Appendix* for tests of sensitivity to unobserved selection features and robustness to specifications of different time windows) these results are consistent with an interpersonal influence process.

Applying latent Dirichlet allocation topic models (39), we identified eight specialty areas (see the *SI Appendix* for details). We linked papers by pairwise similarity to create network visualizations of the topic space (Fig. 2); we found a clear correspondence between the map colored by specialty area (Fig. 2*A*) and the camp membership of the author (Fig. 2*B*).

Because papers include scientists' collaborators, topic and collaboration effects may be confounded. A joint model including topic and peer effects (with controls) confirms the topic map results (Fig. 3 and *SI Appendix*, Model 6 in Table S3). Scientists working predominantly on the topics Virology, Immunology, and Cellular Biochemistry are likely to sign the SFS petition

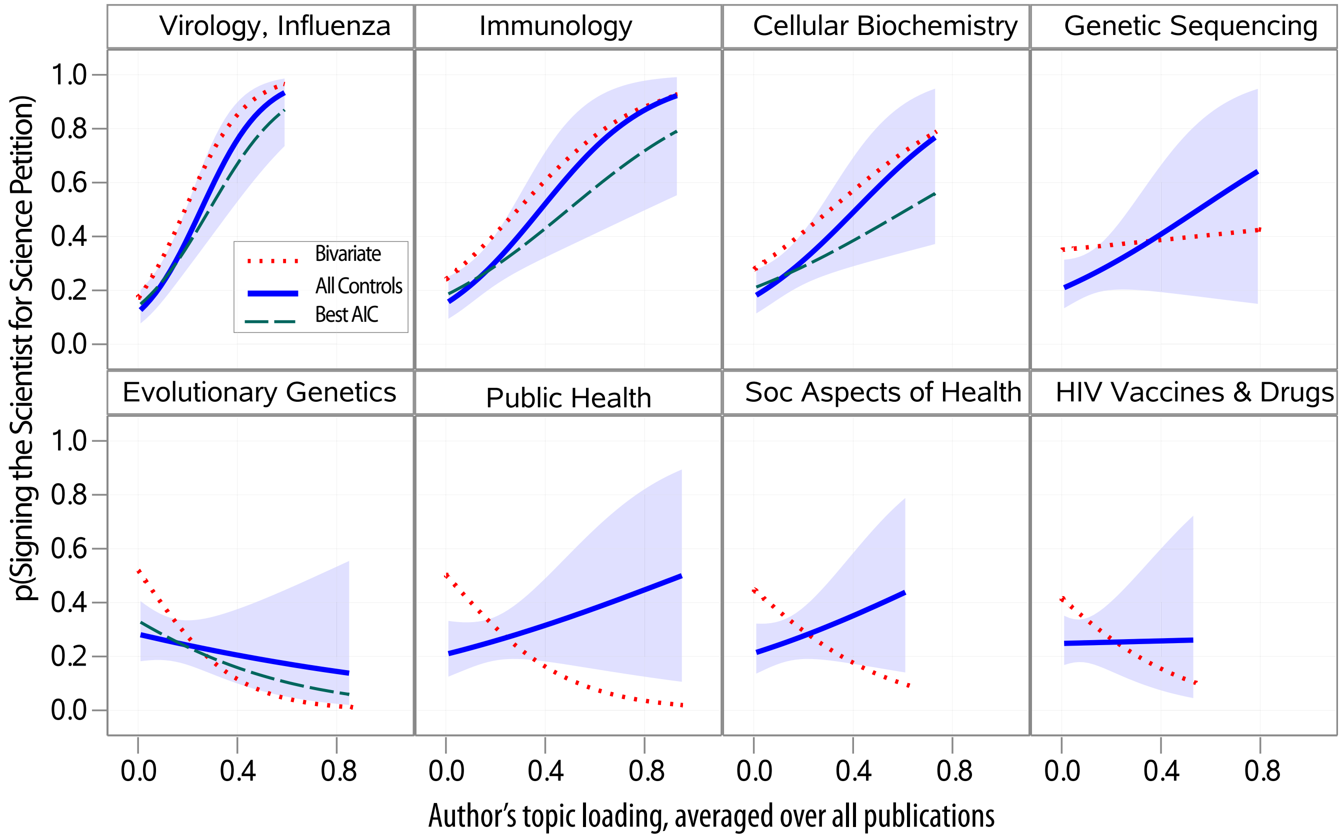

Fig. 3. Effect of topic specialization on supporting SFS. Logistic regression model predicted probabilities of signing the SFS petition as a function of the average author topic loadings; figures extend on the *x* axis to the observed topic maximum; blue lines and 95% CIs (shaded area) are based on the "all controls" model, which adjusts for specialization, publication volume, and demographic characteristics (*SI Appendix*, Model 6 in Table S3). For comparison, the red dotted lines represent the bivariate associations, and the green dashed lines represent the trimmed model with highest Akaike information criterion (AIC) (excludes some topics); $n = 378$.

supporting current safety standards. On the other hand, the more scientists have worked on Evolutionary Genetics, Public Health, HIV Vaccines and Drugs, and the Social Aspects of Health Care, the more likely it is that they will sign the CWG petition in favor of a continued research moratorium.

A comparison of the bivariate and full model results suggests that supporting either of these two positions is driven by different social processes. For CWG supporters, peers are a strong and consistent predictor of the position one takes (Fig. 1*B*) whereas specialty research areas become nonpredictive once peer features enter the model (Fig. 3, *Bottom* row). In contrast, for SFS, the strong bivariate peer effects diminish significantly after specialization is included (Fig. 1*B*), whereas topic effects remain largely consistent across models (Fig. 3, *Top* row).

Conclusion

