

The Limits of Information

Daniel N. Robinson

There is a long, winding, and vexing wrangle among philosophers on the nature and validity of our knowledge of the physical world. Take the example of color. A stroll through the garden reveals a busy bee extracting nectar from a yellow rose. I see the yellow rose owing to certain pigments in the cone receptors of my retina. In a normally sighted person, the neurochemistry of vision operates over a range of wavelengths from about 360 to 760 nanometers (nm)—roughly violet to a deep red. What English-speaking percipients describe as “yellow” is in the near vicinity of 580 nm, a little above the eye’s peak sensitivity. For the honey bee, matters are quite different. Its compound eyes are equipped with three types of retinal receptors—one for very short wavelengths (peaking at 344 nm, or ultraviolet), a medium-type (peaking at 436, or blue), and one for long wavelengths (peaking at 544, or green). Though we and the bee may share floral preferences—revealed in the bee’s foraging and in our table settings—the bee’s representation of the external world clearly includes features to which we are blind.

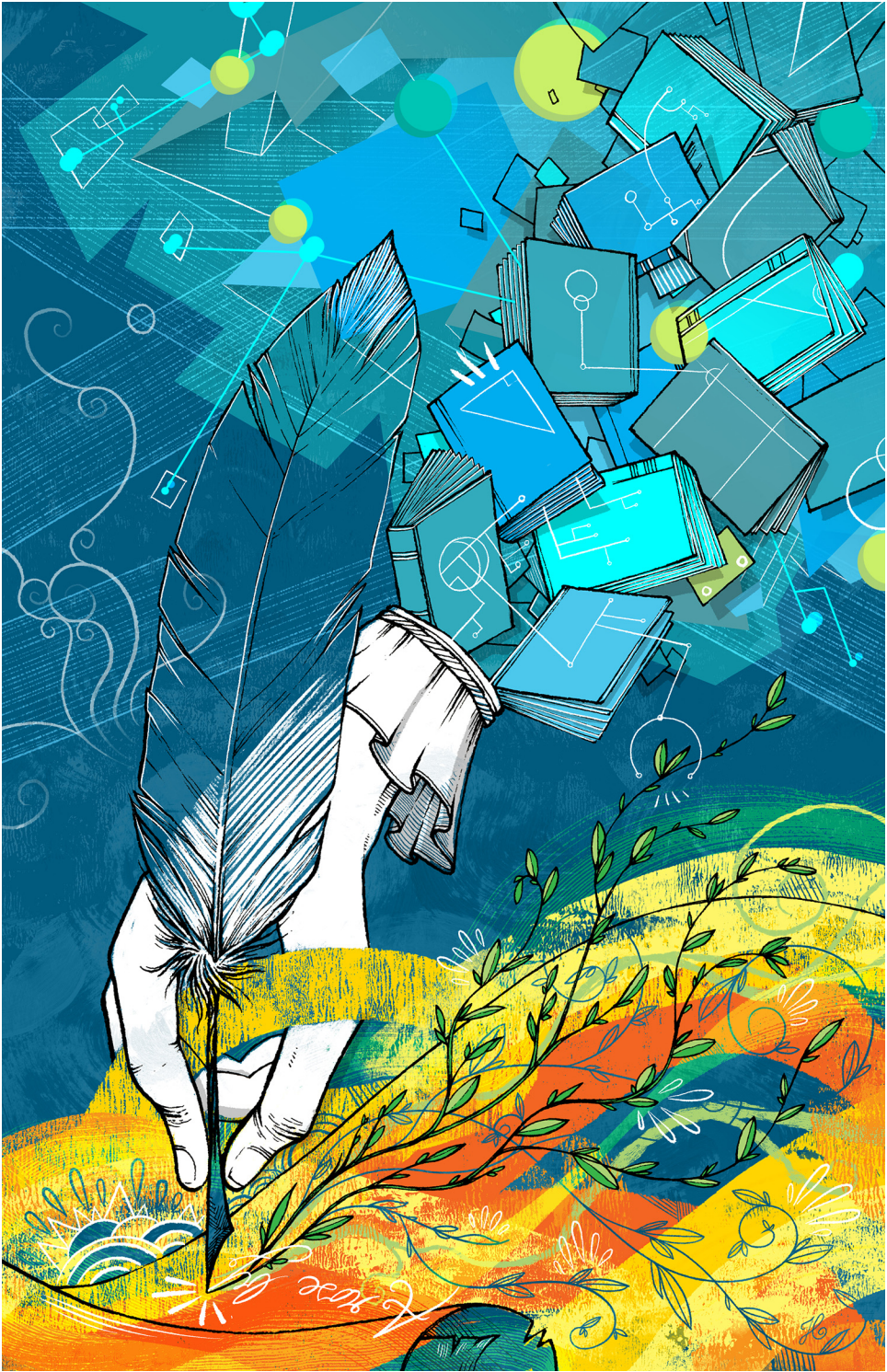
Were all sources of electromagnetic radiation to fall at wavelengths shorter than 340 nm, the affairs of the world would pass us unseen. (And eyes like ours wouldn’t work very well anyway, since excessive exposure to ultraviolet radiation renders the human lens increasingly opaque as a result of cataracts.) Our inability to see (or to endure) much ultraviolet radiation is a heavy price to pay for our eyesight, but it does protect the human retina from destruction by this same radiation. The moral of the tale so far is that creatures are fitted out for the world as given, and modes of adaptation come at a price.

