VALUES AND CREDIBILITY IN SCIENCE COMMUNICATION

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ABSTRACT: Understanding science requires appreciating the values it presupposes and its social context. Both the values that scientists hold and their social context can affect scientific communication. Philosophers of science have recently begun studying scientific communication, especially as it relates to public policy. Some have proposed "guiding principles for communicating scientific findings" to promote trust and objectivity. This paper contributes to this line of research in a novel way using behavioural experimentation. We report results from three experiments testing judgments about the trustworthiness, competence and objectivity of scientists. More specifically, we tested whether such judgments are affected by three factors: consulting or not consulting non-scientists, conducting research under a restrictive or non-restrictive governmental communication policy, and the source of a lab's funding (i.e., government funding, private funding, or a combination of the two). We found that each of these factors affects ordinary judgments of trustworthiness, competence and objectivity. These findings support several recommendations that could help improve scientific communication and communication policies.

KEYWORDS: socially relevant philosophy of science, values in science, experimental philosophy

Introduction

Science communication is integral to our society and its development. Timely access to important scientific information can improve citizens' decision-making and, therefore, their lives. Not only should citizens have access to this information, but they should also have the opportunity to assess it and its relevance.[1] By contrast, limited or distorted information can degrade decision-making and cause serious harm, as has happened recently with renewed outbreaks of the measles and whooping cough in areas of North America where parents choose not to vaccinate

[1] Elizabeth Anderson, "Uses of Value Judgments in Science: A General Argument, with Lessons from a Case Study of Feminist Research on Divorce," *Hypatia* 19, 1 (2004): 1-24.

their children based on inaccurate information.[2] Similarly, there have been outbreaks of other vaccine-preventable diseases such as polio, mumps, and tuberculosis in other regions as the result of not vaccinating.[3] According to science communicators, many scientists are motivated to not only discover the truth about their research questions, but also to share their findings with as wide an audience as possible and to make a positive contribution to society. Accordingly, they care about effective science communication because it is essential to achieving these goals.[4] The perceived credibility of scientists is an essential part of effective science communication.

Philosophers of science have recently begun studying scientific communication, especially as it relates to values and public policy.[5] Some have proposed "guiding principles for communicating scientific findings" to promote trust and objectivity.[6] Others list principles for effective citizen assessment of scientific information.[7] This takes place in the context of a more general recent debate over whether science is, or should be, "value-free."

While value-free proponents argue that non-epistemic values have no role in the scientific process, many now recognize scientific practice as value-laden.[8] Some

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[2] Varun K. Phadke, Robert A. Bednarczyk, Daniel A. Salmon, and Saad B. Omer, "Association Between Vaccine Refusal and Vaccine-Preventable Diseases in the United States: A Review of Measles and Pertussis," *Jama* 315, 11 (2016): 1149-1158.

[3] Eve Dube, Maryline Vivion, and Noni E. MacDonald, "Vaccine Hesitancy, Vaccine Refusal and the Anti-Vaccine Movement: Influence, Impact and Implications," *Expert Review of Vaccines* 14, 1 (2015): 99-117; Saad B. Omer, Daniel A. Salmon, Walter A. Orenstein, M. Patricia Dehart, and Neal Halsey, "Vaccine Refusal, Mandatory Immunization, and the Risks of Vaccine-Preventable Diseases," *New England Journal of Medicine* 360, 19 (2009): 1981-1988.

[4] Anthony Dudo, "Toward a Model of Scientists' Public Communication Activity. The Case of Biomedical Researchers," *Science Communication* 35, 4 (2013): 476-501.

[5] Anderson, "Uses of Value Judgments in Science," 1-24; Kevin Elliott and Daniel J. McKaughan, "Non-Epistemic Values and the Multiple Goals of Science," *Philosophy of Science* 81, 1 (2014): 1-21; Kyle Powys Whyte and Robert P. Crease, "Trust, Expertise, and the Philosophy of Science," *Synthese* 177, 3 (2010): 411-425.

[6] Kevin C. Elliott and David B. Resnik, "Science, Policy, and the Transparency of Values," *Environmental Health Perspectives* 122, 7 (2014): 647-650.

