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Scientific Uncertainty and the Political Process

By DALE JAMIESON

ABSTRACT: In this article, a notion of scientific uncertainty is sketched that is in many ways different from the prevailing view. Scientific uncertainty is not simply an objective value that can be reduced by science alone. Rather, scientific uncertainty is constructed both by science and by society in order to serve certain purposes. Recognizing the social role of scientific uncertainty will help us to see how many of our problems about risk are deeply cultural and cannot be overcome simply by the application of more and better science.

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SOME of the most controversial public policy decisions in American society involve risks that are primarily understood through scientific processes and institutions. The evidence for climate change, for example, comes mainly from experiments run on highly complex climate models rather than from our everyday experience. Other issues with important scientific dimensions include ozone depletion, biodiversity loss, acid rain, and exposure to radon and various toxic chemicals. Without science and scientists, there would be little public concern about a wide range of important issues.

Although science has been very effective in bringing these issues into the public arena, it has been quite ineffective at providing solutions. There are a number of views about why this is the case. Over lunch and at professional meetings, scientists often complain about the lack of understanding or downright perversity on the part of political leaders who ignore scientific information. On the other hand, many policy analysts fault scientists for talking to each other rather than producing "policy-relevant" science.¹ My own view, which cannot be fully developed here, is that the very characteristics of science that enable it to have its unique cultural authority as a knowledge producer disable it from bringing public decisions to closure.²

1. See, for example, E. S. Rubin, L. B. Lave, and M. G. Morgan, "Keeping Climate Research Relevant," *Issues in Science and Technology*, 8(2):47-55 (1991-92).

2. I have developed this view more fully in a number of papers. See, for example, "Ethics, Public Policy and Global Warming," *Science, Technology and Human Values*, 17(2):139-53 (1992).

The conventional wisdom about why science is often so ineffective in providing solutions to problems with important scientific dimensions focuses on the role of uncertainty. In this view, problems such as climate change are characterized by high levels of scientific uncertainty about the likelihood and effects of key events, and so partisans of various policies can use—or misuse—scientific information and authority for their own purposes. For example, although the weight of scientific evidence suggests that large-scale emissions of greenhouse gases are likely to change climate, there are so many uncertainties about the roles of clouds, carbon sinks, and various possible feedbacks that both greenhouse "hawks" and "doves" can reasonably enlist science as an ally while accusing their opponents of misusing science.³ The only way out of this situation, some argue, is for uncertainties to be reduced to the point at which science can determine a rational policy. What is needed is a new generation of supercomputers, greater remote sensing capability, and a larger and more active research community.

In the conventional view, uncertainty is seen as an objective quantity whose value can be reduced by investing in more science. While this may usefully be thought of as one of several understandings of uncertainty, it is at best simplistic and mis-

3. The typology of greenhouse "hawks," "doves," and "owls" is developed in Michael H. Glantz, "Politics and the Air Around Us: International Policy Action on Atmospheric Pollution by Trace Gases," in *Societal Responses to Regional Climate Change: Forecasting by Analogy*, ed. M. Glantz (Boulder, CO: Westview Press, 1988), pp. 41-42.

leading to think of it as the only or most important one. Rather than being a cause of controversy, scientific uncertainty is often a consequence of controversy.⁴ This suggests that the social world is active in the construction and characterization of uncertainty, and if we want to understand uncertainty, we need to understand the social factors that help to produce it.

FALLIBILITY, UNCERTAINTY, AND INDETERMINISM

The first step in understanding uncertainty involves distinguishing it from some related notions with which it is often confused.⁵

Uncertainty is often conflated with fallibility. Fallibility relates to the fact that we could be wrong about virtually any proposition to which we give our assent, from the most homely (for example, "I know how old I am") to the most exotic (for example, "I know how old the universe is"). Fallibility lurks in the background of scientific claims and moves to the foreground when new evidence comes flooding in that suggests that our previous views about some matter were not just wrong, but deeply and profoundly wrong. The discovery of the ozone hole, which was not predicted by any of the atmospheric models, is one example of this, as is

4. This point is argued forcefully in Brian L. Campbell, "Uncertainty as Symbolic Action in Disputes Among Experts," *Social Studies of Science*, 15:429-53 (1985).

5. Although I draw the distinctions in a somewhat different way, my discussion in this section is indebted to Brian Wynne, "Uncertainty and Environmental Learning: Reconciling Science and Policy in the Preventive Paradigm," *Global Environmental Change*, 2:111-27 (1992).

the recognition of the chronic toxicity of DDT.⁶

Fallibility looms large with respect to many health and environmental risks. In some cases, we may know that various exposures are associated with harms, but we may have little idea of what causal mechanisms are at work. Although the statistical evidence may be strong enough for some to attribute causality, even in these cases we may worry about the fallibility of such claims. Our view of the matter may simply be wrong—not in details, but thoroughly so. We may not even be in a position to assess the probability of our being wrong. The fact of our fallibility is usually—indeed, often must be—ignored, but it constantly presents the possibility of bringing down an entire edifice of knowledge.

