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Commentaries

Science and the Public: Debate, Denial, and Skepticism

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Abstract

When the scientific method yields discoveries that imperil people's lifestyle or worldviews or impinge on corporate vested interests, the public and political response can be anything but favorable. Sometimes the response slides into overt denial of scientific facts, although this denial is often claimed to involve "skepticism". We outline the distinction between true skepticism and denial with several case studies. We propose some guidelines to enable researchers to differentiate legitimate critical engagement from bad-faith harassment, and to enable members of the public to pursue their skeptical engagement and critique without such engagement being mistaken for harassment.

Keywords: rejection of science, public involvement in science, critical debate, transparency, harassment of scientists

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When scientists discover a planet in our Milky Way that is made entirely of diamonds (Bailes et al., 2011), public fascination and admiration are virtually assured. Most people revel in the idea, however remote, that one day we might own a chunk of that scientific discovery. By contrast, when the same scientific method yields discoveries that are closer to home but that touch on people's lifestyle or worldviews, or that impinge on corporate vested interests, the public response can be anything but favorable.

The controversy surrounding climate change is just one example of a polarized public debate that seems remote and detached from the actual state of science: Within the scientific community, there is a pervasive consensus that the Earth is warming from greenhouse gas emissions (Anderegg, Prall, Harold, & Schneider, 2010; Cook et al., 2013; Doran & Zimmerman, 2009; Oreskes, 2004; Shwed & Bearman, 2010), but outside science there is entrenched denial of this fact in some sectors of society (e.g., Dunlap, 2013; Lewandowsky, Gignac, & Oberauer, 2013). Media reports occasionally even proclaim that warming has stopped (Ridley, 2014) or that we are heading for global cooling (e.g., Rose, 2013). Those propositions have no scientific support but they may be welcome news to a public concerned about the potential impact of climate mitigation on their lifestyles.

What characterizes the public response to scientific discoveries that are "inconvenient", or threatening to one's lifestyle, livelihood, or deeply-held beliefs? Is it debate, denial, or skepticism? And what options, if any, are there for the public to enter a scientific debate? How can scientists facilitate debate but resist denial? We address those questions in three ways: We first describe the tools of politically-inspired denial. We then report a case study that illustrates the path by which skeptical members of the public are able to contribute to science. We conclude by underscoring the need for scientists to be transparent and to respond to legitimate public concerns, and how the triage between denial and skepticism can be achieved.

Public Debate Versus Denial

Public debate and skepticism are essential to a functioning democracy. Indeed, skepticism has been shown to enable people to differentiate more accurately between truth and falsehood (e.g., Lewandowsky, Stritzke, Oberauer, & Morales, 2005, 2009). However, when medical researchers who investigate the adverse health effects of tobacco are accused of being a "cartel" that "manufactures alleged evidence" (Abt, 1983, p. 127), or when climate change is labelled a "hoax" that is ostensibly perpetrated by corrupt scientists (Inhofe, 2012), or when an American corporate front group likens climate scientists to the Unabomber (an American anarchist convicted of terrorism) in a billboard campaign (Zwick, 2012), then those statements are more indicative of the denial of scientific facts than expressions of skepticism (Diethelm & McKee, 2009; Lewandowsky, Gignac, & Oberauer, 2013; Lewandowsky, Oberauer, & Gignac, 2013; McKee & Diethelm, 2010).

