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The Evaluative Nature of Science:

How do we balance trust and skepticism?

When I released the film, *What Makes Science True?,* on NOVA Digital, along with an accompanying "explainer" article about the reproducibility crisis in NOVA Next (Henderson 2017), I received several criticisms that I could be damaging public trust in science and aiding the cause of climate skeptics. The comments were concerned with the reputation of science in general. Glenn Dolphin, Professor of Geoscience at the University of Calgary, wrote me: "I can see an anti evolutionist or climate change denier grabbing ahold of the 90% of papers are about findings that are not reproducible and feeding their argument." Jeff Dodick from the Weizmann Institute of Science worried that people "will misinterpret the concept of reproducibility as meaning that science doesn't have strong foundations." Dr. David Posnett, Emeritus Professor of Medicine in hematology and oncology at Cornell wrote: "The much easier glib conclusion by the public and lay press is that most science is simply wrong! E.g. Global warming is a hoax, NIH should be abolished (as suggested by Trump people), etc." Robert Peck, Senior fellow at the Academy of Natural Sciences of Drexel University, found the film "unsettling, for it seems to reinforce the opinions of the climate change deniers in the new administration who claim that most of what scientists say is 'false news'…" And my adviser, Carl Wieman: "…I see how the arguments you give could be used to erroneously claim that climate data and its interpretation is unreliable."

The film intended to communicate the nature of science, with a large emphasis on the tentative, changeable, and subjective aspects. It attempted to explain how and why individual scientific studies, mostly in the biomedical and psychology fields, were frequently failing the truth-test of external verification. The comments I received reveal a genuine concern for the perception of science and the institutions of science among the general public. How can we simultaneously encourage skepticism on the one hand and trust on the other? The underlying questions at stake are: is the general public capable of appraising evidence on its own? Can the public be trusted to make scientific decisions via the democratic process?

My own opinion is yes. It has to be yes. In a democratic society, citizens are involved in government decision making. In a scientific society, government decision making involves scientific evidence. Thus, the public's understanding of science is a necessary feature of proper governing. But what does it mean to "understand" science, and how deep does that understanding need to go for the electorate to make responsible decisions?

There is a theory in developmental psychology that very young children have difficulty telling the difference between a person's belief and reality. In other words, it is inconceivable to the child that a person could hold a belief that is demonstrably false. Wimmer and Perner (1983) illustrated this in a series of experiments where children were told a story in which a boy places some chocolate in one location and in his absence his mother moves it to a different location. The children in the study were asked: when the boy returns, where will he look for the chocolate? Wimmer and Perner found that most children under age 4 thought the boy would look in the original location.

It should be noted that this finding has later been revised—children as young as toddlers and even infants can successfully perform false-belief tests when administered in a different way (see Baillargeon et al 2010 for a review)—but my reasons for citing this research are purely allegorical. In her 1998 paper, *A Developmental Model of Critical Thinking* (Kuhn 1998), Deanna

Kuhn laid out four levels of epistemic understanding, the first of which describes the child above:

1) **Realist:** Assertions are **copies** that represent an external reality.
2) **Absolutist:** Assertions are **facts** that are correct or incorrect in their representation of reality (possibility of false belief).
3) **Multiplist:** Assertions are **opinions** freely chosen by and accountable only to their owners.
4) **Evaluative:** Assertions are **judgments** that can be evaluated and compared according to criteria of argument and evidence. (Kuhn 1998, p. 23)

In this paper, I will analyze the public's understanding of science, and various modes by which this understanding is developed, through the lens of Kuhn's four levels of epistemic understanding. The perception of science developed via transmission of a static body of "facts" resembles that of the child who thinks it is impossible for the protagonist not to know the truth: a realist. When science is presented as a controversy, often through the media, this perception rises to the absolutist level, assessing claims as either true or false. Progressive theories in science education that call for contextualized, tentative, and subjective understanding of science rise to a multiplist perspective, relinquishing the idea of certainty altogether. Only rarely do science education and communication efforts achieve the desired fourth level of evaluative understanding, but it is here and only here that the tension between trust and skepticism can be resolved.

