Against Empiricism

Alexander Bird
University of Cambridge

Abstract

I examine the motivations for being an empiricist in the philosophy of science and find them wanting. Either the motivations are inherently weak. Or they fail to provide a rationale for the practices of science.

1 Introduction

This paper takes issue with empiricism—the view that sense-experience is epistemologically foundational or otherwise necessarily significant—in particular as it is found in the philosophy of science.[1] What is sense-experience? Is it a state laden with concepts and judgments, a state with non-conceptual content, or even an array of stimulations of sense organs? Is it something internal or a relation with something external? It doesn't matter: empiricism is erroneous whichever view of sense-experience is accepted. Were empiricism to be framed instead in terms of perception, sense-data, or sensation in place of sense-experience, that would not matter either. This paper will reject any claim that says that something in the vicinity of sense-experience, however understood, is necessarily important for scientific knowledge. My target is as described by Zhai (1990: 15):

> Traditionally, the proponents of empiricism sought for the starting point of knowledge in sensations that happen to us when we open our sense organs to the world.

Thus Quine (1951) articulates one empiricist view of science by writing that:

> 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.

[1] One can use 'empiricism' more broadly to denote the idea that all significant scientific knowledge depends on some kind of interaction with the world (not necessarily perceptual), denying, for example, that there is important synthetic apriori scientific knowledge. This paper does not take issue with that broader empiricism. Nor does it concern itself with empiricism about concepts.

Bogen and Woodward (1988: 303) tell us, correctly:

> According to a widely shared view of science, scientific theories predict and explain facts about 'observables': objects and properties which can be perceived by the senses, sometimes augmented by instruments.

Empiricism is implicit in the very language that philosophers of science use. Definitions of 'observable' or 'evidence' betray empiricist commitments or assumptions. First, a definition shows what is thought to be useful or relevant. Secondly, these definitions entail empiricism in this paper's sense when combined with widely accepted claims about the centrality of evidence or of observation to justification or knowledge, especially in the sciences. Hence the following are empiricist views:

> The proposition *p* is among S's evidence if and only if S knows *p* directly by experience (Maher 1996: 158)

> Observation is an act of gathering information by human sensation without optional interpretations (Chang 2005: 880)

> There are things that one can, under favourable circumstances, perceive with one's unaided senses. Let us call them 'observables' (Chakravartty 2007: 3–4)

> For a philosopher, a property is observable if it can be 'directly perceived by the senses'. Hence, such properties as 'blue', 'hard' and 'colder than' are paradigmatic examples of observable properties in the philosopher's understanding of observability (Andreas 2021).

Van Fraassen (1980) famously also defines what is observable in terms of what is perceptible. Some scientific realists object that the modal aspect of 'observ*ability*' is inconsistent with his Constructive Empiricism (Ladyman 2000). Others want to extend the observable to those things that can be perceived when our senses are augmented by appropriate instruments, such as the optical microscope. But few scientific realists object to the very idea of tying observation to perception. On the contrary, realists by and large accept the restriction of the observational evidence of science to the perceptual, even if their notion of 'perception' is sometimes more liberal. The locus of their debate with van Fraassen and other anti-realists concerns whether one may justifiably make inferences to conclusions concerning the unobservable (the imperceptible) from such evidence. This conception of observation is so common among philosophers of science that it scarcely receives attention. But it is important to note that this is a distinctively *philosophical* usage. Scientists do not use the term 'observe' to mean something akin to 'perceive'. Particle physicists, for example, report their work using paper titles such as

'Observation of a new boson at a mass of 125 GeV with the CMS experiment at the LHC' (reporting the discovery of the Higgs boson) or 'The evidence for the observation of $0\nu\beta\beta$ decay', and so on, while astronomers engage in 'The observation of magnetic fields in nondegenerate stars' and molecular biologists author papers reporting 'Direct observation of individual RecA filaments assembling on single DNA molecules'. That philosophers use a concept of observation that is linked to perception whereas scientists do not is significant since it suggests that empiricism is baked into the very terminology that the philosophers employ and thus in many cases may amount to an unquestioned or even unacknowledged assumption. (Below I use 'observation$_P$', etc. to capture the philosophers' use of 'observation' and 'observation$_S$' to denote the scientific use; likewise for cognates. Separately, when I use the word 'experience' I shall intend that as an abbreviation for 'sense-experience'.)

In this paper I examine the motivations for empiricism and consider whether they support an understanding of science as a rational activity. Some of the motivations are inherently unworkable. Others have consequences that some might be willing to accept. But these, I argue, are such that they make the practice of science unexplainable as a rational activity. For example, if one's view is committed to thoroughgoing scepticism about the future, then the practice of trying to predict the future (as arguably science sometimes does) would be irrational on this view. I do *not* assume that the rationality of science is identical to a commitment to realism.

2 Motivations for empiricism

In this section I list what I take to be the principal motivations for empiricism, while giving some context to each. While I have distinguished these motivations, the views of the actual empiricists concerned do not always do so—the motivations are overlapping.