The dividing line between denial and skepticism may not always be apparent to the public, but existing research permits its identification with relative ease because denial expresses itself with considerable homogeneity irrespective of which scientific fact is being targeted (Diethelm & McKee, 2009; McKee & Diethelm, 2010; Oreskes & Conway, 2010). For example, denial commonly invokes notions of conspiracies (Lewandowsky, Cook, et al., 2015; Lewandowsky, Gignac, & Oberauer, 2013; Lewandowsky, Oberauer, & Gignac, 2013; Mann, 2012). Conspiratorial content is widespread in anti-vaccination material on the internet (Briones, Nan, Madden, & Waks, 2012; Zimmerman et al., 2005) as well as on blogs that deny the reality of climate change (Lewandowsky, Cook, et al., 2015). HIV-AIDS denial frequently invokes the claim that AIDS was created by the U.S. Government (Bogart & Thorburn, 2005; Kalichman, 2009; Nattrass, 2010); and a U.S. Senator has authored a book entitled *The Greatest Hoax: How the Global Warming Conspiracy Threatens Your Future* (Inhofe, 2012). Attributes such as "hoax" or "biggest scam in the world to date" also make up the largest share of affective responses by people who reject climate science when they are asked to provide the first word or image that comes to mind in connection with global warming (Smith & Leiserowitz, 2012). Not surprisingly, therefore, the involvement of conspiracism in climate denialist discourse has been affirmed by a blind test (Lewandowsky, Cook, et al., 2015).[i]

A second common feature of denial, which differentiates it further from skepticism and legitimate debate, involves personal and professional attacks on scientists both in public and behind the scenes. The fact that scientists working in the climate arena receive abusive mail and threats has already attracted much public attention (e.g., Lewandowsky, Mann, Bauld, Hastings, & Loftus, 2013; Mann, 2012; Powell, 2011). To illustrate, the first two authors (S.L. and M.M.) have been variously accused of "mass murder and treason" or have received email from people who wanted to see them "six feet under." Less well known is the fact that such correspondence is unlikely to be random: Abusive mail tends to peak after the posting of scientists' email addresses on certain websites run by political operatives.

Those public attacks are often paralleled by prolific complaints to scientists' host institutions with allegations of research misconduct. The format of such complaints ranges from brief enraged emails to the submission of detailed multi-page dossiers, typically suffused with web links and richly adorned with baroque formatting. The small but growing scientific literature on querulous complainants (e.g., Lester, Wilson, Griffin, & Mullen, 2004; Mullen & Lester, 2006) sheds light on the nature of the majority of such complaints.

In the case of tobacco research there is also evidence that complaints about academics are not random but highly organized (Landman & Glantz, 2009). In at least one case known to us (not involving the present authors), allegations of misconduct to a university rested on the fact that a scientist submitted a commentary critical of an earlier paper to a journal for peer review—this complaint was not upheld, but the potentially chilling effects on academic freedom cannot go unnoticed. The triage between such vexatious complaints and legitimate grievances causes considerable expenditure of public funds, and the development of appropriate institutional procedures and the consequences of complaints is an area of ongoing research (e.g., Bourne et al., 2015).

Recent evidence has revealed that up to US$1billion flows into foundations and think tanks in the U.S. every year that are dedicated to political lobbying for various issues. One of the principal objectives of this network is to support a climate "counter movement" that seeks to reframe public discourse surrounding climate change from one of overwhelming scientific consensus to one of doubt, debate, and uncertainty (Brulle, 2014; Plehwe, 2014). To illustrate, more than 90% of recent books that dismiss environmental problems have been linked to conservative think tanks (Jacques, Dunlap, & Freeman, 2008), and such books typically never undergo peer review (Dunlap & Jacques, 2013). A recent social network analysis has highlighted the role of "echo chambers" in promulgating the perception of a scientific debate where in fact there is none (Jasny, Waggle, & Fisher, 2015). The fact that the contrarian talking points that emanate from this network have little or no scientific validity was recently confirmed by a blind expert test: Lewandowsky, Ballard, Oberauer, and Benestad (2016) translated climatological data and their associated contrarian talking points into an economic context and presented them to expert economists for adjudication. The contrarian interpretations were found to be inappropriate and misleading.

A further target for contrarian activity involves preliminary results or unpublished data. This modus operandi was also pioneered by the tobacco industry, which campaigned hard to gain unhindered access to epidemiological data (Baba, Cook, McGarity, & Bero, 2005). At first glance, it might appear paradoxical that an industry would sponsor laws ostensibly designed to ensure transparency of research. However, access to raw data is necessary for the re-"analyses" of epidemiological data by entities sympathetic to corporate interests. In the case of tobacco, those analyses have repeatedly downplayed the link between smoking and lung cancer (e.g., Cataldo, Bero, & Malone, 2010; Michaels, 2008; Proctor, 2011). Similarly, data published by two of the present authors (M.M. and S.L.) have been subject to re-"analyses" on internet blogs to attenuate challenging implications of the research—namely, that the warming from greenhouse gas emissions is historically unprecedented (Mann, Bradley, & Hughes, 1998) and that some of those who oppose this scientific fact tend to engage in conspiratorial discourse (Lewandowsky, Gignac, & Oberauer, 2013, 2015b; Lewandowsky, Oberauer, & Gignac, 2013).