LEVEL ONE: REALIST

Most of the time, people simply accept science as true. One of the ways this realist perspective develops is through technology. In part, science has earned a façade of infallibility by a track record of real success. Think of the banquet of technological advances we have feasted on in the last century alone: computers, airplanes, cell phones, the Internet, satellites, GPS, digital imagery, nuclear and solar power. In health: antibiotics, vaccines, dialysis, transplants, intensive care, heart surgery, almost every drug you've ever heard of, and more. The world is transformed by science, and people live day in and day out in constant interaction with—and dependency on—the products of science.

And that's the problem: we have great familiarity with the *products* of science, less with the process of science. Unlike the process of science, the products of science have no perceived relationship between cause and effect. Umberto Eco compares it to magic: "Magic is indifferent to the long chain of causes and effects, and above all does not trouble itself to establish by experiment that there is a replicable relation between a cause and its effect" (Eco, 105). You turn a key, the car starts up. You push a button, the computer turns on. You take a pill, the headache goes away. Gone are the multitude of tiny little steps, inferences and failures of the scientific process.

School science delivers a similar message by dealing primarily with what Duschl (1990) calls "final form science." Most of what students learn in school—physics, chemistry, biology etc.—involves science that has already been established beyond a reasonable doubt. The concepts learned are static and authoritative. Student perceptions of this kind of learning can be heard from several qualitative studies: one student described school science as “cut and dried” (Dhingra 2003, p. 249). Lyons (2003) summarized the message from several qualitative studies: “This is it. This is how it is, and this is what you will learn” (Lyons 2003, p. 591). It is a great irony that science, the tool that liberates individuals from the shackles of received wisdom, should be taught to its pupils in that very form.

School laboratory activities, too, portray science in its final, unchangeable form. Science labs are predominantly consumed by “technical and manipulative details” (Hofstein and Lunetta 2004, p. 31), “practical work” (Abrahams and Millar) or “craft skills” (Delamont 1088, p. 326). Robin Millar observes: “The aim is simply to *produce the phenomenon.* The purpose of the task is to get things to work as expected” (Millar 1998, p. 24). Even at the college level, “The professor does examples the ‘right way’ and we are to mimic this as accurately as possible…. Science is made “into a craft, like cooking, where if someone follows the recipe, he or she will do well” (Tobias 1990). Similarly, Linn & Palmer (2008) found, “Many expect scientific research to mimic their college laboratory experiments. Others are unprepared for the failure rate in independent research” (Linn & Palmer 2008, p. 627).

When lab experiments go well, and the predicted results are obtained, students come away with the false conclusion that they have proved the phenomenon in question. Harry Collins writes: “Science education in the classroom continually misleads our future citizens by making it seem as though an hour’s work at the bench can accomplish a level of certainty that took half-a-century to achieve in real life” (Collins 2000, p. 170). Whether it is a single demonstration in a lab, or a historical anecdote of scientific "discovery," the implied leap from observation to conclusion is one that Eco, again, likens to magic:

> Knowledge transmitted by schools is often deposited in the memory like a sequence of miraculous episodes: Madame Curie who comes home one evening and discovers radioactivity thanks to a mark on a sheet of paper, Dr. Fleming who glances absently at some mold and discovers penicillin, Galileo who sees a lamp swaying and suddenly discovers everything, even that the world rotates… (Eco, 109).

Final form science is not limited to school science—it appears throughout informal learning contexts as well. When museums present scientific discoveries as singular moments in history, or items on display, most visitors automatically accept them as true. Helen Graham (2016) discusses the reputation of the glass case in museum literature: "The glass case has been totemic for fifty years of critique—a shortcut for revealing museums' too-simple, modern, imperialist and deadening production of power and of facts" (Graham 2016). Graham's point is that the glass case in and of itself does not necessarily reflect a static image of science, but my point is that it can. Many museums have attempted a more constructivist approach with hands-on activities, but Osborne (1998) pointed out that "arguing that learning can be achieved only through doing… confuses learning with doing and is like arguing that the best way to learn poetry is by writing poetry" (Osborne 1998, p.8). Osborne's critique of hands-on activities in museums reflects the shortcomings of school laboratory activities mentioned earlier. Regardless of whether the means of communication are active or passive, science is still most often learned as an unquestionable truth.