In the context of the post-Cartesian search for secure foundations for knowledge, a key function for sense-experience is the provision of certain foundations. Berkeley (1710) held that the immediate objects of experience are the subject's own ideas. For Berkeley that fact provides certainty, since the very 'existence of an idea consists in being perceived'—'their being is to be perceived or known'. In the twentieth century, Moritz Schlick (1934) and C. I. Lewis (1929; 1946) are prominent cases of philosophers who shared Berkeley's conviction that a subject's reports of their own states of sensory experience are certain. Schlick, for example, in 'The Foundation of Knowledge' (1959) makes it clear that to aim at providing a theory of knowledge is to search for absolutely certain foundations. This absolute certainty is to be found in *Konstatierungen* 'affirmations' of one's current inner experiences. These supply the contents of 'protocol' or 'basic' statements.

So our first motivation for empiricism is this:

CERTAINTY Reports of our own sense-experiences are epistemically fundamental because they are certain. They provide the secure foundations of science.

The (alleged) certainty of knowledge of one's sensory states brings with it a countervailing disadvantage. Assuming we do not adopt Berkeley's metaphysics, it can be plausibly argued that we are condemned to the scepticism that he finds and warns us of in Locke's (1690) epistemology. Knowledge of sensations (or appearances or sense data) may be certain. But any inference from them to the way things are in the 'external world' is very uncertain at best, and even less certain when it comes to inferences regarding the claims of science. For those who regard that challenge as insurmountable, a natural response is to take as epistemically basic our perceptual beliefs about the external world. Now it is easier to see how we might justify our scientific beliefs. On the other hand these perceptual beliefs cannot themselves be certain. Illusions and perceptual error are common. Such beliefs are corrigible. So the epistemology cannot be the simple foundationalism that was available when we took the basic beliefs to be certain.

It is this issue that was at the heart of the protocol sentence controversy of the Vienna Circle. As noted, Schlick favoured what Hempel (1935, 1952) described as the 'phenomenalist' conception of protocol/basic statements. Whereas Neurath (1932) proposed a 'physicalist' conception of protocol statements as perceptual reports of the observer's environment. Because such statements are corrigible, Neurath adopted coherentism in place of Schlick's foundationalism. The most significant descendant of this coherentism (and of the Duhem thesis) was Quine's confirmational holism. 'Observation$_p$ statements' are revisable. But they nonetheless retain a special place within the web of belief in two respects. First, they are the evidence upon which the whole web rests: 'the ultimate evidence that our whole system of beliefs has to answer up to consists strictly of our own direct observations' (Quine and Ullian 1978). And secondly, even if not certain, they are more certain than anything else in the web: 'Observation sentences, taken narrowly, are comparatively foolproof. That is what makes them the tribunal of science' (Quine and Ullian 1978).

The latter gives us our second motivation for empiricism:

RELATIVE CERTAINTY Reports of the world as we experience it are epistemically privileged because they are the most certain worldly reports we can have.

The first two motivations stem from wanting the evidential basis for science to be as epistemically secure as possible. The next two motivations arise from taking experience to be the *source* of all our evidence. Above we noted that for Quine, observations$_p$ are the evidence upon which the whole web rests: 'The stimulation of his sensory receptors is all the evidence anybody has had to go on, ultimately, in arriving at his picture of the

world' Quine (1969). In the words of Hylton and Kemp (2025), 'Observation sentences are the starting point for our acquisition of knowledge, the child's entry into cognitive language. They are also the sentences which are evidentially basic'.

The word 'ultimately' is doing important work. As we saw above, the scientists' use of 'observation' suggests that they work with evidence that is not the stimulation of sensory receptors—they take as evidence observations$_S$ of bosons, magnetic fields, and single DNA molecules. However, these scientific observations$_S$ are clearly the outcome of considerable scientific thinking, both theoretical and experimental. So we can trace an epistemic route backwards, to see where these observations come from and what they depend on. The empiricist claim is that when we do so, we come to a stop with statements of perception (sense-experience). While observation$_S$ statements are dependent on other statements for their epistemic status, observation$_P$ statements have the distinctive role of being directly related to stimulation, in virtue of which they are evidentially basic—there is nothing beyond them.

In summary:

> Basic Reports of the world as we experience it are epistemically ultimate or basic, in that when we trace back the evidential support for a scientific proposition, we find that this tracing ends with such reports.

As we shall see, the details of this evidential tracing back to the ultimate source of evidence are more problematic than might appear at first sight. One response to such quibbling (as it might appear to the committed empiricist) is a simple, general argument that cuts through the foregoing detail.

If one had no experience at all of the world, then one could have no scientific knowledge. Imagine a scientist who is immersed in a sensory deprivation tank. They might be able to expand on their scientific knowledge by making inferences from what they already know. But there would be a limit to what they could thereby achieve. Had they been so immersed in 1850, they would have insufficient resources to come to have much or any knowledge regarding the fields of quantum mechanics, molecular biology, exoplanetary astronomy, plate tectonics, and so forth. It is the lack of sensory experience that prevents them from achieving such knowledge.

> Necessary for science Without sense-experience important components of scientific knowledge would be unavailable. Sense-experience is a necessary precondition of the possibility of (some) scientific knowledge.