A curious feature of these attacks on scientists is that they tend to be accompanied by public calls for "debate"; often the same individuals who launch complaints with institutions to silence a scientist are also proclaiming that they want to enter into a "debate" about the science that they so energetically oppose.

Public Skepticism and the Scientific Process

In a democracy, calls for genuine debate are to be welcomed and must be taken seriously. Given that scientific issues can have far-reaching political, technological, or environmental consequences, greater involvement of the public can only be welcome and may lead to better policy outcome. To illustrate, the historic Yorkshire market town of Pickering recently revised its flood management plan as a result of a year-long collaboration between the local public, social scientists, and natural scientists (Whatmore & Landström, 2011). The flood management plan that was ultimately accepted differed considerably from the initial draft produced by scientists without the local knowledge that later became available through the public's input. The success of this "co-production" of knowledge was arguably manifest during the winter of 2015/2016 when Pickering escaped the severe flooding that gripped other parts of Yorkshire (Lean, 2016).

Notwithstanding the public's entitlement to be involved in issues that are scientifically informed, scientific debates must still be conducted according to the rules of science. Arguments must be evidence-based and they are subject to peer review before they become provisionally accepted. Arguments or ideas that turn out to be false or imperfect are eventually discarded or updated—a process that may sometimes seem to take (too) long but that appears to have served science and society well overall (e.g., Alberts et al., 2015).

Although these strictures may appear rigorous, it is important to recognize that they do not exclude the public from scientific debate. Unless it can be shown that the public can participate in legitimate scientific debate, the denialist activities just reviewed might acquire a sheen of legitimacy as the only avenues open to the public to question scientific findings.

Recently, two of us (H.F. and N.J.L.B.) were co-authors of an article (Brown, Sokal, & Friedman, 2013) that received much coverage for its criticism of a long-standing, much-cited finding in the field of positive psychology. Positive psychology studies the strengths that enable individuals to thrive and aims to aid in the achievement of a satisfactory and fulfilling life. At the time when the project that led to our article was started, N.J.L.B., the first author of that paper, was essentially a stranger to academia, having only attended 3 weeks of a weekend Master's program in psychology at the age of 51 while working full-time as an international civil servant. When he doubted the validity of some of positive psychology's findings that were presented as fact in his London classroom, he pursued the issue by contacting a researcher in the U.S. (H.F.) by e-mail based only on the proposition that he might be sympathetic to his puzzlement. Unsure of the etiquette and politics that might be involved, he found to his surprise that it was remarkably easy to establish a dialog with senior academics. (Support or advice within his teaching institution was not immediately available.) Once a dialog with the external expert had been established, and once N.J.L.B. had convinced his interlocutors of his sincerity (and got over the worst of his own impostor syndrome), a fruitful scientific collaboration ensued that has thus far led to the publication of five articles (Brown et al., 2013; Brown, MacDonald, Samanta, Friedman, & Coyne, 2014; Brown, Sokal, & Friedman, 2014a, 2014b; Heathers, Brown, Coyne, & Friedman, 2015). Notably, this collaboration differs from conventional student-professor interactions in that the parties initially were not known to each other and had no professional relationship prior to an unsolicited approach by e-mail.