[7] Anderson, "Uses of Value Judgments in Science," 1-24; Heidi Grasswick, "Climate Change Science and Responsible Trust: A Situated Approach," *Hypatia* 29, 3 (2014): 541-557.

[8] Kevin C. Elliott, "Direct and Indirect Roles for Values in Science," *Philosophy of Science* 78, 2 (2011): 303-324; Gillian Einstein, "Situated Neuroscience: Exploring. Biologies of Diversity," in *Neurofeminism: Issues at the Intersection of Feminist Theory and Cognitive Science*, eds. Robyn Bluhm, Anne Jaap Jacobson, and Heidi Lene Maibom (London: Palgrave Macmillan, 2012), 145-

claim that non-epistemic values can legitimately play a direct role in the earlier stages of the scientific process, such as deciding which projects to pursue or how to fund them, but that they should have only an indirect role in the later stages, such as deciding which empirical claims to make.[9] Others argue that because people are unavoidably situated in a particular social context, non-epistemic values may have a legitimate role in all stages of their research. On this approach, we should neither ignore nor proscribe the role of values, but instead embrace those values and manage them in ways that improve scientific practice.[10]

Relatedly, science communication is rife with non-epistemic values that play a role in the uptake of scientific information. Some researchers argue that philosophical research on values in science largely ignores the important role that collaboration plays in the scientific process.[11] Collaboration and communication between scientists, among scientific communities and, in some cases, relevant publics, often helps promote progress in science and philosophy of science.[12] Furthermore, research has shown that science communication and the uptake of information can be highly influenced by cultural predispositions.[13] Therefore, the relationship between values in science and science communication warrants further investigation.

This paper contributes to our understanding of these issues in a novel way, by using behavioural experimentation. We report results from three experiments

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9 Heather Douglas, "Inductive Risk and Values in Science," *Philosophy of science* 67, 4 (2000): 559-579; Heather Douglas, *Science, Policy, and the Value-Free Ideal* (Pittburgh: University of Pittsburgh Press, 2009); Heather Douglas, "The Role of Values in Expert Reasoning," *Public Affairs Quarterly* 22, 1 (2008): 1-18.

10 Ingo Brigandt, "The Dynamics of Scientific Concepts: The Relevance of Epistemic Aims and Values," *Scientific Concepts and Investigative Practice* 3 (2012): 75; Sarah S. Richardson, *Sex Itself: The Search for Male and Female in the Human Genome* (Chicago: University of Chicago Press, 2013); Daniel Steel and Kyle Powys Whyte, "Environmental Justice, Values, and Scientific Expertise," *Kennedy Institute of Ethics Journal* 22, 2 (2012): 163-182.

11 Kristina Rolin, "Values in Science: The Case of Scientific Collaboration," *Philosophy of Science* 82, 2 (2015): 157-177.

12 Heather Douglas, "Inserting the Public Into Science," In *Democratization of Expertise? Exploring Novel Forms of Scientific Advice in Political Decision-Making*, eds. Sabine Maasen and Peter Weingart, (Dordrecht: Springer, 2005), 153-169; Carla Fehr and Kathryn S. Plaisance, "Socially Relevant Philosophy of Science: An Introduction," *Synthese* 177, 3 (2010): 301-316.

13 Dan M. Kahan, Hank Jenkins-Smith, and Donald Braman, "Cultural Cognition of Scientific Consensus," *Journal of Risk Research* 14, 2 (2011): 147-174.

testing judgments about the credibility of scientific research. More specifically, we tested whether such judgments were affected by three factors: whether scientists consult with non-scientists, whether scientists conduct research under a restrictive government communication policy, and the source of a lab's funding. We found that each of these factors affected ordinary judgments about credibility. Our findings support several recommendations to improve science communication.

Experiment 1

Some social scientists and philosophers of science have argued that communication from relevant publics is a critical part of the scientific research process.[14] In particular, some argue that relevant publics have knowledge that can help improve scientific research, and that communicating with these publics and learning from can improve scientific practice. However, it has also been argued that this part of the research process often gets overlooked and that scientists should pay more attention to it.[15]

Our goal in this experiment was to test people's judgments about the importance of consulting with relevant publics about scientific research. This experiment is modelled after a well-known case about a group of biologists in the United Kingdom who were studying the cause of high radiation levels found in lamb meat.[16] These scientists were successful in their investigation only after consulting with sheep farmers in the area and learning about the sheep's grazing and drinking patterns. Our research question asked whether consulting with a relevant public increases the perceived credibility of scientific research.