The most prominent contemporary version of empiricism is Bas van Fraassen's Constructive Empiricism (CE). It is not straightforward, however, to extract a clear motivation or argument for the centrality of experience from CE. The core claim of CE is not a claim with any apparent normative component. It is a claim about the aim of the institution of science:

> Science aims to give us theories which are empirically adequate; and acceptance of a theory involves as belief only that it is empirically adequate. (van Fraassen 1980: 12)

Empirical adequacy is a property of theories whose observational component is true. Furthermore, to be observable, according to van Fraassen, is to be perceptible by humans without perceptual aids.

So CE is profoundly empiricist as a description of science. But that tells us little about epistemology. The core of CE is consistent with the claim that there could be a similar institution, Schmience, that aims to give us theories which are true and which can give us knowledge when believed, coupled with the claim that Schmience would be an epistemologically superior institution to Science.

Nonetheless, van Fraassen does have a normative epistemology surrounding CE. He does think that science is rational: the aim attributed to science is plausible and achievable. Furthermore, he denies that Schmience would be superior to CE. His comment 'it is not an epistemological principle that one might as well hang for a sheep as for a lamb' (van Fraassen 1980: 73) is a rejection of the thought that if one is willing to accept the uncertainty involved in the inference from the actually observed to the *empirical adequacy* of a theory, one might as well accept the uncertainty involved in the inference from the actually observed to the *truth* of a theory. As Chad Mohler and Bradley Monton (2025) express it:[2]

> One might reasonably think of belief in the empirical adequacy of accepted theories as the weakest attitude one can attribute to scientists at the same time that one is still able to make sense of their scientific activity. At the same time, belief in the empirical adequacy of a theory is sufficiently cautious as to allow the believer to remain faithful to the spirit of empiricism. Thus, CE is a view which allows one to regard the activity of science as activity the empiricist can safely endorse.

Although this does not directly state a motivation for empiricism—it seems to assume that one is already an empiricist—it nonetheless furnishes such a motivation:

> Constructive Empiricism The pursuit of empirical adequacy is the epistemologically weakest (and hence epistemologically most secure) aim that science could have while also being a plausible aim for science.

Having outlined the motivations one might have for being an empiricist, I will now explain why they are all inadequate, either intrinsically or as a basis for rational science.

[2] See Rosen (1994) for this understanding of CE.

3 Certainty: conceptual drift and the paucity of certain evidence

In this section I will argue that:

> Sense-experience cannot both provide certainty and a suitable foundation for science.

In effect, this is the question raised already by Neurath and others about whether the certainty provided by sense-experience (such as it is) comes at the cost of inviting scepticism.

Analyses of certainty focus on four properties: indubitability, infallibility, indefeasibility, and maximal justification.[3]

There is a substantial literature on why reports of inner experience lack certainty, an important subset of which focuses on the possibility of such reports misapplying the concepts they use (e.g. Alston 1971; Sellars 1997). It is not unusual for the basis of our application of a concept to change and to err, and this is true even if we think of S's language as an idiolect employing her own concepts. Thus it is possible for S to be mistaken in believing that *this* is an experience that falls under her concept *blue*. Infallibility would fail. Knowing this fact about concepts may cause her rationally to doubt whether this experience is of blue, and so indubitability fails. Evidence that this has in fact occurred in her case would defeat knowledge that this is blue, and she would not have the maximal degree of justification for her belief.

S can ensure that her current usage is in conformity with her earlier established concept by remembering the conditions of usage for that concept. But to establish certainty for S, this remembering needs to be certain knowledge. But memory does not provide certainty. She cannot be certain that it is an experience of blue.

The fallibility of memory raises a further and distinct problem in accounting for science. Given the fallibility of memory, S can be certain only of the contents of her *current* experience. But that experience is informationally very thin when compared to the quantity of information that our scientific world picture contains. Recall van Fraassen's Constructive Empiricism. That view takes the aim of science to be 'saving the phenomena', where the phenomena are all the perceptual reports of all scientists, including their past experiences. I will later argue that this is too weak an aim to make sense of scientific practice. But even were van Fraassen right that this is the epistemologically weakest aim science could have while consistent with scientific practice, that would be vastly more ambitious than the aim of saving my current experience alone. Indeed, given that apriori

[3] Baron (2022). See also Alston (1971).

knowledge often depends on memory (think of multiplying two three-digit numbers), even much basic apriori knowledge is not certain.

This problem is a different one from that raised by Berkeley for the realist Locke, that there is no good inference from reports of inner experience to anything concerning the external world. Here the problem concerns not the inference but the paucity of the evidence from which that inference is to proceed.

4 Is sense-experience relatively certain?

We now turn to a more plausible view of the evidential basis for science, that it includes perceptual reports of external states of affairs, memory reports and other reports of one's own mental states. It is acknowledged that these do not provide absolute certainty. Rather their epistemically privileged status comes from their *relative* certainty: such reports, while dubitable, fallible, defeasible, and revisable, are less dubitable, fallible, defeasible, and revisable than reports stemming from other sources. The confirmatory inferences from evidence to theory in science are typically ampliative, i.e. they 'go beyond' (are not logically entailed by) the evidence. And so the basis of science in reports of sense-experience is more certain than the claims ampliatively inferred from them.