To be sure, the process of getting the first rebuttal article published was not easy, given the stature of the article reporting the original, erroneous finding (Fredrickson & Losada, 2005): It was considered one of the cornerstones of the positive psychology movement and had been cited over 350 times. We encountered a certain amount of

resistance—which we would mostly qualify as bureaucratic rather than sinister, despite the presence of certain apparent conflicts of interest—to the acceptance of both our initial rebuttal article (on the basis that it was "too late" to comment on an article published eight years before), and to our attempts to write a subsequent comment on the original author's reply (on the basis that the standard sequence of replies to a target article was now finished). Ultimately, all articles appeared in print in the same journal (Brown et al., 2013; Brown, Sokal, & Friedman, 2014a, 2014b). A detailed account of the story was provided by Rotondaro (2013).[ii]

Based on their experiences, the present authors strongly support the "Pottery Barn Rule" (Coyne, 2014)—that is, the principle that a journal should commit to accepting all relevant scholarly critiques of original work published in that journal. Had such a principle been a normal part of the publishing process, getting the critiques of the Fredrickson and Losada (2005) paper through the system would have been somewhat easier. Nevertheless, in the end, the system worked as it should: everyone remained calm and polite, the various publishing and appeals processes were tested and observed to work, the scientific record was corrected, the field of positive psychology took stock, and nobody felt the need to publish anyone's home address or other personal details on the Internet (a terrifying process, also known as "doxxing"; e.g., Diresta & Lotan, 2015, that is popular not only with political operatives who oppose climate science but also with anti-vaccination activists).

However, we acknowledge that for many scientists, particularly those working in contested areas, there can be a fine line, on the first reading of an initial, unsolicited contact from a lay person, between the dedicated amateur investigator who might be on to something, and the time-wasting, deluded crank. The first author of this article once engaged in good-faith correspondence with a person who turned out to be not a person but a "sock puppet"; that is, an artificial persona controlled by persons unknown who ultimately published the private correspondence on the internet, presumably with the intent to create embarrassment. Lewandowsky (2011) provided a detailed account of this episode. The second author has had similar experiences over the years, which are spelled out in Mann (2012).

The Need for Vigorous Debate

We underscore that there is plenty of room for honest and vigorous debate in science, even among collaborating authors: One of us (N.J.L.B.) is an enthusiastic proponent of the widespread adoption of genetically-modified organisms (GMOs) as a way to alleviate global food shortages, whereas two of us (M.M. and S.L.) at least provisionally accept the safety of GMOs (EFSA Panel on Genetically Modified Organisms [GMO], 2010; though see Hilbeck et al., 2015) but are concerned about their indirect consequences, such as the emergence of herbicide-resistant weeds that has been associated with overuse of herbicides when GMO crops became available that were engineered to be resistant to herbicides (Gilbert, 2013; Mortensen, Egan, Maxwell, Ryan, & Smith, 2012). One of us (H.F.) is concerned about both their indirect consequences and their potential safety to individuals.

Two of us (H.F. and N.J.L.B.) are not convinced beyond doubt that highly complex climate models are as yet sufficiently validated to be used as the basis of major public policy decisions that might have effects for many decades; the other two authors (S.L. and M.M.) acknowledge the uncertainty inherent in climate projections but note that contrary to popular intuition, any uncertainty provides even greater impetus for climate mitigation (Freeman, Wagner, & Zeckhauser, 2015; Lewandowsky, Ballard, & Pancost, 2015; Lewandowsky, Risbey, Smithson, & Newell, 2014; Lewandowsky, Risbey, Smithson, Newell, & Hunter, 2014).

Notwithstanding those disagreements, the present authors found common ground for this article. We also did not use freedom-of-information (FOI) requests for each other's private correspondence, nor would we ever resort to such means to resolve scientific disagreements with other parties (of which there are many).

We also believe that the public is entitled to participate in scientific debate, and we have presented one case study that illustrates this possibility. Based on the experience of two of the present authors (N.J.L.B. and H.F.), we have compiled guidelines in Appendix A for members of the public who wish to contribute to scientific debate and critique but are unsure how to do so. Based on the experiences of the first two authors (S.L. and M.M.) we have provided parallel guidelines in Appendix B for researchers who are approached by members of the public who wish to engage in collaboration. Lewandowsky and Bishop (2016) tabled further criteria for the "triage" between scrutiny and harassment. The appendices can help both sides navigate the dividing line between scrutiny and denial.

