Keynote Address

Nonsense on Stilts about Science: Field Adventures of a Scientist-Philosopher

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ABSTRACT: Public discussions of science are often marred by two pernicious phenomena: a widespread rejection of scientific findings (e.g., the reality of anthropogenic climate change, the conclusion that vaccines do not cause autism, or the validity of evolutionary theory), coupled with an equally common acceptance of pseudoscientific notions (e.g., homeopathy, psychic readings, telepathy, tall tales about alien abductions, and so forth). The typical reaction by scientists and science educators is to decry the sorry state of science literacy among the general public, and to call for more science education as the answer to both problems. But the empirical evidence concerning the relationship between science literacy, rejection of science and acceptance of pseudoscience is mixed at best. In this chapter I argue that—while certainly important—efforts at increasing public knowledge of science (science education) need to be complemented by attention to common logical fallacies (philosophy), cognitive biases and dissonance (psychology), and the role of ideological commitments (sociology). Even this complex, multi-disciplinary approach to science education will likely only yield measurable results in the very long term. Meanwhile science remains, as Carl Sagan famously put it, a candle in the dark, delicate and in need of much nurturing.

KEYWORDS: science literacy, science education, philosophy, psychology, sociology, pseudoscience.

1. INTRODUCTION: THE ACCIDENTAL PUBLIC INTELLECTUAL

Most academics do not engage in public outreach, for a variety of reasons. First off, it is at least implicitly discouraged by the very structure of the academy, where one's career is advanced (in decreasing order of importance, regardless of what anyone would tell you) by one's success in research or scholarship (measured by peer-reviewed publications and grants), one's teaching, and finally one's service. It would be nice if at least the somewhat vague category of "service" included outreach lecturing and writing, but it is in fact pretty much confined to *internal* (and not really very useful) service, such as on departmental or college committees.

Second, many of us are simply never trained for public outreach (or teaching, for that matter), and do not know how to relate in an understandable and engaging way to laypeople. Contra a popular academic myth, there is no particular reason for there to be a strong correlation between one's scholarly excellence in a highly technical field of expertise and one's ability to communicate in a non-technical matter about the broader context in which that scholarly work flourishes or makes sense (Sperber, 2001).

Consequently, until 1997 I was yet another example of a non-engaged academic, pursuing my first tenure track job at the University of Tennessee, within the specialty field of

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evolutionary biology (and more specifically the study of gene-environment interactions in plant model systems). But then something happened that made me pay attention and turned me into the accidental public intellectual that I have become since. A few months earlier, in March 1996, the Tennessee state legislature had attempted to pass a bill that would have ensured equal time for creationism in science classes throughout that state's public high schools. A *New York Times* article published at the time summarized the idea in this manner:

> "If evolution is true, then it has nothing to fear from some other theory being taught; the truth will prevail," State Senator David Fowler, a Republican from Chattanooga, argued on the Tennessee Senate floor this week. "But if intelligent design is the truth, then God forbid we should not teach it to our children." (Applebome, 1996)

The bill actually died in committee (though, unfortunately, the TN legislators were at it again in 2012, this time successfully (Thompson, 2012)). But during those months I had awoken to a reality that perhaps should not have surprised me to begin with: I was now living (and operating professionally, as an evolutionary biologist!) in the middle of the Bible Belt, in a country characterized by one of the most religious-puritanical attitudes among modern advanced societies (Uhlmann Poehlmanb, Tannenbaumc, & Bargh, 2012). As a reaction, I started one of the very earliest "Darwin Day" events on campus, an outreach program aiming at explaining to the public the nature of science and at exploring the relationship between science and religion. It has since become a major international event, with hundreds of locations worldwide every year (darwinday.org).