Koshi Dhingra's (2003) study suggests that among film and television programs, the documentary and magazine genres (such as *Discovery Wild* and *Bill Nye,* respectively) can convey final form science as well. After watching the programs, students had no reason to question any of the truth claims presented in the shows. "It seems that the genre of documentary predisposed many students to accept knowledge claims without question," Dhingra wrote, "…the result is frequently a depiction of science that seems falsely sure of itself" (Dhingra 2003, p. 244).

The statement that science might be "falsely sure of itself" seems intended to provoke those committed to protecting the reputation of science. There is a genuine fear that, if the public loses trust in the institutions of science, there will be severe consequences. All of the comments on *What Makes Science True* that I listed earlier draw from such a sentiment. They make a legitimate point, but I argue for a scale between trust and skepticism that must be balanced. Too often, the ideal public understanding of science manifests as "public appreciation of science: the masses shall know about science and therefor will value it" (Gregory et al 1998, p. 88). Public "appreciation" of science leaves little to no room for fallibility:

> The PUS lobby sees science as basically unproblematic, with their main concern being focused on an ignorant public who need to be enticed into a proper appreciation of science…. The principle objective for scientists is simply to get their message across more clearly, while the message itself it seems is sacrosanct. (Arnold 1996, p. 63)

By these accounts, science in school, museums, and the media seems just as magical as the technology that surrounds us in the real world. Like the 3-year-old child in Wimmer and Perner's study, the learner sees no difference between the assertions made by science and reality itself. One perceives that it is impossible for scientists to believe something that isn't true. While the "public appreciation of science" group has a point in that public trust in the scientific institutions is very important, it is a slippery slope down the road to blind faith. We need people to be able to assess scientific claims as true or false.

LEVEL TWO: ABSOLUTIST

Global warming *is happening.* Smoking *causes cancer.* Vitamin supplements *are good for you*.

The first two statements are true. The second is false. Congratulations, you have entered the absolutist level.

Most of us feel at home in an absolutist understanding of the world. Most of the decisions we make are set up as binaries. In politics: red or blue. On tests in school: correct or incorrect. Someone's opinion: true or false, right or wrong. Even computers are composed of a bunch of ones and zeroes. John Dewey opens his book, *Experience and Education* as follows: "Mankind likes to think in terms of extreme opposites. It is given to formulating its beliefs in terms of *Either-Ors*, between which it recognizes no intermediate possibilities" (Dewey 1938/1997, p. 17). It seems to be how we are set up to think. And sometimes it works.

In some cases, science can be successfully divided into true and false claims, making such rudimentary assessments adequate. This includes the claims made by deterministic studies and proof-of-principle studies—best articulated by Goodman et al (2016):

> In a deterministic system (for example, computational research), the outcome is determined by the initial conditions…. A single failure to reproduce the original results with identical inputs casts doubt on the methodology and on any predictions…. Closely related is a proof-of-principle study, which demonstrates a new phenomenon not previously observed; for example, delivery of the first normal, live-born infant derived from in vitro fertilization or a first case of human limb regeneration would be sufficient to show that such phenomena are possible…. (Goodman et al 2016, p. 3)

In these areas of science, absolutist evaluations of truth and falsity are valuable, helping to debunk claims of cold fusion and self-generating stem cells, for example. But this kind of bright-line demarcation between true and false breaks down when studying complex systems with lots of variability, like climate and health. The statements at the beginning of this section have limited meaning because the answers involve ranges, averages, and trends: how much, to what degree, and how certain are you? It is true that smoking causes cancer, but only in an abstract sense. Smoking a single cigarette won't necessarily give you cancer, and neither will smoking a pack a day for 20 years guarantee it (although you are around 25 times more likely to get cancer than if you don't smoke). The ranges of truth around complex systems make it harder to explain them to someone who disagrees, which is probably why they are so prone to controversy.

Controversial truths also inherently touch on issues of morality, politics and behavior. Storksdieck and Stylinski (2012) distinguishes between “general science” and “areas where value judgments and belief systems influence even whether we want to know, or where knowledge implies subsequent action that may contradict beliefs and personal values…” The debates that rise out of these controversies can become heated and politicized, making a strong case for asking people to just accept what the scientific establishment says is true. Instead, arguments rage back and forth on a seesaw of either-ors worthy of children only slightly older than the one who thought the boy would find the chocolate.

