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Chapter 13

Why not Big-E Empiricism

1. Introduction

The conception of small-e empiricism defended here is optimistic. We can, have and will continue to be informed, by experience, of truths about nature that go well beyond experience and that form the fundamentals of our science. Small-e empiricism renounces the pessimism of Big-E Empiricism, which holds that *all* that we know of the scientific world is *only* that experience. Since Big-E Empiricism has long held a visible position in the empiricist tradition, this chapter collects the reasons given in earlier chapters for why it fails as a scientific empiricism.

First, as recounted in Section 3, to be viable, Big-E Empiricism needs some clean division between propositions expressing experience and those in science that do not. This division is precluded by the relational conception of experience, which in turn is derived from an examination of how experience enters modern science.

Second, as recounted in Section 4 and illustrated in Section 5, Big-E Empiricism elevates experience as the ultimate authority. That authority is routinely belied by the practice of science. No individual experimental result or observation is beyond correction; and a common source of corrections is supplied by the deeper results of scientific theories. Thus, these deeper results have an authority over individual experiences in contradiction with Big-E Empiricism.

Third, as recounted in Section 6, the propositions of experience stand in inductive relations of support with deeper results within the sciences. These are objective relations and that we accept them is a fundamental dictate of rationality. Big-E Empiricism can choose to ignore these relations of support; but it cannot ignore them at the same time as adhering to the dictates of rationality.

Fourth, as recounted in Section 7, a part of the case for small-e empiricism is that its ontology includes experiential processes. We are well-informed by them because they are a real and can convey to us the condition of systems of inference. Big-E Empiricism has to remain uncommitted to this ontology and thus must forgo this foundation for the efficacy of experience.

Section 8 concludes with a small footnote from history. An explicit debate over the issues separating small-e and Big-E Empiricism is not to be expected in routine science. Yet Werner Heisenberg and Albert Einstein undertook just such a debate over the newly emerging quantum theory of the 1920s. Before proceeding to the problems facing Big-E Empiricism, some formulations of Big-E Empiricism are recalled briefly in Section 2.

2. Some Formulations of Big-E Empiricism

Big-E Empiricism shares with all versions of empiricism the defining characteristic of privileging, in some manner, experience in our epistemic enterprises. The distinctive feature is a skepticism about those parts of science that are not directly experiential. A common formulation is that the non-experiential propositions play a purely instrumental role in allowing us to connect experiential propositions. Quine (1951, p.41) in his celebrated "Two Dogmas of Empiricism" expresses it as:

> As an empiricist I continue to think of the conceptual scheme of science as a tool, ultimately, for predicting future experience in the light of past experience. Physical objects are conceptually imported into the situation as convenient intermediaries—not by definition in terms of experience, but simply as irreducible posits comparable, epistemologically, to the gods of Homer.

That this role is meager forms the basis of Hempel's classic "theoretician's dilemma" (1958, pp.49-50):

> If the terms and principles of a theory serve their purpose [of "establish[ing] definite connections among observable phenomena"] they are unnecessary, as just pointed out, and if they don't serve their purpose they are surely unnecessary. But given any theory, its terms and principles either serve their purpose or they don't. Hence, the terms and principles of any theory are unnecessary.

Variations on this formulation are possible. We may, following Hempel's dilemma, allow theoretical propositions to have this connective role only. Or we may, following van Fraassen's constructive empiricism, allow theoretical propositions to have a literal meaning, while not assigning a truth value to them.

3. The Relational Conception of Experience

The most immediate and most serious problem for Big-E Empiricism is that it requires a clean division between experience and theory, for experience only can be veridical. The arbitrariness of this division has proven to be an enduring difficulty for Big-E Empiricism. This division is expressed in van Fraassen's constructive empiricism as the division between the observable and the unobservable. We saw in Chapter 4 that the arbitrariness of this division was repeatedly a point of criticism to which van Fraassen struggled to respond.

If we adopt the relational conception of experience of the earlier chapters here, then this difficulty becomes fatal. Big-E Empiricism cannot even be formulated, since a clean division between experience and theory is precluded. There is no monadic property that designates a proposition as experiential. Experience enters as a continuous physical process that connects with the system of interest. Different stages of the process are closer to or farther from experience according to their proximity in the process to the system of interest.

