

EMPIRICISM

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Empiricism is an *ism* with many meanings. In accounts of the history of philosophy, empiricism is often contrasted with *rationalism*, though serious historians frequently look with jaundiced eye at this way of telling the story (van Fraassen 2002). According to this formula, empiricists emphasize the role of sense experience, rationalists the role of reason. Each position can be given extreme formulations, as in the clashing claims that sense experience is the *only* source of knowledge or that reason is, and each position can be moderated, with the attendant possibility that they no longer conflict. The debate was usually framed in terms of the existence of “innate ideas” and often blurred the distinction between psychological and epistemological questions.

A different kind of empiricism has been central to philosophy of science. Here empiricism contrasts with *scientific realism*, not with rationalism. When Galileo found himself in conflict with the Church, the philosophical issue concerned how heliocentrism should be interpreted. Galileo’s interrogator, Cardinal Bellarmine, did not object to Galileo’s using the hypothesis that the earth goes round the sun as a device for making predictions. His objection was to Galileo’s assertion that heliocentrism is *true*. As a first approximation, realism maintains that well-confirmed scientific theories should be regarded as true, while empiricism maintains that they should be regarded as empirically adequate – as capturing what is true about observable phenomena. Empiricists deny that it is ever rationally obligatory to believe that theories provide true descriptions of an unobservable reality. It isn’t that empiricists *deny* that quarks or genes exist; rather, they regard such realist affirmations as going beyond what the evidence demands. Empiricism is to realism as agnosticism is to theism. A third option corresponds to atheism. This is *fictionalism*, the thesis that scientific theories are always false. A closely related fourth option is *instrumentalism*, which is often interpreted as claiming that theories do not have truth-values and are merely useful tools for making predictions.

In the contest between empiricism and scientific realism, the empiricist’s preoccupation with sense experience takes the form of a thesis about the role of *observation* in science and the rationalist’s emphasis on reason is transformed into a claim about the indispensable role of the *super-empirical virtues* (Churchland 1985). For an empiricist, if a theory is logically consistent, observations are the only source of information about whether the theory is empirically adequate. For a realist, the observations

provide information about whether the theory is true, but there are other relevant considerations as well: if one theory is more explanatory, or simpler, or more unified than another, that counts too. Empiricists often dismiss these considerations as merely pragmatic or aesthetic – theories with those virtues are easier to use or more beautiful to behold, and that is all.

Observation

The verb “observes” has a double meaning, and that requires empiricists to choose between two ways of developing their philosophical position. We observe that various propositions are true and we also observe objects; we say that *S* sees that there is a linear accelerator in the valley and we also say that *S* sees the linear accelerator (Dretske 1969); call these the *objectual* and the *propositional* notions of observation. The important logical feature of the objectual notion is that it involves an extensional context. If *S* sees o_1 , and o_1 is one and the same object as o_2 , then it also is true that *S* sees o_2 . Children and dogs can see linear accelerators, even though they are unable to think of what they see in those terms. The propositional notion of observation, on the other hand, involves an opaque context. If *S* sees that there is a linear accelerator in the valley, and linear accelerators are the things that Joe loathes, it does not follow that *S* sees that there is an object in the valley that Joe loathes. Propositional observation requires conceptual competence; the observer must have mastery of the concepts that figure in the proposition seen to be true.

Van Fraassen (1980) maintains that empiricism needs the distinction between observable and unobservable *entities*, not the distinction between observation and theoretical *statements*. He says that for an object to be observable “by us” (i.e., by human beings) is for there to be circumstances such that, if we were in those circumstances, we would observe the object. Dinosaurs are observable entities even though they existed long ago, and so are Jupiter’s moons, even though they are far away. If we were at the right place at the right time, we would see them both with the naked eye. Van Fraassen (1980: 58) also says that people sometimes observe electrons and molecules. The circumstances do not involve looking through a microscope; rather, a crystal sometimes consists of a single molecule that is big enough for us to see without the aid of instruments, and there are flashes seen by astronauts that turn out to be high-energy electrons.

Observability is a modal notion; for objects that are unobserved but observable, it is counterfactual. The counterfactuals that van Fraassen thinks are relevant involve changing our spatio-temporal location, not our sensory endowment. He thinks it irrelevant that we would see objects that presently are invisible to us if we had more powerful eyes. He also thinks it does not matter that other organisms sometimes observe what we can not, and that the human perceptual apparatus might evolve. Van Fraassen does not discuss the fact that there is variation among human beings with respect to what can be observed. If observability means observability-by-us, why is it the entire human race that constitutes the relevant epistemic community, rather than a group that is larger or smaller?