Uncertainty arises from ignoring fallibility. We take various features of a problem as given and focus on other dimensions. For example, it is widely agreed that the case for climate change is weakened by the fact that we are uncertain about the effects of clouds on the climate system. The solution is more intensive study of cloud formation and effects. But to identify clouds as an area of uncertainty is to presuppose that our general knowledge of the climate system is not uncertain, that the climate models are basically correct, and so on. This background knowledge is "black boxed"—it is taken as a set of assumptions from which we proceed to try to reduce uncertainty. This ap-

6. For discussion of these cases, see D. Budansky, "Scientific Uncertainty and the Precautionary Principle," *Environment*, 33(7):4-5, 43-44 (Sept. 1991).

proach of taking some propositions as fixed while interrogating others is a fundamental part of scientific practice. Scientific progress would be impossible if every proposition were problematized in every investigation.

The general point can be seen from an everyday example: I discuss selling my bike to a friend. In this context, there is no uncertainty about whether I own the bike. We both take it as given that this is the case. Of course, it may be that due to fraud or forgetfulness I do not own the bike. But in our discussion, these possibilities are not on the table, and so there is no uncertainty about whether I own the bike even though it could turn out that I do not. Now imagine a situation in which we are highly suspicious of each other: it is well known that I was once convicted of running a bike theft ring, or that I suffer from amnesia. When the context is changed in one of these ways, the problem of uncertainty may arise. My friend may demand proof that I really own the bike before she will continue the discussion with me. What this homely example shows is that while we can always be wrong about (most) things, uncertainty requires particular contexts and social conditions.

Indeed, this very example has implications for uncertainty about risk. Uncertainty disappears or is minimized when we have complete trust in the institution, person, or data set that is being interrogated. It is magnified or accentuated when there is mistrust, whether founded on fraud

or other failings.⁷

Uncertainty should also be distinguished from indeterminacy. Often what appears to be uncertainty cannot be reduced because there is no reliable fact of the matter to be learned that directly bears on improving our beliefs. At least three sources of indeterminism can be identified: agency, underdetermination, and categorical relativity.⁸

Many of the most serious environmental and health problems we face involve agency. Part of why we do not know what will happen to global climate in the twenty-first century is because we do not know how people will behave in the future. Will they continue to increase their use of fossil fuels? Or will other energy sources be substituted? Will governments undertake policies to geoengineer climate? Will there be other responses to early signs of global warming? These are just a few of the questions whose answers matter in determining what will happen to future climate. Similar questions could be raised about the effects of tobacco smoke, the prevalence of HIV, and so on.

The indeterminism that results from agency is made worse by the fact that predictions about human behavior can themselves change the behavior that is being predicted. Consider a simple case. At 8 a.m. on a warm summer day, the local radio station predicts that there will be massive traffic jams as thousands of people flock to the beach. The traffic jam

8. In addition, some have argued that indeterminism is a fundamental property of nature. See, for example, John Dupré, *The Disorder of Things: The Metaphysical Foundations of the Disunity of Science* (Cambridge, MA: Harvard University Press, 1993).

7. For further discussion, see Paul Slovic, "Perceived Risk, Trust, and Democracy," *Risk Analysis*, 13(6):675-82 (1993).

fails to materialize. Many people heard the radio broadcast and decided to stay home.

A second source of indeterminism flows from the underdetermination of theory by data.⁹ Any particular observation is consistent with an indefinite number of logically distinct theories. For example, the observation that there are a variety of life forms is consistent both with evolutionary theory and creationism. Often we try to distinguish theories by designing a crucial experiment, one in which distinct theories support different predictions. But there are distinct theories that cannot be distinguished in this way. In such cases, people often appeal to conceptual concerns in order to justify the choice of one theory over another—one theory is simpler, coheres better with other beliefs, and so on. While there may be grounds for preferring one of two empirically equivalent theories, in such cases there is no empirical fact of the matter about which theory is true; rather, the matter is indeterminate, for there are no empirical discoveries that would support one theory at the expense of the other.