The shortcomings of absolutism are neatly encapsulated in journalistic balance: “journalists often give equal weight to competing perspectives even if one side lacks merit or is a minority position” (Storksdieck & Stylinski p. 135). The visual presentation of news debates—usually a split screen with a representative of opposing views on either side—perpetuates controversy by promoting a false sense of equality between positions. Binaries around climate change not only misrepresent the scientific community, but also the nature of climate science itself.

In a televised conversation on Feb 27, 2017 (Tucker Carlson Tonight, 2017), Bill Nye and Fox News anchor Tucker Carlson discussed climate change, and vicariously, the nature of science:

> Carlson: “the essence of science is extreme skepticism, we always ought to be asking ourselves, ‘is my hypothesis true?’”

I might agree with Carlson here, except for the word “extreme.” Carlson then identifies what for him is an unverified claim in climate science:

Carlson: “Why the change? Is it part of the endless cycle of climate change, or is human activity causing it? ….And it seems an open question, not a settled question.”

Nye: “It’s not an open question, it’s a settled question. Human activity is causing climate change.”

The conversation so far is limited to absolutist terms: either a hypothesis is true, or it is false. Either human activity is causing climate change, or it isn’t. But then Carlson throws in this question:

Carlson: “To what degree?”

Nye: “To a degree that’s… a very serious problem in the next few decades.”

Carlson (pressing): “To what degree is climate change caused by human activity? Is it 100% of climate change is caused by human activity? Is it 74.3%? It’s settled science, please tell us to what degree.”

Nye: “The word degree is a word that you chose…. Instead of happening on timescales of millions of years, or let’s say 15,000 years, it’s happening on the timescale of decades, and now years.

Carlson: To what extent is human activity responsible for speeding that up?

Nye: “100%, if that’s the number you want.”

Carlson: So, at what rate would it have changed without human activity?

If it's not apparent from the transcript, Nye is visibly thrown off by Carlson's question, "to what degree?" His responses are vague, and he ends up meandering into a lecture about the last ice age, which was 20,000 years ago. Perhaps Nye couldn't remember the answer. Perhaps Nye is so used to public speaking that he automatically reduces what he says into absolutist terms: *Global warming is happening. It is caused by humans. And it will be bad.* Recall that it was Nye's own show which portrayed science in realist terms (science is always true) to Dhingra's students, and his statements on climate change seem in line with that level of epistemic understanding.

Nye's black-and-white portrayal of climate science broke down under Carlson's questioning, probably because he was trying too hard to speak a language that people will understand—the language of true and false. It was an unfortunate missed opportunity to teach Fox's audience something about the nature of climate science. The answer to Carlson's question, however, is a bit complicated, which speaks to the challenge of reaching for the upper levels of Kuhn's epistemic understanding.

LEVEL THREE: MULTIPLIST

If Nye fell pray to absolutism, Carlson—and all global warming skeptics—fell pray to multiplism. The multiplist, Kuhn writes, "[relinquishes] the idea of certainty itself" (Kuhn 1999, p. 22). It is reasonable for an uninformed observer of Carlson and Nye's conversation to think, "If experts with all their knowledge and authority disagree with one another, why should their views be accepted as any more valid than anyone else's?" (Kuhn 1999, p. 22). News reports on all science topics, not just climate change, seem to convey a multiplist understanding. When the children in Dhingra's study watched a health news report (on gender selection of prospective babies), they tended to question the truth claims much more than they did watching *Bill Nye* and *Discover Wild.*

> News and fiction that were used in this study were largely perceived as depicting a nature of science in keeping with postpositivist philosophers…. The depiction of scientific truths as tentative knowledge claims which depend on social negotiation and which may change depending on the operating research paradigm and the sociopolitical climate under which science works. (Dhingra 2003, p. 250)

Such "postpositivist" philosophy, when applied to science education, is prone to denying scientific certainty by overemphasizing uncertainty. Teaching and communicating the nature of science inherently include some element of "recognition that scientific knowledge is tentative (subject to change)" (Pedretti p. 6). While this is true, the nature of science *is* tentative (to a degree), stated in such absolutist terms, learners are ill equipped to engage with scientific controversies.