4. The Corrigibility of Experience

In support of Big-E Empiricism, it is tempting to imagine that propositions closer to experience are univocally more secure than those of deeper theory. For experience is the privileged source for empiricists and propositions reporting experiences are closer to this source. The temptation must be resisted because it is not in accord with how reports of observations and experimental results in science are assessed. Such reports, taken individually, are treated as less secure than results of deeper theory.

There are two aspects to this character that speak against Big-E Empiricism and for small-e empiricism. The first is that all reports of experience in science are corrigible and often in need of correction. The second is that a means of correction lies in the deeper results of science that are themselves more remote from experience than the reports they correct. These two aspects indicate that it is a mistake to harbor skepticism over the deeper results of science while exclusively favoring reports of experience. Rather, we should not seek *a priori* to diminish the status of deeper theory, if well-supported by experience. We should assess the totality of the reports of experience and the deeper results of science on their individual merits. We will find, case by case, which reports of experience and which results of deeper theory are well-supported and which are not.

Consider these two aspects in more detail. The first aspect, the corrigibility of all reports of experience, is surely familiar. A night of patient observation of the motion of the stars by ancient astronomers left them in little doubt that they had observed that the stars are affixed to the surface of an enormous, all encompassing, rotating sphere. The observational report is mistaken. There is no such sphere. In another example, we saw in an earlier chapter that there is a near century of confident observational reports of alien spaceships visiting the Earth. Most of these reports are demonstrably mistaken and all are dubious.

That corrections are inevitable follows from the fact that the sum of all reports of experience rarely cohere as a totality. This is a problem even for the gold standard of scientific evidence, the controlled trial. When controlled trials for an effect yield a positive effect, often enough, some efforts at replication fail. These sorts of failures have become so common in psychology and related sciences, that, starting in the 2010s, it came to be known as the "replication crisis."[1]

The problem is not restricted to the human sciences. Since the later 2010s, cosmology has been struggling with the "Hubble tension" and it persists at the time of this writing. It concerns the most basic parameter of big bang cosmology, the Hubble constant. In an account of the state of the tension in 2019, Knox and Millea (2020, p.1) report that the Hubble constant, when estimated from observations of receding supernova, is $H_o = 74.03$ km/s/Mpc. When estimated from measurements of the cosmic background radiation, it is $H_o = 67.27$ km/s/Mpc. These two values, read simply, are logically inconsistent. If we include probabilistic estimates of the uncertainty in both values, they differ by 4.4σ, which makes joint veracity of both reports very improbable.

Inconsistencies and incoherence in these results can be eliminated by following both evidential processes closer to their origins. We will eventually arrive at a stage in both that consist only of measurements so localized in space and time that they no longer contradict. The

[1] For a brief sample of the huge literature the crisis has engendered, see Witkowski (2019).

incoherence returns, however, as soon as we seek the significance of the observations by proceeding back along the lines of evidence.

The second aspect is that propositions deeper within a science are routinely used to correct reports of experience and experiments. The reverse is rare and, when it happens, it is an occasion for revolutionary change in a science. This asymmetry shows that we treat the theoretical propositions as more secure. When we invoke the principle of the conservation of energy to falsify some particular report of a perpetual motion machine (discussed below), we rely more on the conservation of energy than on the particular report, even though the latter is closer to experience. Individual reports of experience are more fragile than the theoretical propositions that we use to correct them.

Big-E Empiricism asks that we remain skeptical about the literal truth of the theory that corrects a report of experience, because the theory is more remote from experience. Prudence dictates that we invert these last attributions. We should be more skeptical of any *particular* report of experience in some domain than we are of a general theoretical statement that governs the domain.

For Big-E Empiricism, the power of a theoretical proposition to correct some particular report of experience results entirely from the theoretical proposition's role as a mediator among reports of experience. The correcting, theoretical proposition merely reflects the accumulated import of many other reports of experience, whose cumulative effect is to discount the particular report of experience.