Finally, it is important to recognize that although we believe that scientific evidence should inform political debate, it is no substitute for it. To illustrate, the scientific evidence is fairly clear that the fallout from the Fukushima nuclear accident poses no discernible risk to people in North America (e.g., Fisher et al., 2013; Norman, Angell, & Chodash, 2011) or globally (e.g., Thakur, Ballard, & Nelson, 2013), but that finding should only guide, and definitely not preclude, political debate about the safety of nuclear power. Whatever the science may say about the risks of nuclear power—for example, that it causes 100 times fewer fatalities than renewable biomass (Markandya & Wilkinson, 2007)—those data might be legitimately overridden by the "dread" that nuclear power evokes in people (Slovic, 1987). Dread can justify a country's exit from nuclear power (Jahn & Korolczuk, 2012), although even dread does not justify threats of physical violence against scientists who measure nuclear fallout (Hume, 2015).

Enhancing the Resilience of the Scientific Enterprise

Opinion surveys regularly and consistently show that public trust in scientists is very high (Hamilton, Hartter, & Saito, 2015; Mazur, 1977; Pew Research Center, 2015). However, the position of the scientist as the neutral, disinterested guardian of "the truth," someone who is above ideological and financial considerations, has been hard-won and should not be taken for granted. For example, when our above-mentioned article critical of a long-standing finding in positive psychology (Brown et al., 2013) was published, it was cited on several forums and blogs dedicated to creationist ideas or to climate-change denial. The argument typically ran thus: If psychologists can be as badly wrong as Brown et al. showed, and if psychologists are scientists, then how much confidence can we have in the pronouncements of other scientists? This logic, while severely flawed, does have a certain appeal to a specific subset of the public; this explains, perhaps, why it forms the basis of many types of populist political discourse.

While it is certainly possible to refute such logic in reasoned debate, it might be preferable if scientists refrained from giving provocateurs the opportunity to raise this kind of question in the first place. In this regard, we strongly support the principles of the Open Science movement (e.g., Nosek & Bar-Anan, 2012; Nosek, Spies, & Motyl, 2012; Nosek et al., 2015). We also rigorously contribute to the self-correction of science wherever necessary: The experiences of H.F. and N.J.L.B. are self-evidently exemplary in this regard, and where necessary two of the present authors have engaged in self-correction by publishing a corrigendum although the corrections had no impact on the conclusions of the respective articles: Lewandowsky, Gignac, and Oberauer (2015a) discovered a computational error that changed certain values in a table and figure but did not impact the conclusions, and

Mann, Bradley, and Hughes (2004) corrected the list of data sets that were used in an earlier paper (Mann et al., 1998), which did not affect the originally-reported results. Indeed, the original result reported by Mann et al. has been continually refined over the years. The result has been a more robust and definitive conclusion by the scientific community that current global temperatures are unprecedented during the last millennium or more (e.g., Masson-Delmotte, Schulz, Abe-Ouchi, Beer, & Ganopolski, 2013; PAGES 2k Consortium, 2013).

Finally, we believe that scientists, in any field, who may be tempted to cut corners in the interest of publishing something they "know" to be right—perhaps reasoning that the required concessions are only "wafer-thin" (Goldstone & Jones, 1983)—should consider very carefully the possible consequences of their actions, not only for themselves, their lab, or their institution, but also for science in general. However flawed some critics or criticisms of science may be, in the long-run science can flourish only by rigorous correction.

Conclusions

Science is debate. And as we have shown in this article, critical members of the public can partake in this debate. One of the present authors (N.J.L.B.) was a few weeks into his studies when he commenced a process that ultimately led to the deconstruction of a widely cited paper in psychology. Notably, he pursued avenues within legitimate scientific channels and his work has been taken seriously by senior colleagues. Being taken seriously is not an entitlement but a privilege that needs to be earned by participating in scientific debate by acting scientifically. We have shown that skeptics, whatever their background, can enter into this debate (see Appendix A for specific guidelines).