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[14] Karin Bäckstrand, "Civic Science for Sustainability: Reframing the Role of Experts, Policy-Makers and Citizens in Environmental Governance," *Global Environmental Politics* 3, 4 (2003): 24-41; Dan Kahan, "What is the 'Science of Science Communication'?" *Journal of Science Communication* 14, 03 (2015): 1-12; Kahan, Jenkins-Smith, and Braman, "Cultural Cognition;" Douglas, "Inserting the Public;" Whyte and Crease, "Trust, Expertise," 411-425.

[15] Brian Wynne, "May the Sheep Safely Graze? A Reflexive View of the Expert–Lay Knowledge Divide," in *Risk, Environment and Modernity: Towards a New Ecology* eds. Scott Lash, Bronislaw Szerszynski, and Brian Wynne (London: Sage, 1996): 44; Whyte and Crease, "Trust, Expertise," 411-425; Heidi E. Grasswick, "Scientific and Lay Communities: Earning Epistemic Trust through Knowledge-Sharing," *Synthese* 177, 3 (2010): 387-409.

[16] Alan Irwin and Brian Wynne, eds. *Misunderstanding Science?: The Public Reconstruction of Science and Technology* (Cambridge: Cambridge University Press, 2003); Wynne, "A Reflexive View," 44.

Method

Participants

One hundred forty-four participants were tested (aged 19-60, mean age = 32 years; 57 female; 94% reporting English as a native language). Participants were U.S. residents, recruited and tested online using Amazon Mechanical Turk and Qualtrics, and compensated $0.35 for approximately 2 minutes of their time. The same recruitment and compensation procedures were used for all experiments reported in this paper. Repeat participation was prevented.

Materials and Procedure

Participants were randomly assigned to one of four conditions in a 2 (Consultation: extensive/none) × 2 (Outcome: success/failure) between-subjects design. Each participant read one version of a story about scientists who are testing for radiation levels on sheep farms. The Consultation factor manipulated whether the scientists consulted with local sheep farmers before testing began. The Outcome factor manipulated whether the scientists ultimately discovered the radiation's cause. We included the Outcome factor to detect whether lack of consultation affected credibility only when the scientists failed (i.e. whether there was a Consultation × Outcome interaction on credibility judgments). This is the story (with the manipulations separated by a slash in brackets):

> Dangerous radiation was recently found in the lamb meat from a certain country. A group of scientists were then sent to test the radiation levels on sheep farms in the area. Before the scientists began testing, they [consulted extensively/did not consult] with the local sheep farmers and so [did/didn't] take into account their perspective on what happened to the sheep. After the testing was complete, the scientists [discovered/failed to discover] that the sheep were irradiated because they ate contaminated grass.

After reading the story, participants rated their agreement or disagreement with the following statements:

1. The scientists conducted the tests competently.
2. The scientists were objective.
3. The scientists are trustworthy.
4. The scientists should have consulted more with the local sheep farmers.

Each statement appeared on a separate screen while the story remained atop the screen. The statements were always presented in the same order. Participants could not return to a previous screen to change an answer. Responses were collected using a standard 6-point likert scale, 1 (“strongly disagree”) to 6 (“strongly agree”).

Participants then advanced to a new screen and answered a comprehension question from memory (response options rotated randomly):

5. The scientists _____ with the local sheep farmers. [consulted extensively/did not consult]

The correct response depended on the version of the story that the participant read. After testing, participants advanced to a new screen to complete brief demographic questionnaire.

Results

Ninety percent of participants (129 of 144) participants passed the comprehension check. We excluded from the analysis participants who failed, but including them results in the same basic pattern reported below. The same is true in all other experiments reported here. Preliminary regression analyses revealed that participant gender and age did not affect response to any of the dependent measures. The same is true for all the other experiments reported here. These demographic factors will not be discussed further.