For small-e empiricism, the assessment is different. It finds it quite revealing that many reports of experience are so in harmony as to have a unified import that can be captured by a theoretical proposition. In this circumstance, it is generally possible to show that these many, conforming reports of experience provide strong inductive support for the truth of the theoretical proposition. To insist on retaining skepticism about the truth of such theoretical propositions is simply to deny the import of evidence. The irrationality of such a denial is a theme that will be examined in greater detail in Section 6 below.

5. Illustrations of the Corrigibility of Reports of Experience

Here are a few illustrations of how deeper theory corrects reports of experience and experiment. In 1988, Benveniste et al. (1988) reported an extraordinary result. They took biologically active solutions of an anti-IgE antibody, diluted them massively and sometimes still found the diluted solutions to be biologically active. What made the results extraordinary is that this activity persisted at dilutions of 10^{120}. This outcome contradicted some basic science: that the antibody activity is chemical in nature and that the sizes of the antibody molecules are given by Avogadro's number, 6.02×10^{23}, which is almost one hundred orders of magnitude smaller than the dilutions. At such extreme dilutions it is extremely unlikely that even a single antibody molecule remains in the solutions that are still purportedly found to be biologically active.

The conflict with established science was so stark that Benveniste et al.'s paper in *Nature* was accompanied by a note of "Editorial Reservation" that reported the "incredulity of the many referees" and that there is "no physical basis for such an activity." The reported results were so at variance with the deeper science that *Nature* took the extraordinary measure of sending a team to Benveniste's laboratory to check the results. John Maddox, James Randi and Walter W. Steward (1988) concluded the result was spurious. James "the Amazing" Randi was a stage magician who was prominent for his repeated debunking of fraudulent pseudoscience.

In September 2011, the OPERA collaborative reported measurements of neutrinos propagating from CERN in Switzerland to the Gran Sasso Laboratory in Italy that indicated that the neutrinos were propagating faster than the speed of light (OPERA collaborative, 2011). The excess was small if expressed as a fraction of the speed light (mean: 2.48×10^{-5}), but, at 6σ significance, it was not explicable as a random error (p. 22). The result was implausible from the outset and even treated with some skepticism by the OPERA investigators themselves, since it contradicted the prohibition on faster than light propagation of the special theory of relativity. That their observation had breached the special theory of relativity was treated widely with skepticism. The anomalous result was soon explained by various unnoticed sources of error, including a loose fibre-optic cable connection. (See Reich, 2012, for some details.)

Perhaps the most enduring example of deeper theory impugning observational reports concerns perpetual motion machines. These are devices that generate motive power, such as is needed to raise a weight, without depleting a corresponding capacity that is, loosely speaking, the fuel of the device. There have been many proposals for such machines and many reports by observers of their successful operation. All such reports are in conflict with the law of the conservation of energy. On its strength, all these reports are dismissed as instances of self-deception or fraud.

That all attempts at a perpetual motion machine necessarily fail has been a secure result of science. A much-mentioned statement of it was made by the French *Académie Royale des Sciences* in 1775. Its records of works presented to the Academy in 1775 include a decision that the Academy would no longer consider solutions to the three classic, but impossible construction problems in geometry;[2] and also proposals for perpetual motion machines. (Anon, 1778, p. 61). The prohibition on such proposals was justified by the much-quoted assertion (Anon, 1778, p. 65):[3]

> *Le construction d'un mouvement perpétual est absolument impossible.*
>
> The construction of a perpetual motion [machine] is absolutely impossible.

This impossibility was justified by the assertion (p. 65) "*cette [mortice] force ne peut produire qu'un effet égal à sa cause*": "This [motive] force can only produce an effect equal to its cause."

By the middle of nineteenth century, the folly of seeking perpetual motion machines was sufficiently well established that it was the subject of a 400 page monograph. Dircks (1870) catalogued failed attempts at perpetual motion machines spanning seven centuries, from the thirteenth to the nineteenth. Dircks (p. xii) is unequivocal in his historical summary:

> … every mechanical demonstration yet attempted has invariably produced the one ignoble result of palpable failure.