Once I got started, I realized that public outreach ought to be an important part of what academics should be doing, in part because they are among the best-positioned individuals in our society to function as public intellectuals, to aid the layperson—in the words of Noam Chomsky—in the pursuit of a course in "intellectual self-defense" (Baillargeon, 2008). This quickly led me to maintaining a blog devoted to science and philosophy for the public (rationallyspeaking.org), as well as to publish a number of advocacy books concerned with pseudoscience (Pigliucci, 2002, 2010). Most recently, and to my own amusement, my scholarship and outreach converged, with the co-editing of a new book on the philosophy, history, and sociology of the so-called demarcation problem (Popper, 1957), i.e. the conceptual divide between science and pseudoscience (Pigliucci & Boudry, 2013). What follows is a summary of the lessons I have learned while putting together the book and during the now more than fifteen years devoted to interacting with the public, initially as a scientist, and more recently as a philosopher.

2. NOT JUST SCIENCE EDUCATION

It is common for scientists and science educators to bemoan the fact that the American public is not scientifically literate, a state of affairs that is often blamed for much misunderstanding of science and embracing of pseudoscience. Indeed, the American Association for the Advancement of Science thinks that science literacy is so crucial that they have launched an ambitious "2061" project to improve it substantially (www.project2061.org/publications/bsl). There are good reasons to think that scientific literacy matters (Hazen, 2002), including so that people can better appreciate the world around us and, most crucially, make intelligent decisions about their lives—including who they vote for when it comes to public issues informed by science.

However, scientific literacy cannot be the whole story. A report by the National Science Foundation pointed out that *both* Americans and Europeans do not "have a firm grasp of basic scientific facts and concepts, nor do they have an understanding of the scientific process," (2004, p. 7-15) which makes it puzzling why, for instance, denial of evolution is a popular stance in the US but not in Europe (Miller, Scott, & Okamoto, 2006).

Indeed, a number of years ago one of my students and I carried out a preliminary study of the relationship between scientific literacy and belief in pseudoscience, and the results were not at all encouraging (Johnson & Pigliucci, 2004). For instance, while we found a (small, but statistically significant) effect of major (science vs. non-science) in the amount of *factual* knowledge of science that undergraduate students were able to master, we uncovered no significant differences between science and non-science majors in either *conceptual* understanding of science or belief in pseudoscience. (Interestingly, and contra popular lore, there was also no effect of gender on either science understanding or acceptance of pseudoscience.)

A more recent and much larger survey confirmed our results (Impey, Buxner, Antonellis, Johnson, & King, 2011): 10,000 students taking astronomy classes as part of their general education requirements were tested, and it turned out that belief in pseudoscience was high in the sample, that students' degree of science literacy was only marginally better than in the general population, and—most crucially—that there was no correlation between their science literacy and their acceptance of pseudoscience. The authors also found that over a period of two decades there was no measurable improvement in students' science literacy.

This is not exactly surprising to people who have spent years "in the field," so to speak, actually talking to (and sometimes debating) proponents of pseudoscientific notions. Contrary to popular belief among academics (and scientists in particular) these people are both intelligent and knowledgeable about science. Take the issue of creationism, for instance. I have debated the likes of Duane Gish (Institute for Creation Science) and Michael Behe and William Dembski (both associated with the Discovery Institute), among others. Gish and Behe have a PhD in biochemistry, and Dembski has academic credentials in both mathematics and philosophy. They know far more about natural selection, the chemistry of life, and so forth than most, and yet they subscribe to untenable notions of young earth creationism (Gish) and Intelligent Design creationism (Behe and Dembski). This observation is not limited to the leaders of these movements either, as a good number of the rank and file creationists (or paranormalists, or climate change deniers, you name it) that I've met during the years are also well-versed in the basics of science, and can discourse on points of scientific method and even philosophy of science.

None of this argues that science literacy is not a worthy goal, but it certainly points out that—in itself—more general science education is not likely to significantly ameliorate the problem. The implication is that there must be other, so far less explored, factors playing into so much misunderstanding of science and acceptance of pseudoscience by the general public. My suggestion is that we need to consider three other, interconnected, spheres of influence: philosophy (particularly as it concerns critical thinking and informal logical fallacies), psychology (pertinent to people's proneness to engage in cognitive biases and cognitive dissonance), and sociology (concerning the strength and dynamics of people's ideological commitments).

