Facing our **fallibility**

A new way of thinking may help both scientists and society in justifying their beliefs and improving the reliability of their claims. **Professor Sherri Roush** provides context to this novel philosophy

Many of the great philosophers throughout history were also scientists in their own right. Did they have informed opinions on scientific fallibility?

They had views that were appropriate for their place in history. Modern heroes like Galileo and Newton did not have the reasons we do to be circumspect in claiming that they had it right. They could plausibly say their predecessors whom they disagreed with – say Aristotle and Ptolemy – were not really doing science and would give Galileo and Newton no reason to doubt their own conclusions. They after all were doing science.

We can say that Einstein is right and Newton was wrong about gravity, but we cannot say that Newton was not doing science. We are in a fundamentally new situation since we have seen well-executed and well-confirmed science turn out to have the wrong conclusion. So we are in a position where we have to face this and be very clear about why it does not undermine the legitimacy of our results. I have arguments that do that.

Could you provide an example of a recent 'science war' and how your philosophical approach could have changed the outcome?

In the 1990s there was a heated discussion in academia about science that was prompted partly by the sociology of science. Historians and sociologists said you could not deny that science is made up of communities and that the scientist and their results are, in a palpable sense, dependent on that. Scientists and philosophers tended to protest that this was irrelevant to the legitimacy of results as the justification of scientific results comes from arguments and evidence.

The philosophical tradition is right, I think, that you need to self-monitor and self-correct your reliability in order to have a justified belief, but it made the mistake of assuming that you have to be individually conscious and deliberate in your self-correcting in order to succeed in doing it. In science, my condition for justified belief is often fulfilled by conscious argumentation and explicit evidence but also often in virtue of the unconscious aspects of a scientist's active membership in a knowledge community. So if the community structure and dynamics is one that would catch frauds and hasty generalisations, and if the scientist has a disposition to read the community news and respond appropriately, then she is fulfilling the requirement to monitor her reliability and adjust her confidence. The community can enable or disable scientists, but they are not incidental to the legitimacy of the results; when the community is functioning well that is part of what makes beliefs justified.

A sceptic by definition is someone who doubts a general belief. Surely there would be no scientific progress without scepticism?

Science requires doubt and questioning. Healthy scepticism has a specific target and hopefully a substantive reason to doubt. The kinds of sceptical arguments I have found errors in are generic. They raise doubt based on the possibility of error, or on the fact that as our arguments get longer there are a greater number of sources of error, or they are limited by an expectation of a yes-no answer to whether a belief is justified, which a probabilistic approach is not.

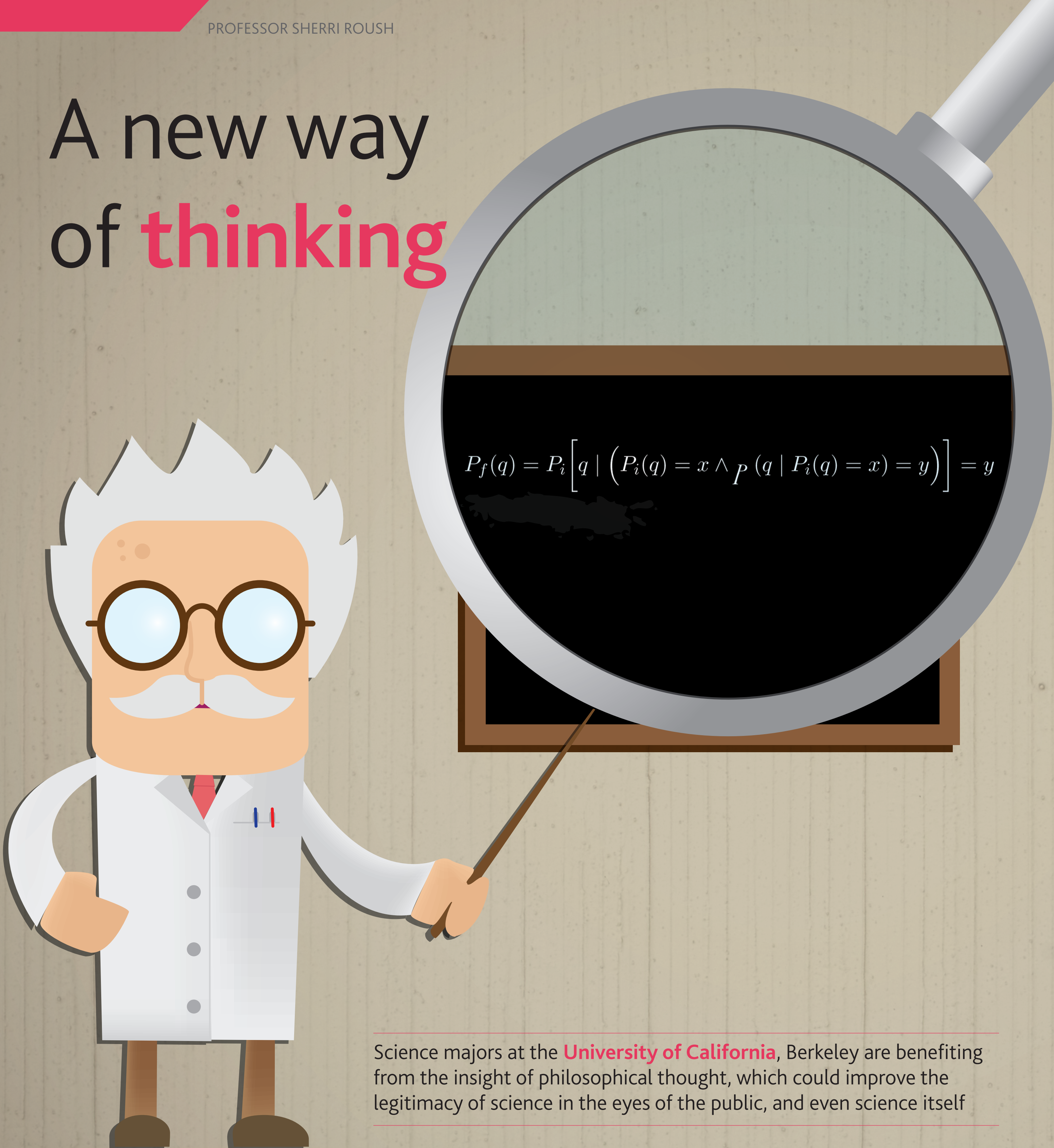
So the difference between scientific and radical scepticism is between 'any' and 'all'. The scientist must feel free to doubt any claim, but does not usually doubt all the deliverances of reasoning or observation at once.