Is this explanation of human perception no more than a poor glimpse into evolutionary forces? Here we face yet another of philosophy’s enduring engagements, to wit: What counts as an explanation, and what standard is to be applied in evaluating competing explanations?

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Explaining the World

In 1814, Pierre-Simon Laplace presented his famous “demon,” as it has come to be known. Imagine a superior intelligence who, knowing the precise location and momentum of every atom in the universe, can account for the past and predict the future from the laws of classical mechanics. For this intelligence, Laplace wrote, “nothing would be uncertain and the future, as the past, would be present to its eyes.” To explain the nature of a thing or occurrence, by this way of thinking, would require that we know with certainty the physical processes at the smallest level, because they determine the events at any larger level.

But then, some two centuries after Laplace, comes Werner Heisenberg and quantum mechanics rendering uncertain any attempt to specify a particle’s position and momentum simultaneously. Of course, uncertainty at the quantum level may impose no barrier to determinism at the macro-level, but even this proposition raises questions regarding the nature of explanation and the level at which scientific explanations are of the right sort.

But why assume there is a fixed and right sort of explanation? Sometimes taken to be the “realist” position in the philosophical debate between realists and anti-realists, the idea that there is a right sort of explanation is predicated on a core of metaphysical precepts. Dominant these days among such ideas is *physicalism*, which takes physical events and objects to be the sole and ultimate furniture of reality. Explaining such events and objects then calls for what is finally a causal account. In principle, all that is really real, even all that we cannot yet observe, is subject to explanations located within a causally closed system—that is, one admitting only of physical causes.

In 1980, Bas van Fraassen published *The Scientific Image* in opposition to the prevailing belief that scientific theories offer a true and closed account of how things “really” are. His “constructive empiricism” limits the reach of science to what is observable. Accordingly, to endorse a scientific theory entails no more than the belief that the theory is empirically adequate, which does not require that we make any grand claims about the nature of reality. This is a more modest position, requiring only agnosticism in the matter of hidden variables and unseen processes. Allegedly complete systems are simply too grandiose for serious consideration.

In his later book *The Empirical Stance* (2002), van Fraassen argues for the rejection of metaphysics as foundational for science and, indeed, the rejection of “foundationalism” itself—“the project to construct all

knowledge on a foundation that cannot be false, by a method that cannot introduce falsity.” A commitment to empirical adequacy can never satisfy the lust for indubitable certainties regarding reality. Whereas the scientific realist begins with metaphysical presuppositions that would have authority in the matter of relevant and irrelevant observations, the empirical stance puts one in a different position: that of an observer whose choice of observables is aimed at adequacy in accounts of how things are. This stance, on van Fraassen’s understanding, liberates one from the burden of futile gestures.

Let’s pause to summarize these main points. First, the search for universally valid physical explanations must be futile, for some physical phenomena themselves lack the requisite certainty, as we know from quantum mechanics. Second, that aspiration cannot include a systematic understanding of what counts as an explanation in the first place. Imagine a Martian, sent to Earth to discover what human beings are. Returning to Mars, the “earthopologist” submits a report accurate in every detail regarding the composition of bodies identified as “human”: potassium, water, calcium, and so forth. All the empirical data are accurate and reproducible, but nothing in the account explains anything of interest about human beings. While this might count as an explanation of the chemical composition of human bodies, it cannot be considered an explanation of what it means to be human.