In general, however, it is not the case that the conclusions of ampliative inferences are less certain than the propositions used as evidence. The Condorcet Jury Theorem tells us that the majority view of a group is more likely to be correct than the view of any individual member, when all individuals have a better than chance degree of reliability (List and Goodin 2001). And this holds true when the individual views are all perceptual reports and the 'majority view' is an inference from these reports. For example, 1,000 observers report on the colour of some object in poor (but not deceptive) lighting conditions, such that a subject has about a two-thirds probability of being correct in a report of colour. Assume that any errors are independent. Let 700 report that the object is yellow and 300 report that the object is orange. The hypothesis that the object is yellow is ampliative given this data. Nonetheless, we should have a very high degree of confidence in this hypothesis, higher than the degree of confidence that one would have in any individual report. Similarly, a coin is tossed a thousand times in quick succession. It is difficult to be perfectly sure of any particular coin toss whether it is heads or tails. But when one has seen what one takes to be 800 heads and 200 tails, one can be very confident indeed that the coin has a non-trivial bias, even though that hypothesis is an ampliative inference from the data.

Reports of sense-experience are not *per se* especially reliable. Error and illusion can make some such reports very unreliable indeed: careless and inattentive reports, visual reports made in bad lighting conditions, reports affected by prior expectations or desires, and so on. Focusing on reports from very careful observers, operating under optimal conditions—e.g. an exemplary scientist in her laboratory—does not change matters.

Consider thermoception, our ability to detect heat and cold. As we all know, human thermoception is very imprecise and is very susceptible to interference from bodily condition, prior exposure, expectation, and other effects. Reports of thermoception thus have a low degree of certainty, even when couched in imprecise terms. Consider next a very high quality resistance thermometer—this will provide a much higher degree of certainty than thermoception. Vision is a more reliable source of information than thermoception. But since vision can err, it is possible to find alternatives that do better (AI analyses of images, for example).

The very general argument against the epistemic privilege of sense-experience is this. Once we consider the senses as evolved instruments for providing information to a subject about her environment, then we can see that like any instrument they can function well or poorly and that in principle (and in this case, in practice) alternatives can be even more reliable. There is nothing special about perception as regards its reliability or the degree of certainty that should be attached to perceptual reports.

5 Is sense-experience evidentially basic?

Perhaps the most common current rationale for taking sense-experience to be basic is the idea that if we trace our reasoning in science back through the theoretical inferences we make, the evidential chains must end somewhere. That somewhere is sense-experience. So, even if reports of sense-perception are not certain nor even more certain than other reports, they are nonetheless evidentially basic.

Furthermore, this may be taken to support the stronger claim that sense-experience is the *only* source of justification. Other reports are evidence only insofar as they stand in for the evidence of sense-experience. *Real* evidence is gained solely from sense-experience. Patrick Maher's (1996: 158) account of evidence is just this:

> E is evidence iff E is known directly by experience.

Elsewhere I have argued against this and related views that take evidence to be non-inferential (Bird 2004). Note first that this is *not* how scientists and others use the term 'evidence'. An astrophysicist will tell you that the cosmic microwave background radiation (CMBR) is the most significant piece of evidence supporting the Big Bang theory. But there is no possibility of directly experiencing CMBR. So such views as Maher's have to say that the proposition asserting the existence of CMBR is not really evidence but is just *proxy*-evidence, used in place of the totality of experiential evidence behind the discovery of the CMBR.

One simple reason why this is wrong is that it entails that no inferred proposition p can be proxy-evidence for a subject who has forgotten the experiences from which p was inferred (Bird 2022: 117–18, 124–5). But this is a common phenomenon. I know that the melting point of lead is 327.5 °C. But I cannot remember how I came to know

this, whether by being taught this in class, having read it, or by seeing a set of measurements made on melting lead. When experience provides us with useful knowledge of the world, often after a simple inference, our long-term memory retains the useful information gained but does not retain details of the experience behind it. We might then use the inferred information as evidence—in the case of lead's low melting point, as evidence for relativistic contraction and the inert-pair effect. In this case, I would be using as evidence a proposition that is not directly known by experience. So it would have to be proxy-evidence, standing in for more basic evidence that is directly known by experience.[4] But I don't have any such evidence—my memory discarded that long ago.[5]

So the claim that inferred 'evidence' is not really evidence, being at best a proxy for evidence that is directly gained from experience, does not stand up.

The claim just considered, that all evidence is (directly) experiential, goes beyond that with which we started, namely that all justification holds in virtue of an origin that is experiential. The latter is consistent with something the stronger view denies, that once justification is passed on to an inferred proposition, then the latter has genuine justification not merely proxy justification, in a way that is not dependent on the retention as evidence of the premise proposition. On this view, one could forget all one's experience and the propositions directly known through experience, yet retain justified belief in the inferred propositions. Nonetheless, it is still the case that the justification that the inferred propositions have is dependent on the uninferred, experiential propositions having had the justification they did have at the time the inferences were made from them.

