Scientific Reasoning Requires Much More than Simply Memorizing Scientific Facts that Support a Favored Conclusion

I was recently an audience member at a presentation on the effectiveness and safety of the various Covid-19 vaccines. The speaker was clearly quite intelligent. The talk was well-researched and very organized, and it was filled with scientific facts and evidence that beautifully supported the speaker's conclusion. The speaker made their case in extremely compelling fashion, and the bulk of the audience left highly convinced by the speaker's argument.

Whether the speaker's argument was that the vaccines are effective versus ineffective, and whether the speaker argued that the vaccines are safe versus toxic, is not relevant to this essay. In fact, the lecture could have been about many other science-related subjects – climate change, for example, or the upsides versus downsides of animal testing or nuclear power.

I, on the other hand, did not leave convinced. It was tempting to simply buy in to the speaker's argument, and I almost did. It was *that* good, and it meshed well with what I already believe. I caught myself, however, because I know that scientific *argumentation* – either creating a compelling argument regarding a scientific subject or evaluating a compelling argument about a scientific subject – is not the same as scientific *reasoning*, no matter how many scientific facts are presented, and no matter how well organized and compelling the argument is. I also know that scientific reasoning, in turn, is only a part of the truth discovery process.

Scientific Reasoning

It's true that for someone to be skilled at scientific reasoning, they must have a good understanding of the relevant scientific facts and data. To property tackle the evolution versus divine creation argument, for example, it helps to understand something about DNA and natural selection. To truly understand that the earth revolves around the sun and not vice versa, it helps to have a basic understanding of astronomy and planetary motion. However, as explained by academics Caitlin Drummond and Bernard Fischhoff, developers of the Scientific Reasoning Scale, scientific reasoning involves 1) learning and understanding scientific facts and concepts, and 2) developing a working understanding of and utilizing the *scientific method*. In other words, memorizing and understanding scientific data, facts, and concepts are necessary for true

scientific reasoning to occur. But they are not sufficient, if maximizing the odds of reaching objective truth about a scientific issue is desired.

A full description of the scientific method is beyond the scope of this essay. In brief, though, science involves forming hypotheses, and then testing them by making observations, collecting and analyzing data, and/or conducting experiments utilizing established approaches that minimize the influences of pre-existing observer bias, random chance, and confounding variables (a confounding variable is a factor that may cause one to conclude there is a causal relationship between two variables, when no such relationship actually exists). Science as a process involves the dispassionate, open-minded search for objective truth. It involves impartially following the data, wherever it leads. It often involves attempting to disprove a favored hypothesis.

Many people who believe they are thinking scientifically actually are not. Many who insist that they "believe in science" and who refer to those who have reached different conclusions regarding scientific issues as "science deniers" actually have little understanding of the scientific method. It is very common for people to utilize judgment heuristics when drawing a conclusion about a scientific issue, while believing that because the issue concerns science and they have a basic understanding of the relevant concepts, they are thinking scientifically.

Judgment heuristics are mental shortcuts – such as deferring to our intuitions, using "common sense," listening to our "gut feelings," and relying on "rules of thumb" -- that allow us to come to conclusions quickly and without putting in much work. As I'll explain, however, this type of reasoning is associated with bias, and with multiple other forms of "mis-thinking" that impede objective thinking and the discovery of objective truth.

Before I go on, in case you (like most people) initially find the concept of judgment heuristics confusing: You are utilizing judgment heuristics when you come to conclusions without performing deep analysis, without searching for and analyzing the best evidence and arguments you can find on both sides of an issue, and without then spending time reflecting on the information you have gathered. In other words, you have probably utilized one or more judgment heuristics if you have come to a conclusion regarding a complex political issue without utilizing a truth discovery process such as the six-point process provided toward the end of this essay. If you are typical – and yes, even if you are highly intelligent and highly educated -- you have probably utilized judgment heuristics for almost all of your political beliefs!

