Dakin Henderson
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Jonathan Osborne

MAKING MEANING

The Role of Bias in Pursuit of Truth

In March 1941, an eminent scientist named Linus Pauling, who would later go on to win two Nobel Prizes—one for chemistry and one for peace—fell ill. His face became bloated, his tongue swollen, and he was chronically fatigued. He was diagnosed with Bright's disease, a poorly understood kidney disease considered fatal at the time. Pauling sought treatment from Dr. Thomas Addis, a leading specialist in renal diseases, who recommended an unorthodox treatment: a low-protein and salt-free diet with vitamin supplements. This regimen, prepared and implemented by Pauling's wife, Ava Helen Pauling, helped him control the disease.

Around 25 years later, inspired by a suggestion from a friend, Pauling began taking Vitamin C in large daily doses, and "immediately felt better and suffered fewer colds" (Linus Pauling Papers). He reviewed the literature and found some evidence for the benefits of Vitamin C, and in 1971, published a book titled *Vitamin C and the Common Cold* (1971). The book became a sensation, helping convince millions of people to take Vitamin C daily. Several years later, Pauling went a step further and proposed that high doses of Vitamin C were effective for treating cancer (1979).

Today, after decades of research, it appears that Pauling was wrong. The current scientific perspective on daily vitamin supplements--including, but not limited to, Vitamin C--may be summarized by the title of the 2014 editorial: *Enough Is Enough: Stop Wasting Money on Vitamin and Mineral Supplements* (Guallar et al, 2014). Worse, Pauling wasn't simply wrong, he was *biased.* According to Mercier and Sperber (2017), when confronted with negative results from a tightly controlled, randomized controlled trial (RCT) on the effects of Vitamin C on cancer conducted by the prestigious Mayo Clinic, Pauling rejected the evidence. He explained it away with objections which, for Mercier and Sperber, suggest motivated reasoning. “Pauling’s evaluation of the therapeutic efficacy of vitamin C,” they write, “is a display of selective picking of evidence and partisan arguments” (Mercier and Sperber 2017, p. 206). Pauling’s evaluation of the relative credibility of the available evidence was, Mercier and Sperber claim, contaminated with bias.

The story of Linus Pauling and his belief in Vitamin C is often used to illustrate the fact that bias affects all of us: “even the greatest minds can reason in the most biased way (Mercier and Sperber 2017, p. 207). The cognitive task of evaluating the credibility of evidence cannot be separated from our personal experience and prior beliefs. In this paper, I will assess the implications of this view on the credibility of scientific claims as a whole. I will conclude that bias can lead us towards truth as much as it leads us astray, and that truth ultimately precipitates from argumentative debate.

MOTIVATED REASONING AND PLAUSIBILITY

In the 1990s, Ditto et al (1998) conducted a study which seemed to describe Pauling’s rejection of the negative results from the Mayo Clinic’s RCT on Vitamin C. Ditto and his team told 48 undergraduate students that they were going to be tested for a newly-discovered medical condition called TAA deficiency. The condition, which they described vaguely as “related to a variety of pancreatic disorders,” was completely made up. The diagnostic test for the fictitious disease involved applying some saliva to a strip of “TAA reactive paper,” which would change color accordingly (this was just a strip of cardboard that would never actually change color). Participants were divided into 2 groups: one group was told that, if the strip changed color, it meant they had the disease. The other group was told they had the disease if the strip *didn’t* change color. The results? Those receiving an “unhealthy” diagnosis spent much more time waiting for the strip to change color, rated the test as much less accurate, and offered more possible factors that could have thrown off the results, compared to those receiving a “healthy” diagnosis.

Ditto et al conclude that people evaluate credibility of evidence based on the implications of that evidence on their own self interest. We are more skeptical of undesirable evidence than desirable evidence. The “TAA reactive paper” should be equally credible regardless of the results, and yet participants evaluated them based on what they wanted to be true (who wants to be diagnosed with a disease?). One could say the same about Pauling’s evaluation of the credibility of the Mayo Clinic RCT. Who wouldn’t want a quick fix for all of our health problems?