Of course, we are all inclined or even forced to make truth claims about objects and events “out there” in the world. For instance, things dissolve in water, and this occurs under so many and different conditions as to lead one to the belief that water is a universal solvent. And there are countless other reliable facts that have the potential of generating beliefs about the world. The process of belief formation begins when, in the welter of worldly things, we focus on some facts at the expense of others, in the same way that our Martian examined the chemistry of human beings but not their artistic productions. Moreover, we have a choice to make about our overarching orientation—our stance—that determines how these facts are to become part of our understanding of the world. Is the right stance that of the rationalist, who requires a body of facts to fit into a more general rational framework, ultimately reducible to, say, a “theory of everything”? Or does one adopt an empirical stance that demands no more than an adequate basis on which to make accurate predictions and achieve practical goals?

It is not my intention to defend anti-realism. My own stance, if it’s even worth considering, is the Kantian position that, like it or not, we are

all destined to be metaphysicians, so it's a good idea to prepare for the mission. Van Fraassen, however, draws attention to the non-scientific dispositions and orientations endemic to the pursuit of knowledge: the choice of facts we attend to in our reasoning, and the stance one adopts in that process. There are also emotional and motivational factors that contribute to our choice of explanations. Once a revolutionary challenge to a previously uncontested scientific theory is vindicated by the facts, the scientist committed to that theory undergoes something akin to an emotional breakdown. There are real personal and psychological forces at work in a realm that textbooks treat as antiseptic and "objective."

Information vs. Meaning

In attempts to account for distinctly human endeavors, explanations have a narrative quality. Thus, Jane's aspiration to be a concert violinist accounts for—that is, explains—the many hours of practice expended over a course of years. Henry wishes to understand the defeat of Napoleon at Waterloo. The story—the explanation—runs along these lines: Wellington, after the battle of Quatre Bras, moved his forces to Waterloo. The allied Prussians moved to positions drawing a large portion of the French forces away from Waterloo to Wavre. With Prussians attacking Napoleon's right flank and Wellington attacking the center, Napoleon's fate was sealed.

Try to translate these two explanations—for why Jane practices the violin, and for why Napoleon was defeated—into terms faithful to evolutionary biology or neuroscience or the concentration of potassium in the human body. Try again. Alas, the thing just doesn't work. Now adopt the empirical stance and see if you can come up with a theory of any sort that, even if not complete, would still be adequate for explaining these events. This won't do much for us either, for events of historical moment express the beliefs, skills, powers, and plans of *specific* persons who, if removed from the narrative, leave us with an entirely different set of events. No doubt, absent a properly functioning nervous system, Jane can't even hold the bow of a violin. Absent the evolutionary roots and branches, there are neither armies nor nations. We might agree with all of this and, at the same time, acknowledge the unique, personal, individuated character of those responsible for the events in question. There could not be *War and Peace* had there not been a developed language. But there could not have been *War and Peace* had there not been Tolstoy. What we search for to account for the great novel is not a causal theory but a deeper *understanding*. Here,

then, is the *Verstehen* school of historiography, which does not try to find a causal explanation of an event based on objective factors alone, but rather to understand the particular intentions and contexts from the standpoint of the people involved.

A word more about battles and unintended consequences: The Battle of the Bulge cost both Germany and the Allied forces heavily. It was decisive as the Second World War moved to a close in the European theater. Until this battle, black U.S. soldiers were assigned to segregated units. Heavy casualties in the Battle of the Bulge resulted in the decision by General Eisenhower to integrate the services for the first time. More than 4,500 black soldiers volunteered for service at the front, a fact that later supported the cause of desegregation nationally. So, if we seek to identify the causal factors leading to desegregation, the Battle of the Bulge has a place in the narrative. Finding a comparable place for evolutionary or neurocognitive processes is an exercise in absurdity.

In May 2009, M.I.T.'s *Technology Review* published a brief online essay titled "The Foundation of Reality: Information or Quantum Mechanics?" After citing some leading-edge theorizing, the essay concludes that

it is not the laws of physics that determine how information behaves in our Universe, but the other way round. The implication is extraordinary: that somehow, information is the ghostly bedrock of our Universe and from it, all else is derived.