The third source of indeterminism is even more basic than the other two. Knowledge claims presuppose categories, but categories are relative. For example, some people point to increases in global mean temperatures and extreme climatic events as evidence of global warming. But why is global mean temperature a significant category? Why not instead focus

on, say, average temperatures? And why bring together in the single class of extreme events such diverse phenomena as hailstorms, droughts, hurricanes, heat waves, cold snaps, and so on? What are the baselines from which the claims of increasing frequency or increasing temperature are projected? What may appear to be an increase from a baseline of 50 years ago may appear to be a decrease from a baseline of 500 or 5000 years ago. Of course, stories can be told about why one form of categorization is better than another; the point is that empirical investigation presupposes categories, without being able to justify them empirically in advance.

Rather than being epistemological problems, fallibility and indeterminism are metaphysical conditions. We have no idea how to overcome our fallibility or how to tame those regions of the world that are indeterminate. Uncertainty, on the other hand, is an epistemological problem. Uncertainty arises from ignoring our fallibility and winking at indeterminacies. What allows us to do this is a substratum of conventions, shared purposes, common contexts, and collective knowledge. Uncertainty is produced not just by narrow scientific mechanisms but also by broad cultural processes. Assertions of uncertainty are not just expressions of our ignorance but part of what brings order to our world. Uncertainty implies both the existence of certainty and the existence of a path from one to the other. Claims of uncertainty reflect and establish epistemological order and imply a research program and a way of moving toward closure.

9. The classic argument for underdetermination can be found in W.V.O. Quine, *Word and Object* (Cambridge: MIT Press, 1960).

THE USES OF UNCERTAINTY

Sometimes, uncertainty claims are used directly in attempts to bring policy debates to closure. For example, the precautionary principle, which has been endorsed by various nations and international bodies, states (roughly) that if an action or policy potentially has catastrophic effects, then we should refrain from undertaking it even if the probabilities are uncertain.¹⁰ On the other hand, some argue that unless it is certain that an action or policy will have harmful consequences, then it should be permitted. Both views figure in the climate change debate. Greens argue that since there is a significant chance that climate change will occur and have catastrophic consequences, we should “purchase some insurance” by capping greenhouse gas emissions. “Browns” argue that unless it is certain that greenhouse gas emissions will cause catastrophic climate change, we should not impose the costs on the economy that capping emissions would entail.

Direct appeals to uncertainty are rarely effective in bringing policy debates to closure. Instead they often open the door to the spectacle of dueling experts—scientists of equal training and stature who have diametrically opposed views about what is the case and what ought to be done. If the experts cannot agree about, for example, climate change, what is an ordinary person to think? Rather than providing a rational means for resolving epistemological differences, uncertainty reduces science to

just another playground for competing ideologies.

While it is true that scientific uncertainty and the debates that it engenders can be corrosive to scientific authority, those who see scientific uncertainty as destructive and delegitimizing overlook the fact that virtually all parties to various conflicts have an interest in maintaining scientific authority. The interest of scientists in maintaining scientific authority is obvious. But scientists also benefit from the right amount of uncertainty. If there is too much uncertainty, an area of research looks hopeless; if there is too little, research appears not to be needed. The right amount of uncertainty supports a call for further research.

Political actors of whatever ideological outlook have an interest in preserving scientific authority because science can provide a rationalization for decisions that are made on other grounds. When a policy decision can be presented as dictated by science, it is a way for a decision maker to evade responsibility for his or her choice. A decision backed by science can be viewed as implied by the nature of things, not as a decision for which a leader should be held accountable. Although political actors have an interest in preserving scientific authority, they also have an interest in keeping it in its place. The optimal role of scientific information for decision makers is to enable and structure decisions, not to determine them.

What I have suggested is that scientific uncertainty mediates between the closed world of scientific knowl-

10. For further discussion, see Budansky, “Scientific Uncertainty.”

edge and the open world of public policy formation. If what I have said is correct, the cultural imperative with respect to scientific uncertainty is not simply to reduce it but more generally to manage it. In a recent article, Shackley and Wynne have identified some of these management strategies.¹¹

Quantifying uncertainty is one way of managing it. In 1990, the Intergovernmental Panel on Climate Change (IPCC) estimated that a carbon dioxide doubling will produce an increase of global mean temperatures of 1.5-4.0 degrees centigrade. This estimate summarizes the results of some experiments run on what are regarded to be the best climate models. The IPCC estimate does not represent a probability estimate nor any kind of normal distribution. Yet specifying this range as the likely result of a carbon dioxide doubling sets limits on the uncertainties, thus making them more manageable.

Locating uncertainty is another way of managing it. When a climate model fails to successfully retrodict a past climatic condition, this could be regarded as evidence against the model. Typically, however, the uncertainties are located not in the model but in the data that the model manipulates. We are directed not toward a fundamental rethinking of the model but toward improving our data collection. When the uncertainties are located in the data rather than in the models, they do not threaten the gen-

eral project of predicting future climate on the basis of computer models.