This weaker claim is nonetheless also false. The important idea at the centre of the claim has two components. First, that there is a distinction between inferred and uninferred beliefs. And, secondly, that the uninferred beliefs include only the beliefs produced by sense-experience.[6] Both components should be rejected.

Regarding the first component of the target idea, there is not a clear distinction between beliefs that are the result of inference and those that are not. Let S learn 'all and only red tomatoes are ripe'. Initially, when S sees a red tomato, she makes the inference to its being ripe. But after repeatedly seeing red tomatoes and making this inference (she is employed as a tomato picker), she begins immediately to see the red tomatoes as ripe, making no inference. Perhaps she is making an unconscious inference. But this is an

[4]Note that even if I did see the experiment, I do not come to know the melting point of lead by direct experience. Quite apart from the theory-ladenness of the measurement methods, a scientific measurement of temperature is not a one-off reading of a thermometer, but is inferred statistically from multiple readings (Bogen and Woodward 1988).

[5]In Bird (2004) I discuss other examples, not involving memory, where earlier evidence is discarded but later, inferred evidence, is retained and correctly used as evidence.

[6]See Mill (1843) for a nice articulation of this idea.

empirical claim and not an especially compelling one either, given what we know about neural networks. Let's focus instead on the easier case for the empiricist, S's judgment that this tomato is red. S's experience of the world, like ours, is that in some lighting conditions objects can look red that are not red. In such conditions she desists from asserting that a tomato that appears red is red. So when S does assert that the tomato is red, is she making the unconscious inference in this case from her observation that lighting conditions are normal and that the tomato appears red, to the conclusion that the tomato is red?

The current view, that justification enters the system of one's beliefs via uninferred beliefs, requires that there *is* a set of beliefs that are uninferred. But the argument just considered shows that it is quite unclear what this proposal is in fact saying, for the distinction between inference and being causally influenced by background knowledge or experience is unclear. If we were to regard the basic beliefs as those that are not at all influenced by background knowledge or experience, then the set of those basic beliefs will be very small indeed, possibly empty—certainly too small to support science. We see, then, that the claim that a belief is revisable (or is confirmable) in virtue of its relationship to the rest of the web of belief is in a deep tension with the claim that such beliefs are inferentially and evidentially basic.

An objection to the second component of this view argues that in order to permit science to be rational, more beliefs than just experiential beliefs must be sources of evidence and justification. In my book *Knowing Science* (2022) I argue that scientists' dependence on *testimony* and on *instruments* cannot be accounted for in empiricist terms. Let us take testimony. The empiricist view of testimony says that testimony provides justification for a testimonial belief only when the subject has evidence that the testifier is a reliable source. This view is widely regarded as unworkable (Coady 1992). In particular, the widespread dependence on testimony in science and on our trusting (rather than verifying) the reliability of our sources in science, shows that we cannot trace the justification we have for those scientific beliefs that are dependent (in part) on testimony back to experience. So either science is irrational in its dependence on testimony. Or testimony can supply a subject with evidence and with justification that do not derive solely from sense-experience. Likewise, a scientist will often use an instrument to generate data and evidence while not being able to give any account of that instrument's reliability. So either the scientist is being irrational. Or, once again, the beliefs she has as a result of using the instrument are not justified solely on the basis of sense-experience.

6 Is sense-experience necessary for science?

The final, very general direct argument for empiricism is simply that without sense-experience we could know at most very little about the world. The individual kept in a sensory deprivation tank could not expand their scientific knowledge by much—they

could not acquire the knowledge that scientists do acquire by experiment and observation.

While this is currently true, it is only a contingent truth, and may not be true in the future. Above I noted that when learning important facts we forget the experience by which we learned them and retain in long-term, semantic memory only the propositional content of the fact. So when asked, 'What is the melting point of lead?' I can answer '327.5 °C' although I have no recollection of how I learned this. The remembered fact itself is somehow encoded in the cerebral cortex, having been processed in the hippocampus. Now imagine that neuroscientists learn how to encode information in the cerebral cortex directly (or, alternatively, they learn how to attach an electronic chip to the hippocampus, through which information can be uploaded). Thanks to such a process, when someone asks me, 'What is the boiling point of caesium?' I can answer '671 °C' even though there was no experience through which I learned this. Let's assume that the encoding process takes place when I am under sedation or am asleep. So I may have no means of distinguishing which of my semantic memories were acquired by the laborious business of reading textbooks and which were acquired via this neural intervention. So I can increase my scientific knowledge without any new sense-experiences.[7]

We should, furthermore, consider the increasingly automated and computerised nature of science (I give a real example below). Experiments can be carried out by machines and their results could also be encoded/uploaded to my cerebral cortex while I sleep, permitting me to reflect scientifically on their results when I am awake. We can extend the science fiction to allow me to instruct the automated scientific machinery to carry out experiments and to upload their results to my brain. Thus I could be a complete scientist, extending my scientific knowledge through experiment, all while remaining in the sensory deprivation tank, having no new sense-experiences.[8]

While this is science fiction, it is not a fiction that is inconsistent with what we know. Sense-experience is not necessary for knowing or doing science. We are well on the way to AI-controlled science (King et al. 2009). An AI system can already generate hypotheses, devise tests of those hypotheses, and analyse the results.[9] Currently humans have to define the research field and direct the AI towards the interesting questions. Nonetheless,

[7] Some developments in this kind of neural enhancement have already occurred. Neuralink, for example, is developing microchips that can be implanted in human brains to read neural signals and to allow users to control electronic devices by thought. See https://neuralink.com, accessed 2026-08-28. Research on the artificial enhancement of memory is currently focussed on improving the ability to form and to access memories. See https://www.darpa.mil/research/programs/restoring-active-memory, accessed 2026-08-28.