For the purposes of analyzing the results, we calculated a “credibility score” based on the first three probes, about competence, objectivity and trust. It is prima facie plausible that these probes measure the same conceptual variable, and responses to the probes were highly internally consistent (Cronbach’s α = .858), strongly suggesting that they measure the same underlying construct. For each participant, their credibility score was the mean of their response to the three items.

A univariate analysis of variance revealed that credibility score was affected by Consultation, $F(1, 125) = 11.25$, $p = .001$, $\eta p2 = .083$, and by Outcome, $F(1, 125) = 47.78$, $p < .001$, $\eta p2 = .277$, but not by their interaction, $p = .425$, n.s. (See Fig. 1.) Follow-up independent samples t-tests compared credibility scores between the Consultation conditions for both the success and failure conditions. In success conditions, credibility scores were higher when the scientists consulted ($N = 34$, $M= 4.70$, $SD = 0.81$) than when they did not consult ($N = 31$, $M = 3.92$, $SD = 1.40$), $t(47.16) = 2.69$, $p = 0.10$. The size of the mean difference was medium-to-large, $MD = 0.78$, 95% CI [0.19, 1.35], $d = 0.78$. In failure conditions, credibility scores were higher when the scientists consulted ($N = 29$, $M = 3.26$, $SD = 1.04$) than when they did not consult (N = 35, M = 2.79, SD = 0.89), t(62) = 1.95, p = .055. The size of the mean difference was medium, MD = 0.47, 95% CI [-0.01, 0.96], d = 0.50.

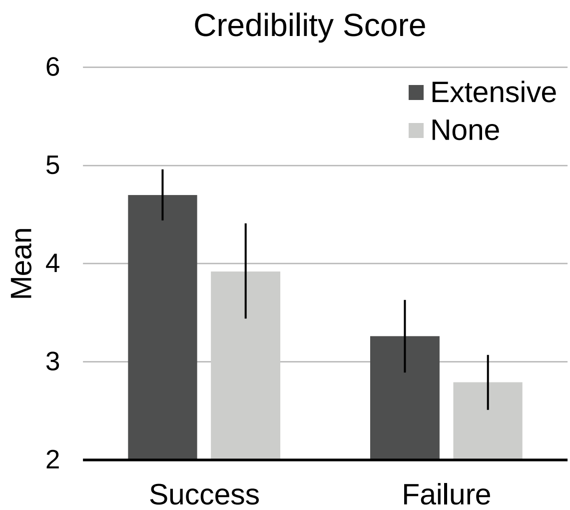

Fig. 1. Mean credibility scores in the four conditions. The scale ran 1 (low) - 6 (high). Error bars represent 95% bootstrapped confidence intervals.

A univariate analysis revealed that response to whether the scientists should have consulted more was affected by Consultation, $F(1, 125) = 84.48$, $p < .001$, $\eta p2 = .403$, Outcome, $F(1, 125) = 6.01$, $p = .016$, $\eta p2 = .046$, but not by their interaction, $p = .544$, n.s. Follow-up independent samples t-tests revealed that in both success and failure conditions, when the scientists did not consult the locals, participants were more likely to agree that the scientists should have consulted more with the locals: success conditions, none/extensive, M = 4.87/3.15, SD = 1.28, 1.02, t(63) = 6.02, $p < .001$, MD = 1.72, 95% CI [1.15, 2.30], d = 1.52 (very large effect size); failure conditions, M = 5.49/3.52, SD = 0.70/1.48, t(38.32) = 6.58, $p < .001$, MD = 1.97, 95% CI [1.36, 2.57], d = 2.13 (very large effect size).

Discussion

This experiment tested whether people's judgments about trustworthiness, competence and objectivity were affected by a scientist's willingness to consult with non-scientists with relevant expertise. We found that consultation significantly affected all three sorts of judgment. More specifically, we found that when scientists consulted with relevant non-scientists about the research, participants perceived the scientists as more trustworthy, competent and objective. When scientists didn't consult with others, participants perceived them as less trustworthy, competent and objective. This suggests an important practical lesson for scientists: building consultation with non-scientists into the research process can make research more credible.