3. FROM EDUCATION TO PHILOSOPHY AND PSYCHOLOGY

Professional skeptics—i.e., people who spend their time debunking all sorts of pseudoscientific claims—will quickly point out that believers in pseudoscience commit an orgy of logical fallacies, particularly of the informal kind (e.g., www.theskepticsguide.org/resources/logicalfallacies.aspx). Indeed, a recent project by Richardson, Smith, and Meaden (2012) has cataloged the most common fallacies and allows internet browsers to paste a fallacy-specific link to any blog, article, or commentary they find around the internet (hence the title of the project: "Your Logical Fallacy Is...").

Examples are in abundance. Consider just the following small sample (more in Baillargeon (2006)):

> Hasty generalization: "Acupuncture works; my brother stopped smoking by seeing an acupuncturist."
> *Ad Populum*: "Most people believe in astrology, so there must be something to it."
> False dilemma: "Either medicine can explain how someone was cured, or it is a miracle."
> Appeal to ignorance: "No one has ever proved that UFOs do not exist, so they might exist."
> Red herring: During a discussion on global warming someone says: "What you really have to worry about is a government too prone to regulating the economy, which will keep people from being decently employed."
> *Post hoc, ergo propter hoc*: "I was wearing a red sweater when I won at the casino. If I wear the red sweater again, I will win again." (Richardson et al., 2012)

And the list could go on and on. If we begin with the (empirically testable) assumption that awareness of logical fallacies helps people think more clearly about issues, then it follows that courses in critical thinking and informal reasoning may be significantly more effective than straightforward science education (though, of course, the two are not mutually exclusive; indeed, there is some evidence that inferential skills are affected both by general education and by specific knowledge (Franks, 1998; Zachos, Pruzek, & Hick, 2003)).

However, this cannot be the end of the matter. It has become better known during the last several years of research in psychology that people have a natural tendency toward a number of cognitive biases, several of which actually explain why some of the above mentioned logical fallacies are so common and persistent. Take the *post hoc ergo propter hoc* fallacy, for instance. This is the mistake of inferring a causal connection between two events simply on the ground that one followed the other (typically within a short period of time). Statisticians constantly warn us that correlation is not the same as causation, and yet this type of elementary mistake in logic is arguably at the foundation of much superstitious behavior. A plausible (if difficult to test empirically (Kaplan, 2002)) argument can be made, however, that a cognitive bias favoring quick causal inference evolved because it was fitness-enhancing in ancient humans.

Moreover, Skinner (1948) famously showed that human beings are not the only animals to engage in superstitious behavior triggered by a false causal inference (although in the case of Skinner's pigeons, presumably such inference was unconscious). He reported:

> [O]ne bird was conditioned to turn counter-clockwise about the cage, making two or three turns between reinforcements. Another repeatedly thrust its head into one of the upper corners of the cage. A third developed a 'tossing' response, as if placing its head beneath an invisible bar and lifting it repeatedly. Two birds developed a pendulum motion of the head and body, in which the head was extended forward and swung from right to left with a sharp movement followed by a somewhat slower return. The body generally followed the movement and a few steps might be

> taken when it was extensive. Another bird was conditioned to make incomplete pecking or brushing movements directed toward but not touching the floor. (Skinner, 1948, p. 168)

The problem, however, is that human beings persist in such behaviors much longer than experimental animals, who typically abandon their superstitious habits when they repeatedly fail to deliver the goods. For instance, work carried out by G.L. Wolford at Dartmouth (summarized by Gazzaniga, 2003) employed a test in which the subject is guessing whether a light will appear on the bottom or on the top of a computer screen. The setup is such that the light appears on top the majority of the times, but the sequence is random (i.e., there is a bias in the random appearances of the light). Rats quickly learn to maximize their performance, simply by limiting themselves to hit the top button. Human beings, however, think they can infer the rule behind the sequence, performing significantly worse than the rats, on average. So much for *Homo sapiens*. In all fairness, though, if the subjects of Wolford's experiment were *told* what was going on they would quickly adjust their behavior as a result of understanding, an option not available to the rats.