What are the limitations to Bayesian probability?

You cannot get betting recommendations out of mere ordinal rankings, so the model attributes precise degrees of belief to the agent, which people do not have. In application this is not a problem since you infer degrees of belief from a subject's behaviour when offered precisely defined bets. But it would be nice to have a more realistic model involving imprecise degrees of belief. Some obvious ways of doing this with probability have led to paradox. Something I have become concerned with is tractability of these rules for real human beings, especially since I have added complication to the Bayesian system. If a human being is not capable of something then he cannot be rationally obligated to do it. I think we have a lot to learn in this dimension.

Probabilities are taken as degrees of belief which some think is subjective. However, the question of whether you are rational is only about whether you do the best you can with the evidence you have. Everyone starts with prior beliefs and rules of rationality allow you to revise those beliefs in light of further information. If you want to ask about whether the subject is actually getting it right in her beliefs about the world, then you are asking about knowledge, not rationality. We can be rational in our beliefs, while still ending up with a false belief, because we always have incomplete information.

A new way of **thinking**



Science majors at the **University of California**, Berkeley are benefiting from the insight of philosophical thought, which could improve the legitimacy of science in the eyes of the public, and even science itself

QUANTIFYING BELIEFS TO assess the validity of one's work brings you closer to the truth, but reliability can never be 100 per cent guaranteed. As new theories emerge and more information is added to the ever-expanding pool, we continue to alter what is perceived as truth and what can be cast off as false. As most of us know, that is why we measure research to a degree of confidence to justify assertions and explain the rationale for scientific discovery. Yet how do we assure the public that our research is well-founded and how can we dispel the false claims made by a minority?

CONVERSION OF A SCEPTIC

Scientists are determined in their quest for reliable information to substantiate their claims, continually improving the collection of data and modelling of scientific theory to diminish the occurrence of falsehoods. Scientists are probing questions human beings are not able to discern just by looking. They ask: what is the age of a fossil? Or, what is dark matter? Or, what are the causes of global warming? So they necessarily employ vastly more information and tools than the public has access to. Sceptics continue to question the discourse to spark debate, and a healthy dose of cynicism can drive progress forward. There are arguments that cast doubt on science among the most naïve and the most sophisticated non-scientists (ie. the general public and philosophers). For philosophers these are theoretical questions, not political tools, but many of the arguments are genuinely challenging, and science doesn't always win in the public rhetoric.

"It is part of the nature of science to address criticism," affirms Philosophy Professor Sherri Roush, and she is confident that there are the tools to do so. "Generic untutored optimism is little better than generic radical scepticism. The public has the right to question, but they do not have the specific information or understanding to answer. This is where philosophers can help to bridge the gap in the discourse."