Having observed that scientists' perceived credibility can be affected by whether they consult non-scientists, we next investigated another factor we thought might influence perceived credibility: the official communication policy in a scientist's home nation.

Experiment 2

Researchers have recently criticized rules requiring government scientists to receive prior governmental approval before publishing research or communicating with journalists about findings.[17] The criticisms have been based on general principles concerning the appropriate role of scientific research in modern democratic and industrialized societies. First, if the public is paying for research, then it should have access to the results. Second, if scientific communication is restricted, then relevant findings are less likely to inform policy decisions, thus degrading the quality of those decisions. Researchers argue that citizens should care about this because the consequences of restrictive communication policies can be, and already are, serious.

Without in any way disputing the relevance and importance of these criticisms or arguments, we are interested in studying another dimension of this critical issue. It is possible that people tend to mistrust scientific research produced in a nation with restrictive rules about science communication. That is, even before the consequences of the restrictions are pointed out to them, people might mistrust scientific research conducted under such a regime. Mere awareness of the restrictions might diminish the perceived credibility of scientific research. We designed a second experiment to test this possibility.

[17] Heather Douglas, "The Value of Cognitive Values," *Philosophy of Science* 80, 5 (2013): 796-806; Thomas Homer-Dixon, Heather Douglas, and Lucie Edwards, "Fix the Link Where Science and Policy Meet," *The Globe and Mail*, June 23, 2014.

Method

Participants

One hundred forty new participants were tested (aged 18-68, mean age = 32 years; 51 female; 96% reporting English as a native language).

Materials and Procedure

The testing procedures were basically the same as in Experiment 1. Participants were randomly assigned to one of four conditions in a 2 (Policy: restrictive/unrestrictive) × 2 (Outcome: help/harm) between-subjects design. Each participant read a single version of a story about government-employed scientists trying to communicate the results of their research. The Policy factor manipulated whether the scientists worked in a country where government scientists are required to receive permission from the government before publicizing results. The Outcome factor manipulated whether the scientists concluded that a certain development would help or harm the environment. This is the story (with the manipulations separated by a slash in brackets):

> A corporation recently built a large facility near a major city. Scientists conducted tests around the facility, which suggest that its operation [helps/harms] the local environment. The scientists are currently writing up their conclusions. In their country, government scientists [are/are not] required to receive permission from the government before publishing papers or speaking to journalists about their research.

After reading the story, participants responded to four test statements and a comprehension question in the exact same way as in Experiment 1:

1. The scientists conducted the tests competently.
2. The scientists were objective.
3. The scientists are trustworthy.
4. The scientists should have to receive government permission before publishing their results.
5. In the country discussed, government scientists _____ required to receive permission before publishing results. [are/are not]

Results

Ninety-four percent of participants (131 of 140) passed the comprehension check. We calculated a "credibility score" for each participant in the same way as in Experiment 1 (i.e. the mean of the first three probes, about competence, objectivity and trust). Responses to the three probes again formed a highly reliable scale (Cronbach's $\alpha = .837$).

A univariate analysis of variance revealed that credibility score was affected by Policy, $F(1, 127) = 8.42$, $p = .004$, $\eta p2 = .062$, but not by Outcome, $p = .407$, n.s., or their interaction, $p = .254$, n.s. (See Fig. 2.) A follow-up independent samples t-test revealed that credibility scores were lower when the communication policy was restrictive ($N = 66$, $M = 4.07$, $SD = 1.03$) than when it was unrestrictive ($N = 65$, $M = 4.57$, $SD = 0.89$), $t(129) = -3.03$, $p = .003$. The size of the mean difference was medium, $MD = -0.51$, 95% CI [-0.84, -0.17], $d = 0.53$.