There are a number of other cognitive biases that are well-known to interfere with our critical thinking abilities, and that accordingly are increasingly taught alongside an understanding of logical fallacies. For instance, people habitually over-rely on their memories, so much so that 25% of participants in a survey were convinced that they got lost for long periods of time in a shopping mall when they were children (Baillargeon, 2008). If true, this would be a phenomenon of epidemic proportions, which would scarcely go unnoticed among the security personnel of shopping centers.

Our unjustified trust in our perception abilities has been well-documented as well, for instance in the cases of the unreliability of eye-witness testimony (Vidmar, Coleman Jr., & Newman, 2010) and in that of a number of standard and yet bewildering optical illusions (Ditzinger, 2001). Interestingly, a common cognitive bias that leads to (or at least reinforces) pseudoscientific belief takes place when unreliable perception combines with an innate tendency to see patterns in the world around us (another example of the human hyper-tendency to infer causality on the basis of scant data). In 2004, for instance, the face of the Virgin Mary "found" on a piece of toast fetched a bewildering $28,000 when sold, a type of (expensive!) cognitive mistake that Hadjikhani, Kveraga, Naik, and Ahlfors (2009) traced to an early activation of face-specific areas of the cortex by "face-like" objects (though exactly what made that particular object face-like remains largely unexplored).

A classic example in the pseudoscientific literature is, of course, the famous "face on Mars," allegedly discovered by NASA, but that clear images from the Mars Global Surveyor revealed to be simply an unusual configuration of a natural mesa, initially photographed at an angle that gave the (vague) impression of a giant sculpture of a human-like head on the surface of the red planet (Fraknoi, 2003). Naturally, the solution of the mystery does not seem to have done much to abate belief in a NASA-inspired conspiracy to hide the truth from the unsuspecting public.

One cannot leave even a cursory discussion of the psychological underpinnings of pseudoscience without mentioning a well-known concept in psychology that helps us make sense of a lot of the phenomenology concerning pseudoscience, and which indeed was invoked initially precisely in the context of a pseudoscientific cult: cognitive dissonance. The phrase was famously coined by Leon Festinger and colleagues in 1956, in their *When Prophecy Fails* (Festinger, Riecken, & Schachter, 1956).

Festinger et al. managed to infiltrate a cult growing around the pronouncements of one Dorothy Martin (initially identified in the book as "Marian Keech"). Martin claimed to be receiving messages from extraterrestrials from the (imaginary, as far as we know) planet Clarion. One day the message said that the world would end on December 21st, 1954. However, a group of flying saucers would pick up Miss Keech's followers. As a direct consequence of their belief in Martin's prophecies, many of those followers cut their ties with their families, quit their jobs, sold their possessions, and joined the wait. Problem was, the appointed date arrived and (predictably) nothing happened. Hours of tension followed, until at 4:45am the following morning, Martin announced the reception of another transmission from the Clarionians: the faith of the believers had saved the world, and no flying saucers rescue mission was needed after all!

Now, one would expect that Martin's followers would be angry and upset, and perhaps would go to the police, or sue Martin for all her worth. Instead, the majority of the cult members began to spread word of the good news, attempting (and succeeding, for a while) to make new disciples. Festinger et al.'s (1956) interpretation of what was going on was that too many of Martin's followers had invested too much at that point, both emotionally and materially. Now they were faced with the choice of either facing up to the fact that they had been gullible fools, or of telling the world (and themselves) that they were valiant heroes whose courageous behavior had actually saved the world. Apparently, for some people this is an easy choice: they avoid the rabbit hole and gladly take the blue pill.

Unfortunately, the Clarionian debacle was far from the last example of the genre. As recently as 2011 a new cultish movement was started by Evangelical Biblical literalist Harold Camping, with similar dynamics (and outcomes) to the classic Martin case (Bartlett, 2012). Just as in the 1950s, followers of Camping firmly believed their leader, who had predicted the end of the world by earthquakes, based on his (unorthodox and unfounded) reading of the books of Daniel and Revelation. Once again, they had to deal with the undeniable fact that the world did not, in fact, end on the announced date of May 21, 2011. And their reactions were remarkably similar to those of the followers of Martin. Here are some excerpts from Bartlett's (2012) article on the aftermath of the cult:

> With less than three months to the day of Christ's return, I desire to spend more time studying the Bible and sounding the trumpet warning of this imminent judgment…
>
> Based on everything we know, and when you look at the timelines, you look at the evidence—these aren't the kind of things that just happen. They correlate too strongly for it not to be important….
>
> Even if it's 99.9 percent, that extra .1 percent makes it not certain. It's like the weather. If it's 60 percent, it may or may not rain. But in this case we're saying 100 percent it will come. God with a consuming fire is coming to bring judgment and destroy the world….
>
> "Of course I'll be disappointed if it doesn't happen, but I feel like God's not going to let us down."