People who deny scientific facts that they find challenging or unacceptable, by contrast, are by and large not skeptics. On the contrary, they demonstrably shy away from scientific debate by avoiding the submission of their ideas to peer review. Instead, the discursive activity of those individuals is largely limited to blogs and the media, accompanied by complaints to institutions and journals which can have no purpose other than to stifle, rather than promote, scientific debate.

There is a growing body of scholarly literature in the climate arena which suggests that the aggressive efforts by contrarians have not only had a generally chilling effect on the academic community but have also adversely affected the communication and even the direction of research itself (Brysse, Oreskes, O'Reilly, & Oppenheimer, 2013; Freudenburg & Muselli, 2010; Lewandowsky, Oreskes, Risbey, Newell, & Smithson, 2015). For example, in a quantitative analysis of media coverage, Freudenburg and Muselli (2010) showed that the vast majority of findings that were reported subsequent to the last report of the U.N.'s panel on climate change (IPCC) revealed the climate to be changing faster than predicted. Rahmstorf et al. (2007) came to similar conclusions in their comparison of observations to projections. Freudenburg and Muselli suggested that the conservatism of the IPCC was the result of the continued asymmetry of challenge, whereby any "alarmist" prediction—even if amply justified—is pounced upon with vigorous critique and denial, whereas "harmless" projections are met with less hostility by contrarians. Brysse et al. (2013) came to similar conclusions, and Lewandowsky, Oreskes, et al. (2015) analyzed the underlying psychological mechanisms that make the "seepage" of contrarian memes into mainstream science difficult to prevent.

We suggest that the scientific community should respond to legitimate skepticism and politically-motivated denial with a three-pronged approach (see Appendix B): First, legitimate public concern about a lack of transparency and questionable research practices must be met by ensuring that research lives up to modern standards. We endorse most current efforts in this regard and one of us (S.L.) is a member of a relevant initiative involving the use of peer review to enforce openness (https://opennessinitiative.org/; Morey et al., 2015).

Second, we believe that daylight is the best protection against politically-motivated maneuverings to undermine science. The first part of this article is one effort towards such transparency, and we hope that it provides editors and university administrators with the necessary understanding of the background and common strategies of attack with which scientists across multiple disciplines are targeted (see also Lewandowsky & Bishop, 2016).

Finally, skeptical members of the public must be given the opportunity to engage in scientific debate: We have shown how two of the present authors—an academic and a member of the public who had been to three evening classes before his skepticism was aroused—teamed up to critique a widely-cited finding and showed it to be unsupportable. None of their activities fell within the strategies and techniques of denial that we reviewed at the outset, clarifying that denial is not an "avenue of last resort" for members of the public who are desperate to contribute to science or even correct it, but a politically-motivated effort to undermine science.

Notes

i) A detailed analysis of how conspiracist discourse and cognition differs from conventional scientific reasoning was provided by Lewandowsky, Cook, et al. (2015).

ii) It could be suggested that the situation of N.J.L.B at the time was more akin to that of a regular graduate student who is expected to conduct research under supervision. This suggestion is inappropriate given the particulars of the situation (e.g., evening course, no supervisor-student research arrangements, no research infrastructure or support by the host institution). The one advantage open to N.J.L.B. at the time was access to a university library; however, most university libraries known to us around the world permit members of the public to subscribe for a modest fee.

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Appendices

Appendix A: Proposed Guidelines for Critical Scientific Engagement by Members of the Public

Jane Q. Public believes to have discovered an error in Dr. A's work, or she has an alternative account of a previously published finding, or an original idea suitable for publication. The research area is highly contested. How should Ms. Public proceed?

0. Preamble: recognize the scientific process

If your goal is to contribute to a scientific conversation, then you need to follow certain rules. One of those rules is that scientific arguments are conducted in the scientific peer-reviewed literature. If you are unwilling to do so, these guidelines are of little value.

1. Build alliances

Journal editors receive articles from "outsiders" all the time; these outsiders are called "graduate students." Apart from having a university affiliation, beginning graduate students have little advantage over Ms. Jane Q. Public when it comes to having their work considered by editors. Graduate students do, however, benefit from having their supervisor's name on the paper, which serves as an indicator of at least a minimum level of credibility of the submission.