This issue was directly addressed in one of the critiques I received of *What Makes Science True?:*

> …Many in the post-modernist world have used this to critique science (without having any practical experience in the field) as producing theories which are just assumptions

> that can be cast aside as fashionable statements the way theories of art or music are wholly exchangeable. (This is not meant as an attack on the humanities in general). I also worry that this topic is very complex and that even though this is essential, younger students in the k-12 years will misinterpret the concept of reproducibility as meaning that science doesn't have strong foundations (Dodick, personal correspondence)

Dodick's point about the age of learners is a good one—there may be a prohibitive level of complexity in teaching the nature of science to younger learners. But his main worry is that the tentative, value-laden picture of postpositivist science will override its legitimacy in a learner's mind. This can have dangerous consequences.

Skepticism is precisely the "merchants of doubt" proselytize in Oreskes and Conway's book of the same title (2010). In the beginning, skepticism of global warming derived from the consequences, not the evidence. In the 1983 *Changing Climate: Report of the Carbon Dioxide Assessment Committee*, Nordhaus, one of the original climate skeptics, wrote,

> "A significant reduction in the concentration of CO2 will require very stringent policies, such as hefty taxes on fossil fuels…. Whether the imponderable side effects on society—on coastlines and agriculture, on life in high latitudes, on human health, and simply the unforeseen—will in the end prove more costly than a stringent abatement of greenhouse gases, we do not now know. (Oreskes & Conway 2010, p. 179)

This is a fair point, worthy of investigation. Weighing the costs and benefits of a stringent abatement of greenhouse gases (and, to avoid absolutism, degrees of stringency) is a debate we ought to be having—but that would require jumping to Kuhn's evaluative level, and we're not quite there yet. Instead, as the '80s wore on, the discussion was driven—very intentionally, according to Oreskes and Conway—into the multiplist's mode of relinquishing the idea of certainty itself. Such an epistemic state is a form of paralysis, which we are still struggling to break out of.

In the parting words of President Obama, "we can and should argue about the best approach to the problem [of global warming]. But to simply deny the problem not only betrays future generations; it betrays the essential spirit of innovation and practical problem-solving that guided our Founders" (Obama 2017). In other words, it betrays the scientific process.

Unfortunately, science education rarely touches on controversial issues. The same fear of being "biased" that led journalists to report false balance tends to make schools and museums avoid controversial topics altogether. According to Erminia Pedretti (2002):

> "Once a science centre or museum has agreed to issues-based installations, the thorny question of multiple viewpoints and advocacy rears its head. Should science centres or museums advocate particular positions? Should they remain unbiased, carefully representing multiple viewpoints? Which viewpoints? Whose viewpoints? Can a 'balanced' exhibition really exist?" (Pedretti 2002, p. 24)

Schools are similarly averse to scientific controversy, for similar reasons. Even news, which feeds off of controversy, eschews judgment when it comes to science. One news editor remarked, “We’re not here to tell the public how to behave—we’re there to tell them what’s happening” (Storksdieck & Stylinski 2012, p. 136).

The dangers of multiplism—which makes no distinction between the IPCC and the NIPCC, for example—make many in the science education wary of postpositivist relativism. Instead, many prefer to reinforce the idea that all science is true. Kuhn articulates the phenomenon far more eloquently than I can:

> People can spend entire lifetimes within the protective wraps of either a pre-absolutist stance in which assertions are equated with reality or, more commonly, the absolutist stance in which assertions can conflict but disagreements are resolved by appeal to direct observation or authority. In the modern world, however, it is hard to avoid exposure to conflicting assertions not readily reconcilable by observation or appeal to authority. As a result, most people progress beyond absolutism, venturing onto the slippery slope that will carry them to a *multiplist* epistemological stance, which becomes prevalent at adolescence. A critical event leading to the first step down the slope toward multiplism is likely to be exposure to the fact that experts disagree about important issues. If even experts cannot be counted on to provide certain answers, one resolution is to relinquish the idea of certainty itself, and this is exactly the path the multiplist takes (Kuhn 1999, p. 22).