He was correspondingly unequivocal in his scorn for those who persist in their attempts (p. xii):

> The present century is rife in the reproduction of patented blundering, serving only to prove the ignorance and mental imbecility of a certain class of infatuated, would-be inventors, whom no history can teach, no instruction reform,

Dirck's dismal prediction of incorrigibility has been vindicated repeatedly. The US Patent Office granted patent US11,047,359B2 on June 29, 2021, for a "Gravitational Turbine Engine."

The more modern version of these ill-fated proposal is for a "reactionless drive." These are closed systems in which a purported imbalance of internal forces leads the device to accelerate itself. They are proposed as propulsion system for spaceships since they would escape a weakness of common propulsion systems. Such systems require a finite resource on the

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[2] Duplication of the cube, trisection of the angle and squaring the circle.

[3] This statement is much quoted, almost invariably without a source, which I finally located in Anon (1778).

spaceship, some form of matter, to be expelled to produce a reaction force that accelerates the spaceship. These reactionless proposals all violate the law of conservation of momentum (which relativity theory has merged with the law of conservation of energy.)

A notable example is the "EM-drive." As reported in Mullins (2006), the drive consists of microwaves enclosed in a chamber. The radiative forces on the walls of the chamber sum, it is suggested, in a way that leaves a tiny, residual force capable of accelerating the chamber. The interesting development is that Harold White and his collaborators at the NASA Johnson Space Center reported experimental measurements of a tiny, residual net force. (See White et al., 2017) Needless to say, the report was met with considerable skepticism, precisely because of its violation of the conservation of momentum.[4]

6. The Irrationality of Inductive Skepticism

An essential component of Big-E Empiricism is some form of an untenable, inductive skepticism concerning the non-experiential content of science. The modern version arises in van Fraassen's constructive empiricism. As we saw in Chapter 4, a constructive empiricist simply discounts the weight of inductive evidence. No matter how strong the inductive support provided by experience, it always fails to sustain in any degree the truth of propositions concerning unobservables or the referential success of the central terms in the propositions. Van Fraassen even denies that there is a cogent account of inductive support.[5] We are allowed, contrary to Hume's maxim, only to infer to the empirical adequacy of the theory and not to stronger conclusions that would support the truth of the propositions concerning unobservables or the referential success of its central terms.

Such inductive skeptics would regard strong inductive support for unobservables as merely a fact about theoreticians of inductive logic. The attitude would be similar to that of a skeptic about astrology. An astrologer might document that there is an alignment of the planets

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[4] See for example, Corneliussen (2016).

[5] I agree with van Fraassen that, in recent decades, the philosophical literature has struggled to supply us with a univocal logic of induction. However, I am allowing myself the conceit that my two books in the material theory of induction (2021, 2024) have provided a univocal account of inductive support, applicable across the science

tomorrow and that it will make tomorrow especially fortuitous or otherwise for some endeavor. For skeptics about astrology, recognition of that alignment has no significance beyond how its recognition might affect the behavior of followers of astrology.

My view of this inductive skepticism is that it is indefensible if we are to proceed rationally. To do so requires that we proceed in accord with reason, that is, in accord with what is directed by logic. One can always simply refuse to be guided by logic. But one cannot do so and, at the same time, pretend to be rational. The difficulty is elementary and familiar. It is the substance of Lewis Carroll's (1895) charming parable, "What the Tortoise said to Achilles." It is so well known that I need here only recall the essential point. Achilles offers the tortoise this inference, which I have edited as indicated to make the logical connectives visible (p. 278):

(*A*) [IF] Things … are equal to the same [THEN they] are equal to each other.

(*B*) The two sides of this Triangle are things that are equal to the same.

(*Z*) [THEREFORE] The two sides of this Triangle are equal to each other.

The tortoise simply refuses to accept that the truth of (*Z*) follows from the truth of (*A*) and (*B*). Our diagnosis is direct and obvious. The tortoise is simply irrational. The inference follows from the meaning of the connective "if … then …" It just tells us that, if the antecedent in the hypothetical is true, then we are authorized to infer to the conclusion. To deny the inference one must either be a prankster, such as is Carroll's tortoise, or one must genuinely not understand what "if … then …" means.