Likewise, you will find it much easier to get your ideas taken seriously if you can introduce them, at least for your first publication, with the support of an established scientist—especially because your first submission is likely to leave considerable room for improvement by a "critical friend."

If you cannot find an ally within academia despite trying repeatedly, you should entertain the possibility that your ideas may not be quite as brilliant as you first thought.

2. Safeguard your appearance

While scientists welcome correspondence from almost anybody, their willingness to continue a conversation will depend at least partly on what they are getting out of it. Most researchers, especially those working in controversial areas, have developed an ability to detect the difference between an approach based on a genuine desire to understand their field, and one that ultimately is just intended to discredit some piece of research or extract information that can be turned against a particular scientist.

As an outsider, no matter how brilliant your idea, you will need to put it forward using the language and the formalities of science; trying to make out that your ideas are beyond such niceties will not help your credibility. Nobody ought to look down on your ideas merely because of your lack of experience. Presenting them appropriately will help to ensure that they are considered and, depending on their merit, robustly questioned.

3. Unless it is unavoidable, avoid questioning researchers' motives

Scientists are required to declare any competing interests in their publications so that external observers can take those competing interests into account.

The fact that a researcher performs consulting work for a pharmaceutical manufacturer must not be hidden or ignored when evaluating her article describing the favorable trial outcome for a new drug from that company; however, corporate funding does not prevent a drug from being an improvement over its predecessors. (Undeclared conflicts of interest are another matter; alert citizens can sometimes play an important part in bringing these to light.)

Scientists are human and can be expected to behave in normal human ways most of the time. Very occasionally one may encounter a form of unethical or corrupt behavior, but in the vast majority of cases, scientists are essentially honest people trying to make their way in an imperfect world where things do not always go according to plan. Science as a career choice is not exempt from the laws of workplace economics and sociology (a fact that scientists themselves might do well to acknowledge more often). Thus, if you discover presumed errors in a scientist's work, the working assumption should be that if the errors are real, they were made accidentally and not in pursuit of some nefarious agenda.

4. Accept that everyone makes mistakes

All scientific results are provisional, and some may be shown to be incorrect, with each new result hopefully making incremental progress towards a better approximation to the truth. Unfortunately, this does not prevent the occurrence of errors, which are a—hopefully—infrequent but inevitable by-product of scientific work.

While the reactions of researchers to being informed about flaws in their work are not always quite as helpful and collegial as they should be, science ultimately does self-correct, even if this is sometimes in the form of the de facto abandonment of a theory rather than any formal renunciation of it by its most earnest proponents.

For the person who brings bad news (by detecting errors or flaws in established science), it follows that the potential for success is greater if the critique is formulated in a constructive way that enables the scientific community to go along with a new way of looking at things.

5. Carefully examine and control the politics

Many people become interested in a scientific topic because they are concerned about its political implications. But the definition of "political" is itself contested. For example, Daniel Kahneman has recommended that scientists should be scrupulously avoiding the political, saying that if science involves a matter "that anybody in Congress is going to be offended by, then it's political" (cited in Basken, 2016). By that broad definition, evolutionary biology, climate science, and much medical research would be political and hence off limits. Indeed, given the number of congressional districts and the diversity among Representatives, Kahneman's criterion might disallow nearly all contemporary science. We therefore adopt a different stance and suggest that politics need not be a barrier to engagement: the fact that smoking causes lung cancer may have political consequences but that must not deter medical researchers. Nonetheless, you should examine very carefully whether the only reason you believe that something is true is because it corresponds with your worldview. If so, you might want to think twice before taking it to the court of science.

Although you will surely find some researchers who agree with you on political matters, and who might champion your cause for that reason, ultimately you will not convince a majority of disinterested scientists of the merits of your argument merely because it would make for a nicer world if it were true.

6. Be patient

As a rule, science moves slowly. It can be hard for outsiders to reconcile themselves to the apparently glacial pace of the publication process. It is not uncommon for a year or more to elapse between submission and publication.

While there are sometimes political reasons for such delays—especially if the article is critical of previously published work—it is often simply a matter of the review process taking time. If your work is critical of established science, it may require more than one submission to find a journal that is willing to accept your paper.