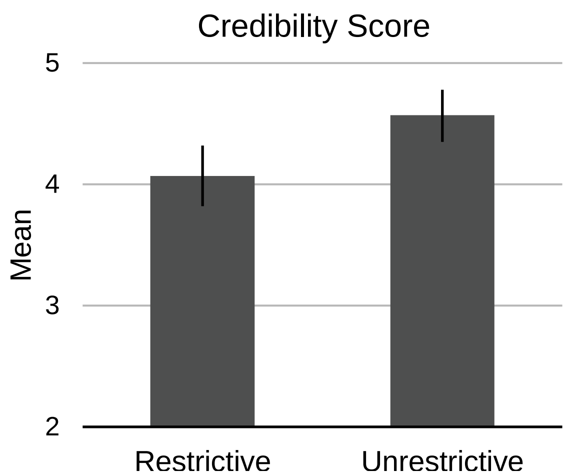

Fig. 2. Mean credibility scores when the communication policy was restrictive or unrestrictive (collapsing across good/bad outcome). The scale ran 1 (low) - 6 (high). Error bars represent 95% bootstrapped confidence intervals.

A univariate analysis revealed that response to whether scientists should have to receive government permission was unaffected by Policy, $p = .110$, n.s., Outcome, $p = .752$, n.s., or their interaction, $p = .335$, n.s.

Discussion

This experiment tested whether people's judgments about scientific credibility are affected by restrictive government policies for communicating scientific results. We found that restrictive policies diminished perceived credibility. More specifically, we found that when government scientists weren't constrained by government policy and were able to communicate their findings to the public, people perceived scientific research as more credible. This suggests an important practical lessons for scientists: having restrictive policies in place that prevent or make it difficult for scientists to communicate their findings to the public makes research less credible. Being aware of this in the earlier stages of scientific practice may help scientists deal with the problems this poses for their research in the later stages. It also suggests that policy changes may be in order if the government wants to improve the credibility of government-funded science.

Having observed that scientists' perceived credibility can be affected by their government's communication policies, we next investigated a third factor we thought might influence perceived credibility: government funding-cuts to important scientific research departments.

Experiment 3

Critics have recently suggested that government bodies are (at least in part) responsible for financially supporting various types of scientific research that is important to their development and prosperity. Moreover, they suggest that the government's financial support is a crucial part of advancing science for individual research labs as well.[18] In other words, government funding plays a large role in the advancement of scientific research both for the scientists and for society, and government funds can be a helpful indicator of socially relevant science.

We are interested in studying the impact of government funding on the credibility of scientific research. For instance, it is possible that the source of a lab's funding, in particular whether it receives government funds, can affect the perceived credibility of that research. We designed an experiment to test this possibility.

[18] Homer-Dixon, Douglas, and Edwards, "Fix the Link."

Method

Participants

Two hundred and forty-two new participants were tested (aged 18-65, mean age = 32 years; 98 female; 94% reporting English as a native language).

Materials and Procedure

Participants were randomly assigned to one of six conditions in a 3 (Funding Source: government/corporate/both) x 2 (Recommendation: change/no change) between-subjects design. Each participant read a single version of a story about an independent meteorological lab conducting research about air traffic quality. The Funding factor manipulated whether the lab was funded by the government, a corporation, or both. The Recommendation factor manipulated whether the lab recommended no changes or major changes to current traffic infrastructure. This is the story (with the manipulations separated by a slash in brackets):

> Atmospheric Labs is a meteorological lab that studies how traffic patterns affect air quality. The lab has a contract to investigate high levels of air pollution in the country. Atmospheric Labs is funded by [the federal government/the corporation Fuel Inc./both the federal government and the corporation Fuel Inc.]. After conducting a series of tests, the lab's scientists recommended [no changes at all/major changes] to the current traffic infrastructure.

After reading the story, participants responded to four test statements and a comprehension question in the exact same way as in Experiments 1 and 2:

1. The scientists conducted the tests competently.
2. The scientists were objective.
3. The scientists are trustworthy.
4. The scientists' recommendation should be implemented.
5. Atmospheric Labs is funded by _______. [government funds/corporate funds/government and corporate funds].

Results

Eighty-three percent of participants (202 of 242) passed the comprehension check. We calculated a "credibility score" for each participant in the same way as in Experiment 1 (i.e. the mean of the first three probes, about competence, objectivity and trust). Responses to the three probes again formed a highly reliable scale (Cronbach's $\alpha = .902$).