However, there is an alternate explanation for this kind of motivated reasoning. I argue that bias is not only influenced by the desirability of the result, but by its perceived plausibility as well. Moreover, I argue that desirability and plausibility are interlinked.

The concept of plausibility can be explained in Bayesian terms. Basically, we judge the meaning or meaninglessness of evidence based on its likelihood of being true. While it is easy to say that skepticism for the TAA strips stemmed from the desirability (or undesirability) of the results, it would be just as easy to explain it in terms of plausibility. The sample participants were supposedly all healthy undergraduate students. They had no prior reason for believing something may be ailing them. Assuming they took the existence of the disease and the diagnostic at face-value, they still had reason to be more skeptical of a purported diagnosis than a non-diagnosis.

For example, an oft-cited example of Bayesian reasoning involves the false-positive rates of real diagnostic tests, such as breast cancer screenings. Szu and Osborne (2011) elucidate how a seemingly accurate diagnostic test can yield an incredibly inaccurate diagnosis, depending on the plausibility of the disease occurring. Say a screening can correctly identify cancer in a patient 80% of the time. If only 1% of the population has cancer, the screening will only accurately diagnose a patient 7.5% of the time. Paulos (2001) describes the same example, with a 0.5% cancer rate and a diagnostic test with 98% accuracy, which yields only a 20% true positive rate. Why are these tests so unreliable? The crucial factor in determining these probabilities is the *prior probability*--in this case, the base rate of cancer in the population.

This same example has also been used to explain the false-positive rate of the scientific literature. Instead of a diagnostic test for cancer, think of any scientific study. Every scientific study will report a confidence level, usually in the form of a p-value. The p-value (together with the power of the study) can be thought of as the “accuracy” of the cancer diagnostic. But what is the base rate for scientific hypotheses? Of all the hypotheses available for scientists to propose, how many of them are actually true? In other words, what is the likelihood of a scientist’s hypothesis being true?

Ioannidis (2005) estimates different prior probabilities for hypotheses in different scientific fields. In epidemiology, for instance, Ioannidis estimates that perhaps 1 in 10 hypotheses are true; in exploratory disciplines like genomics, which sifts through vast troves of data on genes and proteins, one might expect only 1 in 10,000 to be true. These likelihood ratios, a variable represented as R in his equations, led Ioannidis to the conclusion that “most scientific findings are false for most research designs and for most fields” (Ioannidis 2005, p. 699). Bayesian logic shows that, just like the diagnosis received by a patient from a cancer screening is very likely to be false, so is the veracity of a paper published in the scientific literature.

The base rate of cancer in the overall population, the likelihood of a scientific hypothesis being true, and the implications of a strip of “TAA reactive” paper are all factors in judging the credibility of information. Plausibility is equivalent to Bayesian prior probability. While estimating the base rate of a disease may be possible to do objectively, determining the prior probability of a given hypothesis is always somewhat and often entirely subjective. Estimating the plausibility of a conclusion can vary widely among people with different experiences, values, and knowledge.

The connection between Bayesian prior probability, plausibility, and the credibility of claims has been called the “subjectivist view” (De Finetti 1974, cited by Szu and Osborne 2011). Szu and Osborne (2011) equate such reasoning to assessing the trustworthiness of a car mechanic.

> When new evidence arises, such as a friend recommending the mechanic, we are apt to update our assessment (i.e., posterior probability). That new probability, however, depends on both true and false positive considerations. If our friend is reliable and is mechanically knowledgeable, that increases the strength of our certainty. However, if our friend is shifty and owns a stake in the mechanic’s shop, it has the opposite effect of increasing the probability of false positives. (Szu and Osborne 2011, p. 8)

I would add that another factor in judging the trustworthiness of the mechanic is *what the mechanic says.* If you go in for an oil change with a perfectly functioning car, and the mechanic says you need an engine overhaul, that in and of itself is good reason to be skeptical.