And, most revealingly: "I turned my back on the world. I can't afford to doubt."

Just as was argued by Festinger et al. (1956), however, cognitive dissonance has its limits, and some of Camping's followers apparently exceeded them. One of the people he interviewed told Bartlett (2012):

> After October 22, I said 'You know what? I think I was part of a cult. My wife and I joke that when my kids get older they're going to say that we're the crazy parents who believed the world was going to end.

Another wrote: "definitely lost an incredible amount of faith. It makes me wonder just how malleable our minds can be. It all seemed so real, like it made so much sense, but it wasn't right. It leaves a lot to think about." Indeed.

4. THE ROLE OF IDEOLOGY IN PSEUDOSCIENCE

The last aspect of the problem of misunderstanding of science and acceptance of pseudoscience I wish to briefly discuss is perhaps the most difficult to handle: the role of strong ideological commitments in how we filter just about everything else, including what should otherwise be relatively straightforward scientific information.

I will illustrate the issue with a specific example, concerning self-styled professional skeptics and the question of anthropogenic climate change. I am referring to the popular (now no longer airing) television show "Bullshit!," hosted by magicians Penn Gillette and Raymond Teller. The show was funny, if often crass because of Penn's tendency to curse, and very intelligently put together. Each episode examined some pseudoscientific claim and proceeded to debunk it with a combination of investigative journalism and empirical demonstrations. Penn and Teller do not pretend to be doing rigorous science—after all, it is a television program meant to entertain—but their antics also manage to educate, and I actually use them regularly in a class I teach on the nature of science, to provide my students with what turns out to be a very effective combination of laughs and food for serious thought.

Even Penn and Teller, however, sometimes get it spectacularly wrong, and it is instructive to examine one example because it vividly illustrates the role of ideology (in this case, political, though it may just as well be religious) in public science debate. Episode 13 of the first season of Bullshit! aired in 2003 and tackled the problem of climate change (McLaughlin, Moldave, & Small). The choice of topic by Penn and Teller may appear strange at first glance, since—despite the scientific discussions and the sociopolitical controversy—atmospheric physics certainly is no pseudoscience. It takes only a few minutes of background research to begin to guess why they chose to be skeptical of global warming: Penn Gillette is a well-known libertarian and a fellow of the Cato Institute, a think tank that has repeatedly taken positions against the emerging scientific consensus on global warming. The Cato Institute, it should be added, is funded in part by the Exxon-Mobil Corporation, not exactly a neutral player in discussions about energy production and use. Of course, the suspicion of bias is not enough to condemn Penn and Teller's treatment of climate change, but one's baloney detector's alert level should go up a couple of additional notches once a few more things become apparent from the broadcast. To begin with, Penn and Teller set up the episode by pitting oil-industry lobbyists against hippie college protesters to make their case that the climate change movement is a sort of New Age irrational belief. The only credentialed academic to speak on the program is economist Bjorn Lomborg (2001), a notorious skeptic of global warming (and not an atmospheric physicist).

Things became worse as the show transitioned from a clearly imbalanced presentation to outright misrepresentation of the debate. One of the guests was Jerry Taylor (of the above mentioned Cato Institute), who said

> In the mid '70s we were told pollution is going to cause a new ice age . . . The very same scientists who argued an ice age was coming because of industrial pollution then shifted gears and argued industrial pollution will bring on a greenhouse warming world with virtually no breath in between. (McLaughlin, Moldave, & Small, 2003).