RATIONAL DEGREES OF CONFIDENCE

Roush has arguments against the philosophers' sceptical arguments, where she thinks mistakes are being made about error and fallible reasoning. However the public reception of science has been a concern of hers too, ever since high school, when she was not taught evolution. There also, she believes that to address the problem you have to first identify it: "Our cognitive heuristics are largely focused on belief and disbelief; we are uncomfortable with the idea of levels of confidence, and poor at judging base-rate probabilities. So when scientists admit that they could be wrong, or actually were wrong, all hell breaks loose".

EXTENDING BAYESIAN PROBABILITY

Roush's research builds on the Bayesian probabilistic model of human rationality, which tells us how to revise our existing beliefs on the basis of new evidence. What it had not told us was how to revise our beliefs when we receive information about our (un)reliability, information about our belief-forming mechanisms. How should your high confidence that John is the murderer, which is based on your witnessing the event, be affected by news that human eyewitnesses are generally overconfident? This is news about you and your beliefs, not about the murder, so the standard model could not tell you how to revise your view. "Paying attention to such information relevant to your reliability is self-monitoring, and my formula tells you how to self-correct your belief about the murder on the basis of that. The formula is complicated, but it says: adjust your confidence to what the evidence says is your reliability in such matters," Roush elaborates.

Roush's model provides an explicit, very abstract representation of something that scientists already do: "One of the things the late 19th Century statistics revolution brought was tools for evaluating our error and potential error, and this has contributed powerfully to scientific progress. We will never eliminate all error, but there is more and less, better and worse errors, and non-scientists need to get comfortable with that".

A CONTEXTUAL EXAMPLE

The International Panel of Climate Change was the source of great contention in 2009 following erroneous reporting in its 4th Assessment. Although well-established and highly reputable, the IPCC's inaccuracies instilled doubt into the minds of many. In a paragraph on page 493 of the report, Working Group 2 announced that it is very likely that the mountain range will be ice free by 2035. Upon investigation, however, it was found that this now infamous error was drawn from a 2005 WWF report that sourced this data from unpublished research, which had not been peer reviewed. Like a row of dominoes, the mistake caused by grey literature reporting cascaded across international media and led to the discovery of a series of other discrepancies highlighted by the press.

Over the course of two years, the percentage of people who believed 'global warming was happening' plummeted from 71 to 57 per cent (2008-2010). Following the fiasco, scientists spent many arduous hours retracing their steps to ensure their claims held up against scrutiny. This type of reporting hampers the progress of the scientific community and Roush sees her research problem at the heart of it: "Scientists need to be careful in reporting, but what strikes me most in this case is the lack of proportionality in the public response. A plane crash is a tragedy, but the shock of it can make us forget the millions upon millions of people who fly safely," she explains. "A healthy science admits its mistakes and improves the system for preventing them in the future, but when admitting a mistake will drive large numbers of people to conclude the whole enterprise is untrustworthy – and that is the situation we are in – then it is harder for the science to follow its own rules about mistakes. Ironically, when the public does not trust scientists or understand their arguments it gives scientists an incentive to cheat in reporting. Some of the reasons for this disproportionate type of response, I think, are that lots of people don't know and cannot fathom how many scientific planes fly safely every day, and are not good at coping with admission of a mistake except by an all or nothing response. That's where my formula comes in."

EPISTEMOLOGICAL EDUCATION

Roush currently teaches at UC Berkeley, discussing general scientific methodology with real and vivid examples to help students articulate why and how hypotheses are justified by evidence: "Being able to do that is important for a healthy public reception of science. The very abstract and intuitive principles and issues about evidence that we discuss and explain enable the scientist to have a kind of background guide for the processing of evidence; it gives one instincts about what is good and bad use of evidence and a language to talk about it in with non-scientists," she asserts.

FUTURE THINKING IN SCIENCE AND SOCIETY

Evidence-based science involves quantification so that reasoning can be comparative and justified. Increasingly, scientists are doing self-monitoring of reliability not just on individual experiments but at the scale of communities and their mechanisms of review. For example, we have studies of what percentage of journal retractions are due to fraud, and of the effectiveness of peer review. Discovery of systematic problems is disconcerting, but Roush emphasises: "We will never be perfect, but if we know about the problem then we can improve".

FALLIBILITY AND REVISION IN SCIENCE AND SOCIETY

OBJECTIVES

- To investigate how to bring second order beliefs (beliefs about our beliefs) to bear on first order beliefs
- To provide a general formula for how second order beliefs should affect first order beliefs

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