Global warming denial rests entirely on “relinquishing the idea of certainty itself.” It is tempting to pack up our bags and head back to the realist level of simply appreciating science, where all science is trustworthy. In a democratic society, however, this is not possible. For better or for worse, we have no choice but to continue up the steepening slope of understanding.

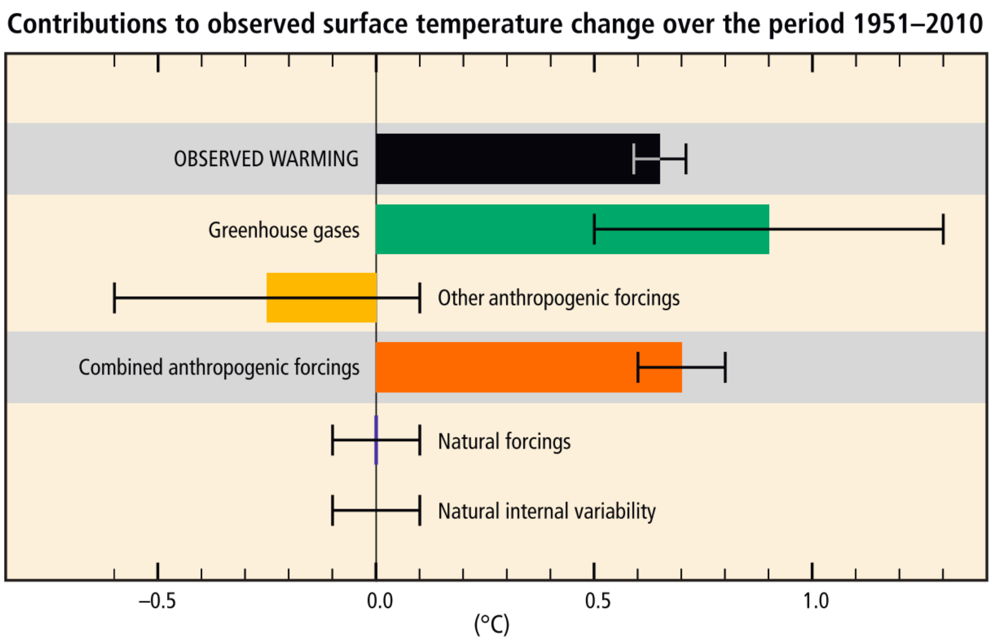
LEVEL FOUR: EVALUATIVE

The answer to Carlson’s question is: at least half. Without human activity, it is extremely likely that the average global surface temperature would be somewhere between 0.33 and 1.06°C lower than it is today (average global temperature increase since 1880 is 0.65-1.06°C). The IPCC climate report states:

> It is extremely likely that more than half of the observed increase in global average surface temperature from 1951 to 2010 was caused by the anthropogenic increase in GHG concentrations and other anthropogenic forcings together. The best estimate of the human-induced contribution to warming is similar to the observed warming over this period. (IPCC 2014, p. 5)

It’s not a very satisfying answer for the climate activist, who would prefer the statement, “humans *are causing* global warming!” Similarly, the wide range of “more than half”—and the attributed 0.33-1.06°C degrees—seems vague enough to at least partially justify climate skeptics. Why is the range so wide? Conservative coverage of the Nye-Carlson debate interpreted the IPCC statement to mean that “climate scientists cannot agree how much human activity contributes to climate change” (Kelly 2017).

I myself wondered why the range was so wide. In the IPCC report, just below the statement is a chart that shows that the mean combined anthropogenic forcings actually *surpasses* the observed warming—and the confidence error bars are only about +/- 0.1°C. Looking only at the graph, one can attribute a much higher amount of warming to human activity, in the realm of over 90%. Other models I have seen comparing "natural" to observed warming are similar (Meehl 2004). So why is the range so much wider in the statement than it is in the graph?