When you accept the first conclusion that pops into your mind, when you defer to your gut feelings or insist that for a particular issue, deep analysis and open-minded reflection are unnecessary and common sense is all that is needed, you are utilizing judgment heuristics. To simplify, you can think of utilizing judgement heuristics as simply deferring to your intuitions. Your intuitions, though, are not as accurate as you think they are.

In attempting to understand our usual approach to a scientific issue that has political implications (such as climate change, vaccine effectiveness, the pros and cons of nuclear power, or a whole host of other subjects), consider the following question about a *highly* complex subject: *Has anthropomorphic (human-caused) climate change become a crisis?*

Carbon dioxide, essentially a trace gas that comprises approximately 1/2500th of the earth's atmosphere, is only one of many factors that impact the earth's climate. In turn, human activity is only one of many factors that impact the carbon dioxide levels of the earth's atmosphere. Both the science and the computer modeling tying human-generated carbon dioxide levels to changes in climate are *highly* complex – so complex that very few of us have ever attempted to tackle this question head-on, utilizing true scientific reasoning. Instead, we utilize judgment heuristics – that is, shortcuts, that are highly susceptible to error.

Forms of mis-thinking associated with heuristics-based belief formation include:

1. We ***substitute***. In approaching the above question, we in essence address simpler, much easier-to-answer substitution questions, such as *How important is it to me to be a good steward of the environment? How concerned am I about making sure my children and grandchildren live in a world in which the environment is clean and safe? How worried am I about the potential impacts of climate change? What have I seen recently about climate change from the media sources I pay the most attention to? What recent major weather events – events that could be associated with climate change – am I aware of? How concerned am I that the climate change issue is being exaggerated by powerful people, to reign in capitalism and consolidate power? Do I trust the politicians who tell me human-generated climate change is a major problem? Do I trust the politicians who tell me concerns about human-generated climate change are overstated? What do my friends believe about climate change?*

2. We answer the substitution questions – that is, we form our belief -- in a manner that is highly susceptible to ***cognitive biases***. Cognitive biases are errors we make when we utilize heuristics-based processing to form our beliefs. Psychologist and Nobel Prize in Economics winner Daniel Kahneman and his research partner Amos Tversky revolutionized the ways in which we think about human judgment by describing how we utilize judgment heuristics to reach our conclusions, and by describing many of the biases that occur when we reason this way. (If you have not read Kahneman's *Thinking, Fast and Slow*, order it as soon as you are done reading this essay.)

The most significant of the cognitive biases when it comes to political thinking is *myside bias.* The political beliefs we form are highly influenced by our existing convictions, those deep opinions, attitudes, and beliefs for which we have emotions and even our sense of self-identity involved, such as our beliefs about abortion, religion, systemic racism, gun control, climate change, equality and equity, and perhaps most importantly, which political party is most worthy of our support. Our conviction-level beliefs, attitudes, and opinions all influence the new beliefs we form.

Myside bias is a form of motivated reasoning. We *want* certain beliefs – those that line up nicely with what we already believe – to be true. And we *want* to believe them. Far more often than not, *myside bias* leads us to automatically conclude that if a politician accused of a crime belongs to the party we support, they are innocent, and vice versa. Myside bias explains why we so often think the coach of our child's sports team should have given our own child more playing time. It's why we so often feel the referees were biased against the team we favor. Myside bias explains why we generally see political leaders on our side as all good, while seeing the other side's leaders as all bad. *It explains why we so often believe our own side's conclusions about complex scientific issues we barely understand*. It explains why we generally support the military actions our political party supports, and why we generally oppose military interventions supported by the other side (unless, of course, our side supports the intervention as well). Myside bias is why we generally believe that any new law or policy proposed by politicians on our side of the political aisle is likely to be successful, while believing that the policies favored by the other side are destined to fail. It explains why we so often attribute favorable economic circumstances to our side's leaders, and unfavorable economic circumstances to the other side. It

helps explain why we so often form very strong beliefs about highly complex and controversial issues after consulting only the information sources that support our side.