For van Fraassen, if x is an observable object, then the evidence can demand that we believe that x exists. However, if y is not observable, the evidence can never oblige us to believe that y exists; the most we can be required to believe is that the claim that y exists is empirically adequate. Many of van Fraassen's critics have argued that if this is what observability means, then the concept lacks epistemological significance – our evidence for the existence of y can be stronger than our evidence for the existence of x (Maxwell 1962; Churchland 1985; Sober 1993).

Since the distinction between observable and unobservable entities is central to van Fraassen's empiricism (which he terms "constructive" empiricism), one might expect him to have provided an account of what is involved in observing an object. He does not; he thinks that science, not armchair philosophy, has the task of explaining why human beings can observe some objects but not others (van Fraassen 1980: 57). Van Fraassen is right that it is an empirical question what the observational capacities are that human beings have, but that does not relieve empiricists of the obligation to say what observing an object involves. By the same token, "Which events cause others?" is an empirical question, but that does not mean that philosophers of causation need not clarify what *causation* is.

Empiricists need to address problems in the philosophy of perception. The most obvious first stab at saying what seeing an object involves is to describe the passage of light from the object into the eye, with the result that a visual experience occurs. However, the invisibility of white cats in snowstorms and the fact that we see silhouettes (like the moon during an eclipse) shows that this is neither sufficient nor necessary (Dretske 1967; Sorensen 1999). Consider, also, van Fraassen's comment that astronauts see electrons but that scientists do not see electrons when they look at the screen of a cloud chamber. Why is an electron the object of perception in the first case but not the second? If electrons lead this double life, should we conclude that *all* electrons are visible or that only *some* are?

The reason van Fraassen (1980: 81) uses the distinction between observable and unobservable entities to formulate his brand of empiricism, and not the distinction between observational and theoretical statements, is his conviction that every term in our language is theory-laden; he takes this to entail that there are no observation statements. Van Fraassen does not explain what he means by "theory-laden," perhaps because this position is so familiar from the work of Kuhn (1962) and others. The thought may simply be that each term in our language requires knowledge if we are to apply it. We can't tell whether the term "apple" applies to something by just looking at it; we need to have beliefs about what an apple is. If these beliefs comprise a "theory of apples," then van Fraassen's claim that all empirical statements are "theoretical" is correct.

If all statements are theory-laden in this sense, how can there be observation statements? The answer is to relativize the notion of an observation statement to a testing problem. The difference this makes can be understood by considering the following two claims, which differ in terms of the order of the quantifiers used:

(EA) There exists a set of observation statements that presuppose no theories whatever, and these can be used to evaluate any theories we wish to consider.

(AE) For any set of competing theories, there exists a set of observation statements that presuppose none of the theories under test, and these can be used to evaluate those theories.

The statement (EA) characterizes *absolute* theory-neutrality, while (AE) defines *relative* theory-neutrality. The claim that all statements are theory-laden impugns (EA), but leaves (AE) untouched. (AE) expresses the important point that observation statements need to be *epistemically independent* of the hypotheses they are used to test (Sober 1990, 1993).

Not only is a suitably relativized concept of observation statement intelligible: it is a concept that empiricism needs. The distinction between observable and unobservable objects is not enough. According to constructive empiricism, the goal of science is to find theories that are empirically adequate. Van Fraassen (1980: 44–7) illustrates this idea with an example from Newtonian mechanics. He says that the observables in Newtonian mechanics (the “appearances”) are “relative motions;” different versions of Newtonian mechanics may accurately represent these relative motions even though they disagree with each other about the location of *absolute space*. One version of the theory says the center of mass of the solar system is at rest with respect to absolute space; others say that it is moving with constant velocity v_1 , v_2 , v_3 , etc. These different theories – $NT(0)$, $NT(v_1)$, $NT(v_2)$, and so on – are empirically equivalent, though incompatible. They disagree with each other, but they say exactly the same thing about observables; either all these theories are empirically adequate or none of them is.

In this example, the observables are “relative motions,” but what does that mean? We know well enough what it means for a billiard ball to be observable, but relative motions are not physical objects. You can bounce light off a billiard ball, but what would it mean to bounce light off the relative motion that one object has with respect to another? What is needed is the idea that there is a set of *propositions* that describe the relative motions of objects. These propositions have the form “Object x is moving with velocity v at time t with respect to object y ”; “Object x is moving with acceleration a at time t with respect to object y ”; and so on. Empiricists may disagree about how the objects x and y should be restricted, but that is not the point of importance here. Rather, the point is that these statements are the *observation statements* on which the different theories just mentioned agree. Van Fraassen thinks that these observation statements are theory-laden. He is right: the idea of instantaneous velocity is highly theoretical – it is defined as the limit of velocities over temporal intervals as those intervals are made smaller and smaller. However, there is no need for observation statements to be *absolutely* atheoretical. The point is that we can tell by observation which statements about relative motions are true *without assuming any of the versions of Newtonian physics that we wish to compare*.