The subjectivist view allows that reasoning is biased while “also claiming that updating those beliefs should nonetheless follow certain elements of logic and reason (Szu and Osborne 2011, p. 8). We may have priors, the logic goes, but as long as we continuously reevaluate them in light of new evidence, our conclusions will gravitate towards truth. The problem is, when new evidence is both abundant and contradictory, with which evidence do we update our beliefs? Which friend’s advice should we listen to? Surely we must adjust our beliefs only with credible evidence. And as we have seen, this process is also biased.

Is bias a bad thing? Most of us would say yes. Or at least, that bias is an obstacle in the path to truth. But if this is the case, then Bayesian inference is also an obstacle in the path to truth; and if the Bayesian model is our best explanation of human reasoning reasoning, then reason itself is an obstacle. If reason can’t lead us to truth, what are we left with? Madness? Instinct? In homage to the college students who rejected a diagnosis from a “sciencey” looking piece of cardboard, I reject the notion that bias is the enemy of truth because of the implications of such a view. Instead, I choose to explore the ways in which bias can lead us *towards* truth.

TRUE BIAS

Collins and Pinch (1993) narrate the tale of one of the experiments which "proved" Einstein's theory of relativity. To summarize a very complicated business, Newton's and Einstein's theories both predict that large sources of gravity would cause light to bend, but Einstein's theory predict a greater effect. For example, if the light from a star just barely grazes the sun on its way to earth, Newton's theories predict a displacement of 0.8 seconds of an arc, while Einstein's predict 1.7. The question was, which theory is true?

Sir Arthur Eddington is known to have "triumphantly verified" (Pauli 1958, cited by Collins and Pinch 1993, p. 39) Einstein's theory with his observations of the displacement of stars during the 1919 solar eclipse. Two expeditions took photographs of the eclipse, one in Sobral, Brazil, and the other from Principe, an island off the coast of West Africa. The official results which confirmed Einstein's theory, published by Eddington and the Astronomer Royal, were: 1.98 +/- 0.18 arc seconds for the Sobral photographs, and 1.60 +/- 0.31 arc seconds for the Principe photographs. Taken together, these numbers strongly favor Einstein's prediction of 1.7 over Newton's 0.8.

However, Collins and Pinch point out that these results were biased. In fact, the 1.98 Sobral result came from only one of the two telescopes used on that expedition--the 18 photographs from the other telescope (an “astrographic” telescope) yielded a displacement of 0.86, which was much closer to Newton’s prediction of 0.8. These results, however, were rejected and excluded from the analysis that publicly confirmed Einstein’s theory. Why? One the one hand, they could reasonably be rejected because of the poor quality of the photographs. On the one hand, one could say they were rejected because of the theory they supported. According to Collins and Pinch, the decision to exclude the 18 astrographic Sobral photographs while including the Principe photographs (which were arguably even worse) was related to Eddington’s--and the scientific community’s--subjective belief.

> [Eddington] ignored the 18 plates from the Sobral astrographic and simply described the 1.98 result from the 4-inch and the 1.671 result from his own two plates. When one has these two figures alone to compare with a Newtonian prediction of around 0.8 and an Einsteinian prediction of around 1.7, the conclusion is inevitable. But there was nothing inevitable about the observations themselves until Eddington, the Astronomer Royal, and the rest of the scientific community had finished with their after-the-fact determinations of what the observations were to be taken to be. Quite simply, they had to decide which observations to keep and which to throw out in order that it could be said that the observations had given rise to any numbers at all. (Collins and Pinch 1993, p. 48)

Collins and Pinch are careful to emphasize that they are not poking holes in the truthfulness of Einstein's theory. Rather, they are challenging the standard definition of the process by which that truthfulness was established. The Theory of Relativity was not, they claim, "forced on us by the inexorable logic of a set of crucial experiments" (p. 50). On the contrary, the interpretation of those experiments "depends upon what people are ready to believe" (p. 38). The truth of Einstein's theory "came into being… by agreement to agree about new things" (p. 50). Bit by bit, subjective judgments about which information to trust and which to reject led the world of physics *towards* the truth, not away from it.