This is simply false, as the idea of a temporary cooling of the earth's temperature was advanced in the popular press (not in academic, peer-reviewed journals), prompted by speculations about the massive injection of aerosols in the atmosphere. To compare a few magazine articles with the overwhelming scientific literature on global warming is a joke, and not a particularly funny one, given what is at stake.

While the Bullshit! episode is obviously anecdotal (though, I think, actually representative of ideological distortions of science policy debates), there is also systematic research bearing on the issue of science and ideology. A comprehensive presentation of the cognitive science aspects of this research has been summarized recently for a broader public by Chris Mooney (2012), while Corey Robin (2011) has put together a more nuanced historical and philosophically informed analysis of conservative ideology.

Robin (2011) develops his central thesis by way of a number of case studies (from Thomas Hobbes to Ayn Rand), defending the idea that conservatism is, at core, a combination of reaction against challenges to power hierarchies as well as a strong sense of entitlement about private property. Interestingly, as some commentators have noted, Robin's analysis helps making sense of the otherwise strange association between social conservatives and libertarians in the United States: while the latter endorse all sorts of positions that are abhorred by the former (e.g., legalization of drugs, prostitution, etc.), they share a sense of the inviolability, almost sacredness, of private property. It is this very thing that associates the otherwise progressive thinking and science endorsing Penn Gillette and Raymond Teller with the like of US Senator Jim Inhofe of Oklahoma, who famously refers to climate change as a "hoax."

Mooney's (2012) book is a bit more problematic. The research discussed in it is certainly interesting, if not quite as definitive as the author boldly states, but one wonders what exactly we are learning from the general conclusion that conservatives' and liberals' brains are wired differently. Quite apart from the fact that the terms "conservative" and "liberal" are highly sensitive to their particular cultural and historical setting, and from the fact that they do not capture but a fraction of people's attitudes toward political positions and ideologies, Mooney's book is another example of a recent trend that belongs to the "This is Your Brain on X" genre (or cottage industry, depending on how one looks at it). *Of course* the brains of people who think differently about X will be different. How *else* could distinct ways of thinking and behaving be carried out by the human animal? In fact, I am willing to go so far as to agree with Mooney that there may even be some genetic factors that may bias people's developmental psychology toward the conservative or progressive end of the spectrum (though then we enter the complex and empirically treacherous territory of gene-environment interactions (Pigliucci, 2001)).

The danger with Mooney's and others' approach to the biologization of ideology is that people will take the existence of genetic and/or neurobiological differences among groups as indicative of strong determinism (a position, to be fair, not endorsed by Mooney himself), quickly leading to the conclusion that nothing could therefore possibly change people's minds. This would be a highly unfortunate outcome that would essentially negate the value of public discourse about pretty much anything at all we care about, and this in turn would be a serious blow to the very idea of democracy. Ideological biases are important to explain some people's rejection of science and embracing of pseudoscience, but we need to thread carefully about the implications of research on ideology for the prospects of science education and even political progress.

5. CONCLUSION: THEN WHAT?

Carl Sagan, in his influential *The Demon-Haunted World* (1996) famously referred to science as "a candle in the dark," a precious thing, always in danger of being extinguished by a variety of threats, ignorance and superstition among others, but also ideological demagoguery in the service of political, religious, or corporate interests.

The analysis outlined above shows why Sagan got it right, and why the task confronting us is much more difficult than some may have thought. Rejection of science and belief in pseudoscience are not just the product of science illiteracy, more or less easily fixed by augmenting science teaching (and at any rate, certainly not by doing so primarily at the college level, or chiefly by way of more instruction about science facts as distinct from an understanding of science as a set of methods). It is much more complicated than that. Progress will be slow and will require much effort, and it will not be accomplished without taking seriously the contributions of philosophy (critical thinking, informal fallacies), psychology (sources and types of cognitive biases, cognitive dissonance), and sociology (roles and dynamics of ideological commitments).

It may very well be that the best that science educators, philosophers, and social scientists can do in the short run is to keep the candle lit, and that it takes a long view to remain confident of the possibility of progress (after all, a few centuries ago most people still believed in witches and demons...). Even so, what is at stake is well worth the fight. We just need to keep sharpening our tools along the way.

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