If empiricism requires the concept of an observation statement, how should that concept be defined? I suggest the following explication of “ S sees that p ” (where p is some proposition):

S sees that p if and only if (1) S knows that p , (2) S sees objects $o_1 \dots o_n$, and (3) condition (1) is true because (2) is.

Propositional seeing is knowledge mediated by seeing objects. The definition allows that you can see that the gas tank in your car is empty by seeing the gas gauge on the dashboard. You don't need to see the gas tank to see that it is empty. We sometimes use the word "see" to mean "realize," with no implication that vision is involved; this is not a usage that the definition of propositional seeing is intended to capture. The definition of propositional seeing is an example; similar definitions apply to the concept of hearing that p , and similarly for the other senses. Observing that p is the genus of which propositional seeing is a species.

The concept of observing that p can be used to define the relevant notion of an observational statement:

Proposition p is an observational statement for S in the context of testing hypothesis H_1 against hypothesis H_2 if and only if (1) S observes that p and (2) S 's reason for believing p does not depend on S 's believing that H_1 is true or that H_2 is true.

Observation statements are a subset of the non-question begging considerations that may be able to adjudicate between the competing hypotheses under test.

It is an important consequence of this definition that a proposition can be an observation statement in one testing problem while not having that status in another. For example, even if van Fraassen is right that we do not see electrons in cloud chambers, this does not rule out the possibility that there are testing problems in which reports about electrons in cloud chambers count as observation statements. Not, of course, if we are trying to test the hypothesis that electrons exist. However, if the testing problem concerns some other matter, and the electron theory is already well established, there is nothing wrong with describing what one observes in this way.

Another feature of the definition is that *whether p is an observation statement depends on the individual S* . The usefulness of the measuring devices found in laboratories depends on our ability to perceive those devices and to tell with ease what states they occupy. Sighted people can see what a thermometer says, but blind people can not. It is a contingent biological fact that people share, to the extent they do, the ability to make various perceptual discriminations. There is no reason why individuals with different observational abilities cannot form an *epistemic community*, sharing information with each other and conducting their inquiries together. But this does not undercut the fact that blind people do not see that this or that proposition is true (in the sense of using vision to obtain this knowledge). Even so, blind people can *hear* that a proposition is true, and this can make the proposition an observational report for them. The individuals in an epistemic community experience perceptual inputs and share information with each other by sending and receiving information, which involves further acts of perception. We tend to think of epistemic communities as groups of people, but pet-owners and primatologists have formed such communities

with non-human animals, and our descendants may do the same with extraterrestrials, should such beings ever present themselves. The range of *objects* you can perceive is limited by your perceptual faculties, but the range of *propositions* you can observe to be true can be expanded by making contacts.

Acceptance

If the concept of an observation statement should be understood along the lines just described, what becomes of empiricism? It is relevant here to consider another feature of van Fraassen's constructive empiricism. After saying that realists hold that the goal of science is to find true theories while empiricists maintain that the goal is to find theories that are empirically adequate, van Fraassen (1980: 8, 12) adds a comment about *acceptance*. For realism, acceptance means regarding theories as true; for empiricism, acceptance means regarding them as empirically adequate. I suggest that these comments about acceptance burden empiricism and realism with extraneous commitments. How much evidence in favor of a proposition does it take for one to be entitled (or required) to believe it? I suspect that there is no uniquely correct answer to this question. In addition, the lottery paradox (Kyburg 1970) lurks in the background as a further warning against embracing the concept of acceptance. It is well to think here of Jeffrey's *radical probabilism* (2002), which is an epistemology that abandons the dichotomous concept of acceptance and restricts itself to using the concept of *degree of belief*. You do not need to be a Bayesian to see the merits of this approach. Realists do not need to *accept* theories as true, and empiricists don't need to *accept* theories as empirically adequate.

If we drop the concept of acceptance, new questions arise concerning what remains of van Fraassen's description of the difference between realism and empiricism. Since "T is true" entails "T is empirically adequate," evidence confirming the latter will often confirm the former, at least when confirmation is understood on the Bayesian model:

Observation O confirms hypothesis H if and only if $Pr(H|O) > Pr(H)$.