Abundant data, such as that from Keith Stanovich and his research partners, reveal that the highly intelligent and highly educated are at least as susceptible to *myside bias* as are those without elite-level intelligence and advanced degrees – and perhaps more so! (Consider reading Stanovich's 2021 masterpiece *The Bias that Divides Us: The Science and Politics of Myside Thinking*. It's a slow, somewhat difficult read, as it's written for academicians who already have a strong background in heuristics and biases. In my opinion, though, it's one of the most important books ever written).

Another critically important cognitive bias is referred to by many different names, so I simply refer to it as *the tendency to form new beliefs biased by the beliefs of our associates*. People of all levels of intelligence are highly influenced by this bias as well.

3. Once we have formed our belief, we ***think backward***, building an argument by gathering confirmatory evidence in support of the belief we have formed. We think it's the other way around – that we formed our belief in response to the evidence we have gathered – but it rarely is. We decide – that is, we form a belief – and we then gather confirmatory evidence, to create a neat new belief-plus-supporting-evidence-and-other-reasons argument that makes sense to us, that is coherent with our existing beliefs and convictions.
4. We ***ignore conflicting evidence and arguments***. In creating our beliefs and belief arguments, we simply ignore evidence and arguments that would cause us to consider an alternative conclusion, and we write off sources that might provide it as unreliable and dishonest. We now have the sense of satisfaction that we *know*, and we typically feel no need to question or explore further.
5. We become quite confident – yes, ***overconfident*** – in the belief and the narrative (argument) we have formed. As long as the story makes sense to us, and as long as it is coherent with the beliefs we already have, we *know* we are right. The level of confidence we have, however, is much greater than the level of confidence we should have, given the approach we have used to arrive at our conclusion.

Confidence, it turns out, comes from having created a coherent story that makes sense to us, with little or no conflicting information. It comes from having a set of beliefs that fit together well. However, while a high level of confidence in one's beliefs is generally associated with the illusion of knowing, it has little to do with whether objective truth has been achieved. A high level of confidence is often even a warning sign that one does not understand the complexity of one's subject matter, and that one does not understand one's own belief-forming approaches and limitations!

6. We develop ***belief perseverance***. That is, we cling ferociously to the belief we have formed, we refuse to entertain any evidence and arguments that might cause us to reconsider, and we steadfastly refuse to even consider changing our minds.

Our worldview and overarching political ideology, usually based heavily on the views of those most influential in our lives during our late teens and early twenties, are generally formed similarly (though genetics appears to play a role as well). And yes, we use the non-reflective, heuristics-based approaches outlined above when we determine which information and opinion sources we deem accurate and trustworthy, with *myside bias* weighing heavily. If a politician or political information source reinforces our political beliefs, convictions, worldview, and ideology, we tend to consider the source as competent, reliable, and truthful; and even assume its goals are aligned with our own. Meanwhile, we simply write off sources favorable to the other side as incompetent and untruthful, and often assign malevolent motives.

It's relatively easy to see the above forms of mis-thinking in those we disagree with. It's *extremely difficult* to see them in ourselves.

Another point regarding scientific reasoning deserves special mention: science is rooted in skepticism – not in ready and willing acceptance. Skepticism allows the scientist (or scientific reasoner) to remain objective, to refrain from jumping to conclusions in the face of insufficient evidence. Healthy skepticism forces the scientist to open-mindedly and thoroughly search for and review contradictory evidence and arguments before arriving at a conclusion. It also forces one to remain open-minded after a conclusion has been reached, and to treat the conclusion not as what University of Pennsylvania political judgment expert Philip Tetlock refers to as a treasure to be

guarded, but rather as a hypothesis that should continually be reevaluated. Of course, skepticism is different than denialism (which is the refusal to reject a preferred hypothesis in the face of overwhelming contradictory evidence)!