In most cases, the rejections along the way will help improve your work, especially if the reviews were negative (so long as they are detailed), because your paper will become increasingly bullet proof the more opportunity you have had to respond to adversarial comments.

However, if you get flat rejections without the paper going out for review, or if all reviewers are uniformly scathing in their judgment, then you may eventually want to reconsider whether your idea is really as meritorious as it first appeared to be.

Appendix B: Proposed Guidelines for Researchers who Are Approached by a Member of the Public Seeking Critical Engagement

Dr. John Q. Researcher is approached by a member of the public who has discovered an error in his work, or presumes that there is an error in it, and seeks access to the data. The research area is highly contested. How should Dr. Researcher respond?

0. Preamble: recognize the public's right to be involved

Science in the public interest deserves public scrutiny. Science is meant to be transparent and subject to self-correction, and members of the public may well detect errors in one's work. Research data and procedures should therefore generally and wherever possible be in the public domain and freely accessible by anyone.

1. Build rapport

Polite enquiries from the public deserve a polite response. Scientists should assume that a constructive dialogue with an interlocutor is possible. We believe that most members of the public who approach a researcher do so with the intention of constructive dialogue.

2. Safeguard your appearance

Researchers can take several simple safeguards to minimize risks. Researchers should not provide any materials in private correspondence with the interlocutor that they would not be willing to provide to the public at large. The assumption should be that all correspondence may become public in one way or another.

Researchers should also recognize that some interlocutors may be acting in bad faith and are "trolling" (i.e., behave in a "deceptive, destructive, or disruptive manner in a social setting on the Internet with no apparent instrumental purpose"; Buckels, Trapnell, & Paulhus, 2014, p. 97). Because engagement with critics is a core element of science, researchers may feel obliged to respond even to trolls. Trolling has been associated with sadism and psychopathy (Buckels et al., 2014), and scientists should guard against engagement with such individuals.

3. Unless it is unavoidable, avoid questioning the requestor's motives

Scientists should assume that requests for data or clarification are made in good faith and are reasonable. Scientists should also generally not be concerned about the motives of the requestor as simple disagreement must not preclude access to data.

There are, however, exceptions that involve considerations of privacy when medical or behavioral data are involved (e.g., Lewandowsky & Bishop, 2016). For that reason, the ethics code of the American Psychological Association (Sec. 8.14 a) stipulates that data be released to "other competent professionals" (http://www.apa.org/ethics/code/index.aspx). Similarly, the U.K. Medical Research Council's guidelines state that "The custodian [of the data] must ensure that the group [receiving the data] accepts a duty of confidence and protects confidentiality through training procedures, etc, to the same standards as the custodian" (https://www.mrc.ac.uk/documents/pdf/personal-information-in-medical-research/).

It follows that the motives and competence of the requestor do matter in some circumstances. Determining when those circumstances apply is non-trivial and merits further research (e.g., Sydes et al., 2015).

4. Boundaries of transparency

Although most requests for data are reasonable and made in good faith, there are instances when this does not apply. For example, persistent requests for as-yet unpublished data, draft manuscripts, or personal correspondence of any sort is more likely to be vexatious than a good-faith effort to advance science.

The triage between the reasonable and unreasonable is difficult but some proposals have been put forward (Lewandowsky & Bishop, 2016; Sydes et al., 2015).

5. Carefully examine and control the politics

Although the requestor's motives generally should not matter in determining data access, it is important for researchers to understand why their work is being scrutinized. The motives (and techniques) of the tobacco industry when reanalyzing epidemiological data may diverge from those of the original researchers (Baba et al., 2005; Cataldo et al., 2010). Knowledge of motivation can be helpful in anticipating what a requestor's likely intentions are.

Some scientists feel passionately about the political implications of their research. It is important to be aware of one's feelings and politics, and how they might impact one's attitudes towards an interlocutor. One should examine very carefully whether the only reason you believe that something is true is because it corresponds with your worldview. Just because an interlocutor has a different worldview must not prevent them getting access to data.