ARGUMENT

What is the difference between Linus Pauling's rejection of the Mayo Clinic RCT and Eddington's rejection of the 18 Sobral astrographic photographs? Perhaps it was the accuracy of the respective prior probabilities attributed to the Vitamin C and relativity theories. Pauling erroneously deemed the health benefits of Vitamin C as highly plausible, while Eddington correctly did so with relativity. Did one reason better than the other?

Mercier and Sperber (2017) describe Pauling's reasoning as seriously flawed. Choosing *not* to believe in Vitamin C, they propose, should have been pretty clear-cut: "on the one hand a fringe theory and a small, poorly controlled study; on the other hand, the medical consensus and a large, well-controlled clinical trial" (Mercier and Sperber 2017, p. 206). The weight of evidence around Vitamin C seems to have been more strongly skewed against the theory, not for it. While in the case of relativity vs. Newtonian physics in 1919, the existing balance of evidence may have been more of a toss-up.

Perhaps we can conclude that Eddington did reason better than Pauling, albeit only in retrospect. However, I agree with Mercier and Sperber in proposing that it doesn't matter. Better reasoning in and of itself doesn't lead to truth; moreover, it can only be recognized after the fact. Instead, what matters is argumentation and debate. This is what Mercier and Sperber call the "interactionist" approach to reason. The purpose of reasoning is not to lead an individual towards truth, but rather to "justify themselves and to convince others, two activities that play an essential role in their cooperation and communication" (Mercier and Sperber 2017, p. 107). Actual truth, then, becomes an auxiliary benefit that precipitates from debate, from interactive reasoning, not isolated reasoning.

> ...when people who disagree but have a common interest in finding the truth or the solution to a problem exchange arguments with each other, the best idea tends to win; whoever had it from the start or came to it in the course of the discussion is likely to convince the others. This conclusion might sound unduly optimistic, but it is supported by a wide range of evidence, from students

> discussing logical problems, to juries deliberating, and to forecasters trying to predict where the next war will erupt. (Mercier and Sperber 2017, p. 10)

Mercier and Sperber portray debate as a war in which, if the battlefield is fair and open, truth will ultimately win. I do not believe this idea is “unduly optimistic,” as the authors concede. Instead, I think the undue optimism lies in the assumption that people who disagree “have a common interest in finding the truth,” and that they will actually exchange arguments with each other.

The NRA chief lobbyist was quoted as saying, in respect to the political issue of gun control, “Basically, it’s a war for the minds of the uncommitted” (Kuhn 1991, p. 297). Such a description would be flattering to the current state of public discourse, which I would describe as a war between the minds of the committed. This is no debate, but a shouting match which, unrestrained, quite possibly could lead to actual war.

The decline of argument in our democracy can be attributed to the simultaneous increase in polarization and decrease in engagement. Of the 138,846,571 people who voted in the 2016 U.S. presidential election, how many of them could have been swayed to vote differently by reason? I suspect the answer is precious few. Then there are the 111,209,163 who did not vote at all. Seen through the lens of Deanna Kuhn’s developmental model of critical thinking (1999), the voters are “absolutists” who are certain that they are right and the other side is wrong, while nonvoters are “multiplists” who relinquish the idea of certainty itself. According to Kuhn, only “evaluative” thinkers employ the kind of reasoning conducive to a productive debate.

I fear that evaluative thinkers are a dwindling bunch. In such an environment, argumentation has no purpose.

> People must see the point, the value, of argument if they are to engage in it. If one accepts the absolutist view of knowledge as entirely certain and accumulative, or the multiplist view of knowledge as entirely subjective and based only on the desires and tastes of the knower, argument becomes superfluous. (Kuhn 1991, p. 265)

Some may claim that Kuhn’s evaluative level of critical thinking is incompatible with the subjectivist view of Bayesian reasoning. If the subjectivist view were true, and all reasoning is influenced by bias, they would conclude that multiplism is inevitable. I disagree. Biased reasoning is better than no reasoning, and argumentative reasoning is better than isolated reasoning. Moreover, if our biases manifest in the prior probability of a hypothesis being true, then bias *belongs* in debate. The problem isn’t the presence of bias, it’s our reluctance to acknowledge it; it isn’t a lack of reason, it’s a lack of genuine argument.

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