What drives scientists' position taking on a contentious policy issue when empirical answers are unavailable or contradictory? Our results suggest different bases of support for each position and suggest how the different sides might see the issue. Scientists working in Virology, Immunology, and (to a lesser degree) Cellular Biochemistry are much more likely to sign the SFS petition, and inclusion of field effects generally supplants the SFS peer effect. This pattern suggests that scientists who are more familiar with biomedical experiments are more likely to endorse maintaining current safety protocols. The combination of weak peer effects with strong specialization effects suggests that these scientists are drawing on disciplinary knowledge in making their choice, perhaps reflecting greater familiarity with the laboratory risk mitigation techniques, and thus judge the risks as acceptable. In contrast, specialization effects are generally weaker for CWG and spread over a wider array of substantive fields. In the full models, we find only minimally significant effects for fields associated with population risk, natural evolution of virulent pathogens, and vaccines, whereas peer effects remain consistently strong. This suggests that taking a stand that opposes gain-of-function research is driven by particularistic recruitment through peers above and beyond factors related to one's research specialty, likely reflecting a community of scholars united less by a particular way of doing science than by a general concern for the epidemic potential posed by gain-of-function research.

At the 2009 National Academy of Sciences Annual Meeting, President Barack Obama called for "restoring science to its rightful place" and to "ensure that federal policies are based on the best and most unbiased scientific information" (40). The efficacy of scientific expertise in public policy debates turns on scientists' unique standing with respect to the production of knowledge, access to critical data, and technical expertise based on a life dedicated to data-driven investigation. However, the efficacy of scientific expertise also rests on the assumption that scientists support positions based on knowledge of the case at hand. If it is well understood and clear, scientific knowledge will drive policy positions (as with climate change or vaccine safety, for example). However, in debates where reasonable disagreement over key knowledge claims persists because, for example, unknowable future risks have to be weighed against one another, the experiences of scientists clearly shape the public positions that they take. Explicitly identifying the social foundations of position taking might allow parties to understand each other's perspectives and claims for legitimacy better. Such clearer understandings can then help avoid echo-chamber effects, resolve disagreements between scientists, better inform the public, and ultimately maintain the role of science as an objective arbiter for policy.

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