[8] This proposal is clearly externalist in spirit. I maintain that internalist assumptions are woven into the history of empiricism. But that is a matter for another discussion.

[9] For a recent development, see, for example, Sakana.ai's AI Scientist https://sakana.ai/ai-scientist/, accessed 2026-08-27.

the generation of new scientific knowledge, from conceiving the hypothesis, through experiment, to production of publishable paper has all been achieved. In so doing, the AI has no sense-experience. Science without sensation is already here.

It remains true, of course, that the AI must interact causally with the world. But this does not mean that the AI thus has senses, let alone sensory experience. Let's say the AI devises a hypothesis and implements an experiment to test it, which involves taking the temperature of a substance, for which it uses a standard resistance thermometer. If you or I use the thermometer we look at its digital readout. When the AI uses it, the same readout data are sent digitally to the AI. If the thermometer is not part of our senses when we use it, it is not part of the senses of the AI when it uses it.

The conclusion we should reach is that the senses are our in-built, evolved mechanisms for receiving information about the external world. But they are not the only way information can be received. Information can be passed along causal channels without those channels constituting or depending on senses.

7 Does Constructive Empiricism describe the aim of science?

Does the minimalist epistemology of Constructive Empiricism (CE) provide grounding for its empiricism? Above we saw that the argument given depends on CE being a plausible account of the aim of science. If CE is too weak to make sense of scientific practice, then this justification fails. In this section I argue that this is so.

The key to understanding this is to recognise that the role of perception has changed radically in modern science. Compare, for example, the discovery of the moons of Jupiter by Galileo and the discovery of pulsars by Jocelyn Bell Burnell and Antony Hewish. In the latter case, Hewish had developed a method for using interplanetary scintillation to distinguish different types of radio sources, enabling an array of radio antennae extending over four acres near Cambridge to scan the sky automatically. The output was recorded mechanically on a paper chart. Bell Burnell examined the chart manually and in 1967 spotted the trace that was produced by a pulsar.

In Galileo's case, visible light entered his telescope and then his eyes. His perceptual experience was essential to that act of observation. He could not have known about the moons without that experience or one much like it. In Bell Burnell's case, invisible radio waves entered the array of radio antennae, then an electrical receiver converted these into an electrical signal that underwent electronic amplification and processing, which was then used by the electromechanical pen recorder to produce an ink trace on paper. Only at that point did perception come in, when Bell Burnell saw the 'scruff', an anomalous trace on the chart. Her *perception* was not at all essential to this process. She herself says

that visual inspection was required 'because a human can recognize signals of different character whereas it is difficult to program a computer to do so' (Bell Burnell 1977).

While the importance of Bell Burnell's expertise to the discovery should not be underestimated, the point she makes shows that perception *per se* was not crucial. A better computer programme could have done the same job of identifying an anomaly. And indeed that is exactly what computers are used for in modern science. Move forward 45 years, to the first observation of the Higgs boson at CERN. Again we have the automated production and processing of data, though on a vastly larger scale. However, in this case there is no pen-and-ink trace needing inspection. The data is analysed by computer software and signals are detected by making statistical analyses of that data. In this case the only perception that the scientist will have is of her computer screen when running that software. Typically, then, what a scientist engages with is linguistic (where 'language' includes mathematical symbols). At the most trivial level, what experiences she has on looking at her screen depends on what language her software uses. That experience need not be visual. It could be auditory or rendered in Braille.

What then does the empirical adequacy of, for example, the Higgs hypothesis amount to? It has no direct consequences for anything humanly perceptible. The only indirect consequences of which we know concern the perceptible outcomes of experiments that test this hypothesis. The principal outcomes of that kind are the appearances of the scientists' computer screens and depend on the construction of hardware used to gather or produce the data, on the software used to interrogate the data, and on the actual commands issued by the scientist at her keyboard. The empirical adequacy, to the extent that we know if it, of such a hypothesis is therefore a matter of the truth of conditional propositions of the form:

> (EA) If equipment (a radio telescope array, a particle collider) is constructed to specifications X, software W is run on the collected data, and commands C are issued by the scientist, then she will have experiences E on looking at her computer screen.

A simple but powerful objection to CE is that it is utterly implausible that science should have the aim of establishing the truth of propositions of the form of (EA). There is no reason why anyone should have any interest in such propositions for their own sake. Rosen (1994: 162) says that CE is the most cautious empiricist stance which renders the phenomena of scientific activity fully intelligible and ratifiable. I submit that it is far from intelligible to see science as content to spend considerable intellectual and other resources in order to determine the truth of (EA)-type propositions. Much more plausible is the contention that science makes that investment in order to find out about the nature of key components of the universe.