To identify a sufficient condition for confirmation of a logically weaker statement W to imply confirmation of a stronger statement S , let A be the additional content that the stronger statement has; this means that $S \equiv W \& A$, where W does not entail A . Now consider the following:

$$\begin{aligned} Pr(S) &= Pr(W \& A) = Pr(W)Pr(A|W). \\ Pr(S|O) &= Pr(W \& A|O) = Pr(W|O)Pr(A|W \& O). \end{aligned}$$

This entails that if $Pr(W|O) > Pr(W)$ and $Pr(A|W \& O) = Pr(A|W)$, then $Pr(S|O) > Pr(S)$. The confirmation of the weaker proposition entails the confirmation of the stronger proposition if W screens off A from O . Van Fraassen's example about Newtonian mechanics fits this pattern. Let W be Newtonian mechanics with no

mention of absolute space, and let A assert that the center of mass of the solar system is at rest relative to absolute space. The observations that confirm W , such as the observation that the tides and the phases of the moon are correlated, do not affect how probable A is given W . Because of this, all the empirically equivalent theories $NT(O)$, $NT(v_1)$, etc. are confirmed when the claim that NT is empirically adequate is itself confirmed.

Van Fraassen grants that the $NT(O)$, $NT(v_1)$, and so on can each be *disconfirmed* by observations. According to Bayesianism, this means that they also can be *confirmed*. Given this, what would it mean to say that confirming and disconfirming "T is empirically adequate" is the goal, and that the confirmation or disconfirmation that accrues to "T is true" is a mere by-product, not the goal of science at all? Both "T is true" and "T is empirically adequate" have their probabilities rise and fall. A purely Bayesian approach to evidence thus throws doubt on van Fraassen's definitions of empiricism and realism, once "acceptance" is deleted.

A similar conclusion concerning how empiricism should be formulated follows if we use other conceptions of evidence. Consider, for example, the law of likelihood (Hacking 1965):

Observation O favors hypothesis H_1 over hypothesis H_2 if and only if $Pr(O|H_1) > Pr(O|H_2)$.

If an observational result favors " T_1 is empirically adequate" over " T_2 is empirically adequate," it also will favor " T_1 is true" over " T_2 is true." This follows from the fact that, for any observation O , $Pr(O|T_1 \text{ is empirically adequate}) = Pr(O|T_1 \text{ is true})$ ($i = 1, 2$). Given this fact about likelihoods, what would it mean to say that the goal of science is to solve the first discrimination problem but not the second— that solving the second is merely a byproduct? Observations can be brought to bear on theories that make claims about unobservables; when such theories confer different probabilities on what we observe, it is perfectly possible to discover which theory is better supported. Various frequentist frameworks of inference — model selection theory, for instance — also allow that data can discriminate between theories that make reference to unobservables; this happens when the different theories make different predictions about matters we can observe.

Contrastive empiricism

Empiricism should not regard propositions that postulate unobservable entities with suspicion. Rather, empiricism should be formulated as a thesis about *testing problems*, not about *propositions* (Sober 1990, 1993, 1999). If two theories make different predictions about observations (and here we need to think of prediction probabilistically, not just deductively), science may be able to test the two hypotheses against one another; but if they are predictively equivalent, science has nothing to say about how the theories compare. To see the importance of formulating empiricism as a thesis about problems, not about single propositions, consider the parallel epistemological problems posed by the following two triplets:

- (P_1) Quantum mechanics is true.
 (P_2) Classical mechanics is true.
 (P_3) Quantum mechanics is empirically adequate, but false.
- (Q_1) Dinosaurs once roamed the earth.
 (Q_2) There were no dinosaurs.
 (Q_3) It is false that dinosaurs once roamed the earth, though all the evidence we will ever have suggests that they did.

Let us grant, for the sake of argument, that P_1 is about unobservable entities and that Q_1 is strictly about observables. For van Fraassen, this makes all the difference in the world, but according to the version of empiricism I am describing, it does not matter. Rather, the point of importance concerns the similarities that unite the P s and the Q s, not their differences. Observations can discriminate between P_1 and P_2 , just as observations can discriminate between Q_1 and Q_2 . And observations cannot discriminate between P_1 and P_3 , just as observations cannot discriminate between Q_1 and Q_3 . The reason observations cannot discriminate between P_1 and P_3 has nothing to do with the fact that P_1 describes unobservable entities; the same impossibility attaches to testing Q_1 against Q_3 . Science is in the business of addressing problems of the first kind, not problems of the second.