Scheduling reductions in uncertainty is a third way in which uncertainty is managed. The 1990 IPCC report speaks confidently of reductions in uncertainty that will occur as a result of better data sets and more powerful computers. In 1988, the British Department of the Environment laid out a 25-year plan for eliminating all of the uncertainties with respect to future climate.¹² Of course, no one knows exactly how these uncertainties will be eliminated. Nonetheless, simply attaching a date to their elimination appears to make the problems more tractable.

IMPROVING DECISION MAKING

Despite the fact that scientific uncertainty plays a functional role in our public decision-making processes, many people are unhappy about how we make decisions that have important scientific dimensions. The core of the unhappiness, I believe, is that the gap between science and policy seems unnecessarily wide. As a society, we have a large investment in science, yet science seems to influence policy only indirectly. Science and policy can be brought into closer contact, but there is a price that must be paid. Here are some positive suggestions for how science can be brought into closer contact with policy questions.

First, greater attention can be paid to problem definition at the beginning of a decision-making process. When policy problems are not clearly defined and characterized, it is quite

11. Simon Shackley and Brian Wynne, "Representing Uncertainty in Global Climate Change Science and Policy: Boundary-Ordering Devices and Authority," *Science, Technology and Human Values* (in press).

12. *Ibid.*, p. 25 (in manuscript).

unclear what scientific information is relevant to bringing them to closure. Better problem definition involves being clear not only about what questions are being asked but also about the context in which they are asked and the purposes that answers to these questions are supposed to serve. The debate over climate change policy is an example of how things can go wrong when there is little agreement about what question is being asked. Some people claim that it is uncertain whether emitting greenhouse gases will change climate; others seem to deny this. In some cases, they are not really disagreeing. Both parties to the dispute may agree that, for the purposes of counting as scientific knowledge, the proposition is uncertain. More research needs to be done, data collected, and so forth. But those who seem to deny that there is significant uncertainty are often claiming not that there is no scientific uncertainty but that there is no uncertainty for the purposes of public decision making. In their view, the risk of climate change is known to be great enough, and the costs of mitigation and prevention are low enough, that some "no regrets" strategies ought to be pursued. This is an example of a case in which it is clear that the scientific data may rightfully be regarded as uncertain for some purposes but not for others.¹³

Second, various reforms in the practice of science would help in bringing scientific information into closer con-

tact with public decision making.¹⁴ Science, as it is practiced in American society, is an elite institution, to a great extent self-governing, with primary allegiance to its own internal values. While many people have access to the deliverances of science, very few people are involved in the production of science, and scientists themselves are overwhelmingly white, male, and upper middle class.

Finally, there are various reforms in our public decision-making processes that would also help to bring science into greater contact with policy. As things now stand, science and science policy are scattered throughout the federal government. We are one of the few industrialized nations that does not have a cabinet-level department of science and technology. Moreover, the adversarial way in which policy debate is conducted in this country may also have the effect of marginalizing or needlessly problematizing scientific information. Scientific institutions are in many ways authoritarian and directed toward the creation of consensus and thus are often at odds with the prevailing values of policy debate.

Broad changes in the areas I have identified would bring scientific information into closer contact with policy, but as a result, science would become less autonomous, and public decision making might become more technocratic. Even if it were thought that this price was not too high to pay, the effect that science would have on

13. These suggestions are more fully developed in Charles Herrick and Dale Jamieson, "The Social Construction of Acid Rain," *Global Environmental Change*, 5(2):105-12 (May 1995).

14. I have discussed some of these reforms in "What Society Will Expect from the Future Research Community," *Science and Engineering Ethics*, 1(1):73-80 (1995).

policy decisions would still remain limited.

One reason the role of science would remain limited is that our most important public policy decisions involve questions of value that cannot be addressed by science. A second reason why science would continue to have a limited role relates to the prevailing cultural attitudes that frame our decision-making practices. We are living in a time in which citizens are deeply insecure about their own futures and those of their children and have very little trust in institutions of any sort. In such an atmosphere, the bonds of community are strained and the willingness to make trade-offs is limited. Against such a background, science, however

certain, is of limited effectiveness in shaping people's view of the world.

CONCLUDING REMARKS

In this article, I have sketched a notion of scientific uncertainty that is in many ways different from the prevailing view. Scientific uncertainty is not simply an objective value that can be reduced by science alone. Rather, scientific uncertainty is constructed by both science and society in order to serve certain purposes. Recognizing the social role of scientific uncertainty will help us to see how many of our problems about risk are deeply cultural and cannot be overcome simply by the application of more and better science.