To respond to this argument the Constructive Empiricist will have to argue that there is more to the empirical adequacy of, for example, the Higgs hypothesis than just

(EA)-type propositions. But what? For many hypotheses it is difficult to devise any kind of test at all. So it is perfectly plausible that particle accelerators and computers are the only way of connecting that hypothesis to any kind of human experience. While it *might* be that there are other ways of making the connection, of which we have not yet conceived, they are unlikely to make any more direct a connection between the Higgs hypothesis and human experience than (EA), and so the same objection stands.

In summary, CE denies that the value of science rests in its ability to provide knowledge of (unobservable$_P$ aspects of) the universe, as a scientific realist might claim. Rather, according to CE the value of science lies in its providing theories that are empirically adequate, i.e. in its successfully predicting the observable$_P$ phenomena. Modern science not only generates theories about the unobservable$_P$, its measurements and methods of analysis are also focussed on the unobservable$_P$, since they involve collecting data on entirely unobservable$_P$ entities (such as microwave radiation) and analysing that data automatically, with computers whose processes are likewise unobservable$_P$—with the exception only of what appears on a scientist's computer screen. Since the latter is of no intrinsic value, CE can give no account of the value of this sort of science—a sort of science that is increasingly the norm. Consequently, CE tells us that this kind of science is of little value. This is not a plausible rationalisation of the practices of science.

Recall now the Constructive Empiricist argument for its empiricism. It was that Constructive Empiricism is the view of science's aim that is the least epistemically demanding while also plausible as a rationale for scientific practice. Our discussion shows that this is false. In the context especially (but not I think uniquely) of the automation, digitisation, and computerisation of science, it is not possible to connect the aim of science to what is observable$_P$, i.e. perceptible, other than by (EA)-type propositions. That is too weak an aim to make sense of science. So this rationale for empiricism fails.

8 Conclusion—Science without empiricism

The empiricist picture of empirical knowledge and of science in particular is this. We open our senses to the world and we construct hypotheses to accommodate what we experience. Some empiricists are optimists, holding that we can infer that hypotheses that best explain our experiences are likely to be true, and some are pessimists, denying that we can rationally make such an inference, maintaining that we should aim at something less demanding, such as empirical adequacy. Nonetheless, the shared picture is clear: the starting point of scientific reasoning is always experience and whatever we accept in science is accepted on the basis of some kind of inference from that starting point.

An anti-empiricist epistemology of science denies that the starting point is inevitably sense-experience. Other sources of information about the world are available. One can, for example, take a reliabilist approach—so long as one's belief is produced by a reliable

process, it is knowledge. Reliabilism need not discriminate between kinds of process nor require any of them to depend on sense-experience.[10]

In my *Knowing Science* I advocate a knowledge-first picture in which the starting point for scientific reasoning is what the scientist (or, better, the scientific community) currently knows. Again, this knowledge does not have to be of any special type, e.g. uninferred or experiential knowledge. *All* knowledge may be used as a starting point, and it is no surprise that scientists thus take to be observational evidence knowledge that is highly theory-dependent in nature. Theory-dependence is a problem for empiricism that needs to be explained away. Whereas it is precisely the fact that we build instruments and inferential techniques based on well-established theories, theories that are known to be true, that allows us to expand our knowledge so widely and so deeply. If one traces scientific reasoning back, it is true that one will often find scientists having perceptual experiences as part of doing science. Often, however, especially in modern science, this will be of negligible scientific or epistemological interest—a scientist reading her computer screen, for example. Such experiences are not essential to science and they are not the foundation for science. For it is part of this picture that even when such perceptions do play a role, they may be discarded—they are scaffolding at best. The knowledge they help generate stands on its own feet once generated and has no epistemological need for its origins to remain as part of the epistemological system. This goes both for any experiences a modern scientist has and for any experiences her historical predecessors had. The knowledge gained by past scientists has been passed to us in large part on the basis of testimony, a source of knowledge that is not essentially experiential but is not inferred either. And while those predecessors depended on their senses for engagement in science, that is not for evidentially foundational reasons—it is because we humans evolved to interact with the world through our senses. Increasingly those senses are irrelevant in science. Instruments have made them redundant. It is often said, by the optimistic empiricists for example, that instruments *extend* our senses. But this is not the case. Instruments produce knowledge by measuring and detecting things, such as magnetic fields and subatomic particles, that were never available to our senses at all. Remaining uses of the senses to interact with machines are also being minimized and potentially phased out altogether, as AI does science without experience and artificial neural enhancements for humans bypass the need for perception. Historically, for most humans, the use of human or animal muscle power was necessary for producing the essentials of existence. But with the invention of the steam-engine we began to find that this was not an inevitable fact of life. Likewise, empiricism is not a necessary feature of knowledge. At best it is an

[10] In his reliabilist account of justified belief, Goldman (1979) does distinguish between inferred and uninferred beliefs in a manner that threatens to relapse into something like empiricism. But this is not a necessary feature of reliabilism.

historical phase necessitated in its time only by the constraints of our bodies, constraints that scientific knowledge has itself increasingly allowed us to transcend.