This version of empiricism, *contrastive empiricism*, maintains that the goal of science is to bring observations to bear on the comparison of theories (Sober 1990). This goal is *attainable*; in fact, it has frequently been attained. I do not deny that scientists often want to discover which theories are true and often think they have done so. However, the humbling fact of the matter is that scientists are able to consider only those theories that have been formulated thus far. And, for the most part, there is no reason to think that the theories we have at hand exhaust the range of possible theories (Stanford 2006). The same point shows that what van Fraassen regards as the goal of science is often not attainable. Scientists may seek theories that are empirically adequate; however since the theories they consider are rarely exhaustive, they are often in no position to say that the best of their theories is empirically adequate. It may be objected that finding true theories or theories that are empirically adequate must be among the goals of science, since scientists would be pleased if their pet theories had that status. My reply is that "the goals of science" in this context should be understood as the goals that scientific modes of inference are able to achieve; the hopes that scientists harbor for their theories are not at issue. The debate between realism and empiricism concerns the power of scientific inference, not the psychology of scientists.

Whither the super-empirical virtues?

Empiricists have sometimes been skeptical about the role of simplicity and unification in theory evaluation, thinking that their empiricism obliges them to hold that the simplicity of a hypothesis cannot be evidence that it is true or empirically adequate

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(see, e.g., van Fraassen 1980: 87). However, it is far from obvious that empiricist standards require this stance. Empiricists have the resources of mathematics and logic, as well as the observations, to bring to bear on competing theories. Perhaps, in an interesting range of circumstances, there is an empirically grounded reason why simplicity should be a defeasible guide to truth or empirical adequacy.

If the relative simplicity of theories H_1 and H_2 is epistemically relevant, the empiricist needs to explain why this is so without invoking the thesis that simplicity is an end in itself, a *sui generis* constraint on what it means to be a good scientific theory. Here is a simple example in which it is possible for the empiricist to make good on this commitment. Suppose some students are sitting in a seminar room that overlooks a lake. At time t , all of them come to believe that a red sailboat is crossing the lake. Why did the same belief suddenly take hold? Consider two hypotheses. H_1 says that there was a single red sailboat crossing the lake at time t ; H_2 says that the students independently and simultaneously suffered hallucinations at time t . Why is H_1 a better theory than H_2 ? One thought is that H_1 is simpler; it postulates a single cause that explains the observations, whereas H_2 regards the simultaneous occurrence of the observations as an elaborate coincidence. But that is not the end of the story. It also is true that the students simultaneously having the same experience is rendered more probable by H_1 than by H_2 . Here the simpler hypothesis is also the hypothesis of higher likelihood, in the sense of the *law of likelihood*. This is the sort of justification of simplicity that empiricists can embrace. There are less trivial examples that follow the same pattern. A longstanding question in evolutionary theory concerns the use of a parsimony criterion in phylogenetic inference. Biologists have so far identified two different models of the evolutionary process that each render parsimony and likelihood ordinarily equivalent (Sober 2008). If we have empirical reasons to accept one or the other of these process models in a given problem, we thereby have a reason to think that parsimony is relevant to deciding which phylogenetic hypotheses are better supported by the data.

One complication that empiricists need to face is that *simplicity* may have different justifications in different inference problems. Even if a given model of the evolutionary process entails that parsimony and likelihood go hand-in-hand in phylogenetic inference, the situation seems very different in model selection problems in which more complex models fit the data better than simpler ones (Forster and Sober 1994). Unfortunately, empiricists must think about the so-called "super-empirical virtues" piecemeal. But so, too, should everyone else. The claim that simplicity and unification really are *super-empirical* guides to truth or empirical adequacy requires a positive argument. It is not enough that we presently do not understand the roles of simplicity and unification in theory evaluation. Empiricists and realists both have work to do here.

Concluding comments

Empiricism is best viewed as a thesis about the power of scientific reasoning; that power is not unlimited. Philosophers of science have long recognized that non-deductive reasoning is uncertain, but there are more limits than this on what science can achieve. At any moment, scientists are limited by the observations they have at hand. That

limitation does not force them to restrict their attention to theories that are strictly about observables; still less does it force them to limit themselves to hypotheses that do not go beyond restating the evidence at hand. Rather, the limitation is that science is forced to restrict its attention to problems that observations can solve.

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See also Bayesianism; Explanation; Inference to the best explanation; Logical empiricism; Metaphysics; Observation; Probability; Realism/anti-realism; Underdetermination; The virtues of a good theory

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Further reading

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