Here are some examples of scientific reasoning:

- Carefully designing a double-blinded randomized controlled clinical trial, to help minimize the impact of bias
- Collecting data, and then performing a regression analysis, to minimize the impact of confounding variables
- Open-mindedly reviewing scientific data and reading scientific arguments in an attempt to disprove a favored hypothesis
- Open-mindedly reading and reflecting upon the totality of peer-reviewed studies on a particular issue, including studies that conflict with each other, and with one's existing convictions, worldview, and political ideology
- Maintaining skepticism regarding a science-related conclusion reached by one's favored political party

Here are some examples of thinking about science that do not meet the above definition of scientific reasoning, and that do not maximize the odds of reaching objective truth regarding a scientific issue (especially one that has become political):

- Memorizing science-related data and other material for a high school or college science test
- Adopting the science-related belief that one's political party, one's associates, and / or one's favored media sources have adopted, without additional analysis, without additional reflection, and without skepticism
- Simply adopting the conclusion of the scientific consensus, especially regarding conviction-level beliefs for which both you and the scientists care about the outcome and have your sense of self-identify involved. Sure, this will often (but not always!) get you to the right answer -- but it is *not* an example of scientific reasoning.
- Reading and quoting only the scientific papers that support one's existing beliefs

- Building an argument, filled with supporting data and evidence, in support of a favored hypothesis
- Building an argument to support a conclusion you formed via the utilization of judgment heuristics (highly influenced by *myside bias* and the *beliefs of those you associate with*), by collecting large amounts of supporting scientific data and organizing it into a highly compelling cause-and-effect narrative

For those with a good working understanding of the scientific method, scientific reasoning (such as impartially following the data wherever it leads), treating beliefs as mere hypotheses, and remaining skeptical can become natural ways of thinking even for non-scientific issues. However, when it comes to political issues, even skilled scientists frequently subconsciously abandon scientific reasoning, in favor of heuristics-based approaches. When a scientist enters the realm of politics, or when a scientific issue becomes political, all bets are off!

Earlier in this essay, I mentioned that scientific reasoning includes both a) learning and understanding scientific facts and concepts, and b) understanding and applying the scientific method – and that even when done well, it is only part of the truth discovery process. Consider the following model for discovering objective truth:

1. Begin by asking yourself: *am I attempting to build or bolster an argument, or am I attempting to arrive at objective truth?* These are *very* different goals, requiring *very* different thought processes.
2. Make a conscious effort to stay as open-minded and objective as possible. Resist the temptation to simply defer to the first intuitive answer that pops into your mind. And attempt to separate yourself from your exiting beliefs, convictions, worldview, and political ideology; from your favored party's political platform; and from the beliefs of those you associate with.
3. Carefully gather evidence and arguments from the most credible sources on each side of the issue.
4. Assimilate and analyze the information gathered, including using "specialized" forms of thinking as indicated, such as probabilistic reasoning, scientific reasoning, and statistical reasoning.
5. Spend a significant amount of time reflecting, and just *thinking*.

6. Reach a conclusion you treat as a working hypothesis, as opposed to a firmly established fact gripped in a tightly clenched fist. In other words, maintain an open mind, continue to search for and evaluate conflicting data and arguments, and remain open to adjusting or even changing your belief as often as evidence and superior arguments lead you to do so.

Scientific reasoning, even when done well, is only one step in the above 6-step model for reaching objective truth regarding a scientific issue! It is simply not enough to proclaim "I believe in science," and to then refer to those who have reached opposite conclusions as "science deniers" while avoiding the utilization of true scientific reasoning, and while having no good understanding of how scientific reasoning fits in to the truth discovery process.

If you haven't searched for and open-mindedly considered the best evidence and arguments that contradict your favored beliefs, you are not done yet, no matter how intuitively obvious your conclusion seems.