The situation is no different with inductive logic. The observations of the cosmic background radiation and the motion of the galaxies provides strong inductive support for a primordial big bang. The term "strong inductive support" simply means that we are authorized to infer to the propositions supported and, according to the material theory of induction this meaning is recovered from the meaning of the propositions that warrant the inductive inference. Since the support is inductive, the truth of the observational propositions does not guarantee the truth of the big bang proposition supported. Since the support is strong, the inference to it can be taken with only a very small inductive risk. One can simply refuse to make the inference. To refuse it is to be a mischievous, inductive tortoise. However, one cannot refuse it, while, at same time, proceeding rationally.

7. The Lack of Ontology

A strength of small-e empiricism is that it accepts the efficacy of inductive inference. Thus, as articulated in Chapter 12, it allows experience to support inductively an ontology that includes the experiential processes themselves. How is it that these processes can inform us? They can do so, small-e empiricism responds, because we have good reason to accept that they are real. The gravitational waves detected by LIGO are real. They really did propagate to Earth for eons of time through vast stretches of space from cataclysmic gravitational collapses that really happened eons ago.

Big-E Empiricism is trapped in its skepticism and cannot call draw on a corresponding justification. For it maintains that all we learn about the world from experience is the content of that experience itself. Although a science may offer results that go well beyond experience, those results are to be discounted in some way. Perhaps they are merely instrumentally useful in allowing inferences to further experiences. However they are discounted, they can make no claim to representing the way the world really is. They might figure in an argument for Big-E Empiricism, but they can only serve in an instrumental capacity. Arguments for Big-E Empiricism must be essentially skeptical in character, for what distinguishes Big-E Empiricism from small-e empiricism is skepticism about this further content of the science. Arguments for it must cast doubt on the idea that we can learn facts of the world beyond experience.

In sum, Big-E Empiricism can only admit the instrumental efficacy of a supposition of the reality of experiential processes. It is precluded from admitting their reality and thus precluded from using that reality to support the efficacy of experience.

8. Einstein and Heisenberg

As a general matter, the decision between small-e and Big-E Empiricism is one to be taken in the philosophy literature. However, the decision between them in a particular case arose at a decisive moment in the history of physics.

A quantum theory of atomic matter was slowly emerging in the first quarter of the twentieth century. Niels Bohr had proposed that electrons, bound energetically within atoms, could only orbit the atomic nucleus in discretely spaced trajectories. The proposal met with success upon success empirically, even though the discreteness and stability of the orbits contradicted the classical electrodynamics that was also assumed to govern the orbits. By the mid

1920s, however, the soon to be called "old quantum theory" faced sufficiently many anomalies that Werner Heisenberg sought a fresh start. His 1925 "*Umdeutung*" paper, "Quantum Mechanical Reinterpretation [*Umdeutung*] of Kinematical and Mechanical Relations," is taken traditionally as the initiation of the "new quantum theory." His starting point, we can now see, conforms with Big-E Empiricism in favoring observables over any ontological commitment to quantities of deeper theory. The abstract of the paper read in its entirety (Heisenberg, 1925, p. 261):

> The present paper seeks to establish a basis for theoretical quantum mechanics founded exclusively upon relationships between quantities which in principle are observable.

The retreat to observables involved abandoning key parameters of the electron orbits of the old theory. They were then, Heisenberg noted (p. 261), "apparently unobservable in principle, e.g., position and period of revolution of the electron."

The new quantum theory continued to present significant interpretational problems so that this sort of Big-E Empiricism remained an option for at least some physicists. Edwin C. Kemble, a distinguished physicist at Harvard, developed this view in his early, comprehensive 1937 textbook on quantum theory. He formulated it as follows (Kemble, 1937, p. 331):

> We are again led to emphasize the fact that the wave function of a pure-state assemblage is merely a mathematical tool for computing from all previous observations what the relative probabilities are for different results when we make our next observation.

Anecdotally, this simple sort of instrumentalism still has some adherents today, perhaps when a quick escape from vexing foundational problems is sought.