A univariate analysis of variance revealed that credibility score was affected by Funding, $F(2, 196) = 8.20$, $p < .001$, $\eta p2 = .077$, and by Recommendation, $F(1, 196) = 50.48$, $p < .001$, $\eta p2 = .205$, but not by their interaction, $p = .524$, n.s. (See Fig. 3.) We conducted a series of planned pairwise comparisons within each type of recommendation, using independent samples t-tests. When the lab recommended no changes, credibility scores did not differ between government funding ($N = 39$, $M = 3.71$, $SD = 1.08$) or dual government-corporate funding ($N = 34$, $M = 3.37$, $SD = 1.04$), $t(71) = 1.34$, $p = .182$, n.s; credibility scores were higher for government funding than for corporate funding ($N = 29$, $M = 2.91$, $SD = 1.17$), $t(66) = 2.92$, $p = .005$, $MD = 0.80$, 95% CI [0.25, 1.35], $d = 0.72$ (medium effect size); and credibility scores were marginally higher for dual government-corporate funding than for corporate funding, $t(61) = 1.66$, $p = .10$, $MD = 0.47$, 95% CI [-0.09, 1.02], $d = 0.43$ (small effect size). When the lab recommended changes, credibility scores did not differ between government funding ($N = 38$, $M = 4.46$, $SD = 0.82$) and dual government-corporate ($N = 35$, $M = 4.47$, $SD = 0.67$), $t(71) = 0.01$, $p = .992$, n.s.; credibility scores were higher for government funding than for corporate funding ($N = 27$, $M = 3.94$, $SD = 0.84$), $t(63) = 2.52$, $p = .014$, $MD = 0.53$, 95% CI [0.11, 0.94], $d = 0.64$ (medium effect size); credibility scores were higher for dual government-corporate funding than form corporate funding, $t(60) = 2.75$, $p = .008$, $MD = 0.53$, 95% CI [0.14, 0.91], $d = 0.71$ (medium effect size).

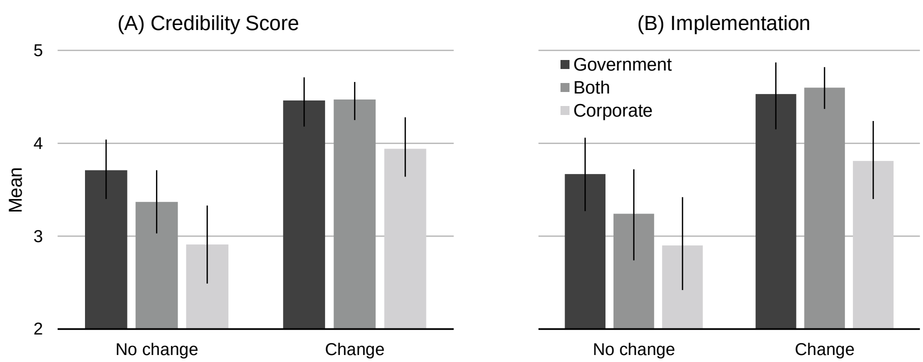

Fig. 3. Panel A: Mean credibility scores in the six conditions. Panel B: mean agreement that the policy recommendation should be implemented. Scales ran 1 (low) - 6 (high). Error bars represent 95% bootstrapped confidence intervals.

A univariate analysis revealed that response to whether the lab's recommendation should be implemented was affected by Funding, $F(2, 196) = 6.47$, $p = .002$, $\eta p2 = .062$, and by Recommendation, $F(1, 196) = 37.91$, $p < .001$, $\eta p2 = .162$, but not by their interaction, $p = .399$, n.s. Judgments about implementation were very strongly positively correlated with credibility scores, $r = .842$, $n = 202$, $p < .001$.

Discussion

This experiment tested whether people's credibility judgments were affected by the source of a lab's funding in three cases: government funding, corporate funding and a mixture of government and corporate funding. We found that the funding source affected credibility judgments. More specifically, we found that people view a lab as more credible when it receives government funding, regardless of whether the lab also receives corporate funding. When a lab received only corporate funding, it diminished the lab's perceived credibility.