References

Alston, W. 1971. Varieties of privileged access. *American Philosophical Quarterly* **8**: 223–41.

Andreas, H. 2021. Theoretical terms in science. In E. N. Zalta (Ed.), *The Stanford Encyclopedia of Philosophy* (Winter 2022 ed.). Metaphysics Research Lab, Stanford University.

Baron, R. 2022. Certainty. In *The Stanford Encyclopedia of Philosophy* (Spring 2022 Edition ed.).

Bell Burnell, S. J. 1977. Little green men, white dwarfs or pulsars? *Annals of the New York Academy of Sciences* **302**: 685–89.

Berkeley, G. 1710. *A Treatise Concerning the Principles of Human Knowledge*. Dublin: Jeremy Pepyat.

Bird, A. 2004. Is evidence non-inferential? *Philosophical Quarterly* **54**: 252–65.

Bird, A. 2022. *Knowing Science*. Oxford: Oxford University Press.

Bogen, J. and J. Woodward 1988. Saving the phenomena. *Philosophical Review* **97**: 302–52.

Chakravartty, A. 2007. *A Metaphysics for Scientific Realism: Knowing the Unobservable*. Cambridge: Cambridge University Press.

Chang, H. 2005. A case for old-fashioned observability, and a reconstructed constructive empiricism. *Philosophy of Science* **72**: 876–87.

Coady, C. A. J. 1992. *Testimony*. Oxford: Clarendon Press.

Goldman, A. 1979. What is justified belief? In G. Pappas (Ed.), *Justification and Knowledge*, pp. 1–23. Dordrecht: Reidel.

Hempel, C. 1935. On the logical positivists' theory of truth. *Analysis* **2**: 49–59.

Hempel, C. G. 1952. *Fundamentals of Concept Formation in Empirical Science*. Chicago, IL: University of Chicago Press.

Hylton, P. and G. Kemp 2025. Willard Van Orman Quine. In E. N. Zalta and U. Nodelman (Eds.), *The Stanford Encyclopedia of Philosophy* (Fall 2025 Edition ed.).

King, R. D., J. Rowland, S. G. Oliver, M. Young, W. Aubrey, E. Byrne, M. Liakata, M. Markham, P. Pir, L. N. Soldatova, A. Sparkes, K. E. Whelan, and A. Clare 2009. The automation of science. *Science* **324**: 85–9.

Ladyman, J. 2000. What's really wrong with Constructive Empiricism? Van Fraassen and the metaphysics of modality. *British Journal for the Philosophy of Science* **51**: 837–56.

Lewis, C. I. 1929. *Mind and the World Order: Outline of a Theory of Knowledge*. New York, NY: Charles Scribners.

Lewis, C. I. 1946. *An Analysis of Knowledge and Valuation*. La Salle, IL: Open Court.

List, C. and R. E. Goodin 2001. Epistemic democracy: Generalizing the Condorcet Jury Theorem. *Journal of Political Philosophy* **9**: 277–306.

Locke, J. 1690. *An Essay Concerning Human Understanding* (1964, A. D. Woozley ed.). London: Fontana.

Maher, P. 1996. Subjective and objective confirmation. *Philosophy of Science* **65**: 149–74.

Mill, J. S. 1843. *A System of Logic, Ratiocinative and Inductive*. John W. Parker. Reference to the 1974 edition, J. M. Robson ed. Toronto: University of Toronto Press.

Mohler, C. and B. Monton 2025. Constructive empiricism. In E. N. Zalta (Ed.), *Stanford Encyclopedia of Philosophy*. Metaphysics Research Lab, Stanford University.

Neurath, O. 1932. Protokollsätze. *Erkenntnis* **3**: 204–14.

Quine, W. V. 1951. Two dogmas of empiricism. *Philosophical Review* **60**: 20–43.

Quine, W. V. 1969. Epistemology naturalized. In *Ontological Relativity and Other Essays*, pp. 69–90. New York, NY: Columbia University Press.

Quine, W. V. and J. Ullian 1978. *The Web of Belief* (2nd ed.). New York, NY: McGraw-Hill.

Rosen, G. 1994. What is constructive empiricism? *Philosophical Studies* **74**: 143–78.

Schlick, M. 1934. Über das Fundament der Erkenntnis. *Erkenntnis* **4**: 79–99.

Schlick, M. 1959. The foundation of knowledge. In A. J. Ayer (Ed.), *Logical Positivism*, pp. 209–27. New York, NY: The Free Press. Translation of Schlick (1934).

Sellars, W. 1997. *Empiricism and the Philosophy of Mind*. Cambridge, MA: Harvard University Press.

van Fraassen, B. 1980. *The Scientific Image*. Oxford: Oxford University Press.

Zhai, Z. 1990. The problem of protocol statements and Schlick's concept of "Konstatierungen". *PSA: Proceedings of the Biennial Meeting of the Philosophy of Science Association, 1990*: 15–23.