The small-e empiricism response to Heisenberg's 1925 proposal came from Albert Einstein. In the Spring of 1926, Heisenberg gave a colloquium on his new theory in Berlin. Einstein was in the audience and asked to meet with Heisenberg afterwards. We have a lengthy account in two places in Heisenberg's recollections of what was discussed in that meeting: the longer Heisenberg (1989, Ch. 5) and the shorter Heisenberg (1971, pp. 113-15). Einstein challenged precisely Heisenberg's failure to include electron trajectories in his theory. Heisenberg recalled Einstein's reaction as follows (1989, p. 113):

> He pointed out to me that in my mathematical description the notion of "electron path" did not occur at all, but that in a cloud-chamber the track of the electron can of course be observed directly. It seemed to him absurd to claim that there was indeed an electron path in the cloud-chamber, but none in the interior of the atom. The notion of a path could not be dependent, after all, on the size of the space in which the electron's movements were occurring.

Einstein protested against Heisenberg's idea that (in Einstein's words as recalled by Heisenberg, 1971, p. 63) "none but observable magnitudes must go into a physical theory." Einstein's rejoinder was a version of the idea that one cannot cleanly separate observations from theory. He said on Heisenberg's recollection (1971, p. 63-64):

> … it may be heuristically useful to keep in mind what one has actually observed. But on principle, it is quite wrong to try founding a theory on observable magnitudes alone. In reality the very opposite happens. It is the theory which decides what we can observe.[6] You must appreciate that observation is a very complicated process. The phenomenon under observation produces certain events in our measuring apparatus. As a result, further processes take place in the apparatus, which eventually and by complicated paths produce sense impressions and help us to fix the effects in our consciousness. Along this whole path—from the phenomenon to its fixation in our consciousness—we must be able to tell how nature functions, must know the natural laws at least in practical terms, before we can claim to have observed anything at all. Only theory, that is, knowledge of natural laws, enables us to deduce the underlying phenomena from our sense impressions. When we claim that we can observe something new, we ought really to be saying that, although we are about to formulate new natural laws that do not

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[6] [JDN] It is too easy to misread this now much-quoted sentence in isolation as a skeptical reflection that theory so controls observations that they cannot be used to assess novel theoretical proposals objectively. The fuller quote shows that it is not the novel elements of the new theory at issue that controls the observations, but an older body of theory that governs whole process of observation, including the operation of the instruments.

> agree with the old ones, we nevertheless assume that the existing laws—covering the whole path from the phenomenon to our consciousness—function in such a way that we can rely upon them and hence speak of "observations."

This exchange occurred in the earliest days of the new quantum theory. Heisenberg's simple instrumentalism persists as just one of the bewildering array of proposals still today for how quantum theory should be understood.[7] Einstein's instinct that electron trajectories are to be preserved persist in what is known as the "Bohmian" account.

The episode does illustrate a useful function for Big-E Empiricism. When a new theory is needed, it can greatly accelerate the arduous work of eliminating old, superfluous elements of theory. Such was the case with Heisenberg's *Umdeutung*. Einstein himself had used the same strategy to eliminate absolute simultaneity from physics in his 1905 work on special relativity. It was clearly an embarrassment for Einstein when Heisenberg pointed this out. Heisenberg (1989, p. 114) recalled Einstein's retort: "Perhaps I did use such philosophy earlier, and also wrote it, but it is nonsense all the same."

Einstein's awkward retraction might reflect what I think is the right assessment. This use of Big-E Empiricism may serve the purposes of the moment. But it is indiscriminately destructive. After its useful work is done, we should retract to the more fertile approach of small-e empiricism. We can affirm more of the world than merely what we observe of it.

9. Conclusion

Big-E Empiricism offers a promise of greater security compared with small-e empiricism. By limiting acceptance to experience and eschewing any further commitment, we might suppose that we are better protected from error. It is a false promise. For the science has no access to experience, pure and simple. It can only judge which results are closer to experience. More seriously, an unqualified reliance on experience is naïve. All experience in science is corrigible and often in need of correction. Those corrections come from deeper theory. That the deeper theory can correct experience shows that the deeper theory is more secure than any individual experience; and it is certainly more secure than the totality of experience, since that totality is inconsistent. To persist in treating this deeper theory as purely instrumental corrections to

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[7] It is mentioned, for example, in Greiner (1989, p.477).

experience is inductively irrational, for the deeper theory has attained its securer position through the strength of its inductive support on the evidence.

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