"Information," of course, is not palpable. Its place is found within advanced theories that rely on unseen properties and events that are probabilistic in principle. It is said that ours is an "information age." This is apt at several levels. Thanks to Claude Shannon, Warren Weaver, and other mathematicians, engineers, and cryptographers, we now have a veritable metric for information, and we are but a click or a swipe away from megabytes on any topic of our choosing. Our world's broadcast technologies alone were able to transmit some 430 exabytes (10^{18} bytes) in the year 1986 and 1,900 exabytes three decades later. The sky's the limit. Yet, the bounty might be fool's gold to those who merely click their way to facts. Consider the *Oxford English Dictionary*, the second edition of which contains 59 million words and requires 540 megabytes of storage. Randomly accessing the contents is unlikely to generate a string yielding *King Lear*. We cannot explain Shakespeare's achievement by noting how much information is contained in a play, or how much information was available to him when he wrote it. Nor are the uncertainty relations revealed at the quantum level of any consequence here.

Shakespeare’s “stance” was a *narrative* stance; by revealing the reasoning and ambitions of his characters, their foibles and highly individuated personalities, he was able to tell a story. The story of the person is readily recognized as the story of a type of person. And then one discovers that each such type is present in each of us, to be tapped or suppressed by opportunity, fate, contingency, or mere luck. “The play’s the thing” reminds us that it is only when the story is fully told that we can locate ourselves within it. What counts here is not information in the dimensionless sense of bytes, but meaning in the full sense of a story told.

Matter Alive

Let us recur to that Martian visitor, intelligent and thoughtful but from a culture radically unlike our own. We had him sent as an explorer, charged with the principal task of establishing the nature of humans. After careful study and measurement, he returns to Mars and submits this summary: *Human Nature*—oxygen (65 percent), potassium (0.4 percent), carbon (18.5 percent), and so on. His information is correct in every detail, but says nothing about “human nature” in the fullest sense.

So, too, with neuroscience: in the centuries since the anatomist Herophilos performed human dissections in ancient Alexandria, the “brain sciences” have developed at a rate comparable to any other branch of biology or even physics—especially with the new tools of recent decades—but they still offer only a very incomplete picture of human nature. Of all bodily organs, the brain is the one most reliably associated with thought, perception, memory, emotion, and activity. These features of conscious life are accessible to each of us directly. We are not made aware of our awareness by adopting an empirical stance. Nor do we await causally closed accounts before risking a guess as to why Mary is taking her umbrella to work on a rainy day. Notwithstanding the progress in neuroscience, the elements of lived life yield a “folk psychology” without which the brain would be of no greater interest than the spleen. We are as good (or bad) at explaining ourselves to each other now as were our remote ancestors, including those who had no knowledge of brains at all. By ordinary standards and expectations, this suggests a fundamental gap between the character of lived life and the neural processes grounding such a life—and thus, again, between the various types of explanation.

Back to the Battle of the Bulge. Consider a person with prejudices that have hardened over the course of a lifetime, willing to do anything rather than include a black man within his all-white civic space. He then sees

for the first time a photograph of African-American soldiers, in full battle gear, heroic in the defense of freedoms they themselves do not have. What value is there in connecting the sudden epiphany to some alteration in the metabolic activity of structures in the limbic system? And who would sit still for the claim that it was the brain that revised its prejudice-center?

The problems generated by billions of persons living lives shaped by culture, religion, education, and history are and will remain daunting. They are not to be outsourced to scientists or technologists promising to strip them of their complexity. As best as we can tell under the light of history, we are moved finally by beliefs for which empirical vindication is never complete or convincing. It is said that Kant's ritual of afternoon walks was interrupted by the pages of Rousseau's *Emile*. Arthur Rubinstein claimed that on the occasion of his death he would know if he had reached heaven if he heard the Adagio movement of Schubert's Quintet in C major. In the masterful work *Flow: The Psychology of Optimal Experience* (1990), Mihaly Csikszentmihalyi writes of

what a painter feels when the colors on the canvas begin to set up a magnetic tension with each other, and a new *thing*, a living form, takes shape in front of the astonished creator.... [P]eople who have survived concentration camps or who have lived through near-fatal physical dangers often recall that in the midst of their ordeal they experienced extraordinarily rich epiphanies in response to such simple events as hearing the song of a bird in the forest, completing a hard task, or sharing a crust of bread with a friend.

In these moments the moral, spiritual, and aesthetic dimensions of lived life may be informed by physics and physiology, but only from the third-person perspective. From our own first-person perspective, words alone fail, and making the experience known to another requires appealing to what is common in our humanity—yet another gap.