It took me some time to figure this out, but the reason is that the official statement ("more than half") uses the words, *extremely likely*, whereas the whiskers on the bar graph assess *likely* ranges. The level of confidence for each phrase is 95-100% and 66-100%, respectively. So, one could answer Carlson's question in two ways: it is extremely likely that humans are causing at least half of the observed warming, or 0.33-1.06°C (since 1880), and it is likely that we are causing over 90%, or 0.59-1.06°C. (Note that I applied the degree of human influence from

1951-2010 to all the warming since 1880, an additional 0.2°C, which probably throws off the technical levels of confidence in that statement, so a strict scientist might refuse to answer Carlson's question altogether)

But let's be conservative and accept that human activity may be causing only 50% of the warming of the planet. In the same breath, we also accept that we may be causing 100% of the warming, with degrees of likelihood inbetween. Does it matter? How will our response be different, if our greenhouse gasses are driving all of global warming, or only half? Ironically, if human forcings account for less warming, the logical action may be *more* stringent emission policies—since more mitigation would be need to curb the same amount of effect. That said, there is a cutoff point below which, if human activity is only causing so much warming, implementing strict policies would not be worth it, since warming would be inevitable. For me, this cutoff is below 50%—exactly where, I'm not sure—but it doesn't fall within the "extremely likely" scenario presented by the IPCC. Therefor, I see no reason to reject climate action.

The difficulty in accurately answering Carlson's question—as in, providing a range of answers and being honest about levels of confidence—is not insignificant. The official statement sounds unsatisfactorily vague, and at first blush seems inconsistent with graph it describes. Moreover, there are so many different ways to answer this kinds of questions—depending on the confidence intervals, date ranges and other variables one chooses to report—that even a highly educated observer is easily confused. The scientific understanding required to engage in this debate goes well beyond knowing a bunch of facts. Much of it rests on the concepts of risk, uncertainty, and degrees of influence—topics rarely covered in formal and informal science education (Goldacre). It requires critical thinking and argumentation, or, as Melissa Lane says, judgment:

> I use the term 'judgment' advisedly to denote an epistemic state distinct from knowledge…. Citizens in many real-life scenarios do not need merely or primarily to choose between rival experts or to root out a few obvious frauds. Rather, they need to decide how to assess and use what the spectrum of scientific expertise on a given issue reveals, a broader problem which is likely to be accompanied by the need to cope with multiple levels of uncertainty." (Lane 2014, p. 98; p. 104)

For some, achieving a public understanding of science in these terms is too much to ask. Morris Shamos believes it is hopeless: "Nevertheless… even this modest criterion puts scientific literacy beyond the reach of most educated individuals…. The notion of developing a significant scientific literacy in the general public… is little more than a romantic idea" (Gregory & Miller 2998, p. 92). Due to the complexity of the task, many observers, liberal and conservative, simply shrug their shoulders and trust an expert. Unfortunately, those "experts" are, for many, the likes of Bill Nye and Tucker Carlson.

Carlson's questions—and, I would say, the questions asked by all climate skeptics—deserve to be heard and answered. And if Carlson's cutoff for taking action to curb emissions is above 50% for the human impact on climate, then we can have an argument about likelihood, risk, and the usual values around the role of government. But this discussion necessarily requires understanding and communication at an evaluative level. The static and straightforward "facts" presented by Bill Nye in his show and in talking about climate go nowhere in a genuine debate, leading the public further down the slippery slope to multiplism.

As for Carlson, I am encouraged by the fact that he actually seems to want to understand. I wonder how he would have responded if Nye had been able to explain all of this to him, or at least given a range of degrees of human forcings. The problem is, as a group, climate skeptics don't seem to be actually looking for answers; instead, they're just trying to poke holes in whatever part of the global warming theory they can find. They conflate uncertainty with controversy. The wide range of values in the statement, 'the earth would be 0.33-1.06°C cooler without human activity,' is not because you have one group of scientists saying 0.33, and another saying it's 1.06—it's because of the variability inherent in complex systems.

But I prefer focus on the individual, rather than the group. In the words of Tommy Lee Jones' character in Men In Black, "The person is smart. People are dumb, panicky, dangerous animals and you know it." If an individual asks a skeptical question about climate change, an absolutist response will not do. We need to hear the question, buy them a cup coffee, open up a laptop, reach for Kuhn's evaluative understanding, and respond.

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