General Discussion

An important part of the scientific process is communicating results to interested publics. When scientific results are important for current policy debates and matters of public interest, perceptions of scientific credibility will affect public uptake of science. Nowhere is this more evident than in the recent controversies over the status of evolutionary theory in the science curriculum and the safety of childhood vaccines. It is no surprise, then, that researchers have begun considering the role that values play in the perceived credibility of scientific research and the effectiveness of science communication. For example, some researchers have recently argued that scientific results should be communicated with complete transparency about the values and background assumptions underlying the research, in an effort to promote trust and effective uptake.[19] This is part of an important recent discussion, in science studies and the philosophy of science, about the role that values do and should play in scientific research.[20]

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[19] Elliott and Resnik, "Science, Policy, and the Transparency of Values," 647-650.

[20] Anderson, "Uses of Value Judgments in Science," 1-24; Brigandt, "The Dynamics of Scientific Concepts," 75; Douglas, "Inductive Risk," 559-579; Douglas, "The Role of Values," 1-18; Douglas, *Science, Policy, and the Value-Free Ideal*; Einstein, "Situated Neuroscience," 145-174; Helen Longino, *Science as Social Knowledge: Values and Objectivity in Scientific Inquiry* (Princeton: Princeton University Press, 1990); Helen Longino, *The Fate of Knowledge* (Princeton: Princeton University Press, 2002); Helen E. Longino, *Studying Human Behavior: How Scientists*

In this paper we reported the results of three experiments testing people's judgments of scientific credibility. More specifically, we tested judgments about the trustworthiness, competence and objectivity of scientists and their research. We tested whether these judgments were affected by three factors: whether scientists consulted with non-scientists, whether scientists conducted research under a restrictive government communication policy, and the source of the lab's funding (government funding, private funding, or a combination of both). We found that perceived scientific credibility was increased by consulting with non-scientists (Experiment 1), by working in a nation with unrestrictive science communication policies (Experiment 2), and by receiving government funding (Experiment 3). We also found that perceived credibility was, unsurprisingly, strongly positively correlated with people's willingness to support a policy recommended by scientists (Experiment 3).

These findings suggest some recommendations for scientists interested in communicating their research to the public, or having their research affect debates or public policy. First, when feasible, scientists could build into their research programs consultation with interested non-scientists. For instance, a lab working to develop a vaccine could consult with local parent associations and inquire into concerns that parents might have about vaccines. Then, when communicating the results, the lab can report that parents were consulted and explain how the research directly addresses those concerns. Second, scientists could, either individually or through their professional associations, advocate for unrestrictive government communication policies for scientific research. Our findings suggest that a scientist's credibility can be affected by simply living and working in a country whose government imposes prior restrictions on scientific communication. This should be alarming to all scientists. Indeed, as the recent uproar in Canada over the Harper administration's science communication policy shows, retrograde communication policies can suddenly afflict even advanced democratic societies.[21] Third, scientists should keep in mind the potential cost in credibility of restricting themselves to private funding for their research, because receiving government funding increases a scientist's credibility. To increase the perceived credibility of their research, they could seek support from government agencies and grant sources.

Investigate Aggression and Sexuality (Chicago: University of Chicago Press, 2013); Richardson, *Sex Itself*; Whyte and Crease, "Trust, Expertise," 411-425.

[21] Homer-Dixon, Douglas, and Edwards, "Fix the Link."

Future work on this set of issues could take many directions, in addition to investigating limitations or weaknesses in any of the findings reported here. One direction is to explore the effect of other factors on people's credibility judgments. For instance, perhaps having a demographically and epistemically diverse research team or working in a nation that has recently cut funding for scientific research affects perceived credibility. Another direction is to investigate credibility judgments among more specific populations. Although public uptake of science is a worthy goal and, in many cases, integral to a research team's mission, it is not always a goal. But scientists are almost always concerned with communicating their results to other scientists, either for publication or for securing funding. It is an open question whether the same factors that affect ordinary people's credibility judgments also affect professional scientists' credibility judgments. Accordingly, it would be worth exploring investigating these same questions among a population of scientists. Finally, whereas we investigated these issues by having people read information about scientific research, different factors might be relevant for assessing the credibility of scientific research communicated in other media, such as radio, podcasts, or television.[22,23]

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[23] All the data reported in this paper is openly available at the following Open Science Foundation project: Janet Michaud John Turri (2018, June 15). Values and credibility in science communication. Retrieved from osf.io/v2udm.