

Scientific Knowledge: Truth, Induction and Falsification *Jennifer Booth*

Prima facie it seems obvious that the findings of scientific research constitute knowledge. Albeit often a specific and highly detailed type of knowledge, but knowledge nonetheless. The question I want to ask concerns what exactly our common sense notion of scientific knowledge amounts to. In doing so, I suggest that in order to understand a conception of what scientific knowledge is, we must look to how we characterise science in itself. The reason being that the model of scientific methodology that we choose to adopt will govern what *kind* of knowledge (if any) science can be seen to produce. What we need to ask is which of the models purported to capture scientific methodology will best account for our common sense view of scientific knowledge. It is in attempting to answer this question that I turn to two contrasting accounts of scientific method: inductivism and falsificationism.

First and foremost however, we must decide on what exactly it is that we commonly understand to be scientific knowledge. One way to do this is by first explaining what types of knowledge do not qualify. There is a type of knowledge best described as 'practical' knowledge, which involves such things as knowing how to ride a bicycle or brush one's teeth comprehensively. Such knowledge is non-conceptual or basic and it can exist without our knowing how to give verbal expression to it. Certainly I can choose to reflect upon my possession of such knowledge, I can state that I *know* how to ride a bicycle, but this reflection is something quite separate to the practical knowledge itself. It seems the case that such pieces of knowledge can act as their own explanation. That is, if someone questioned whether I could ride a bicycle, all I would need do to exhaust his or her query is to demonstrate my ability. There is no 'higher level' explanation that I should give in order to justify my knowledge. This is not the type of knowledge I have in mind for scientific knowledge.

Another type of knowledge which I mean to avoid is that which grounds our 'rule-governed' behaviour.¹ When we operate within our society we do so according to a body of rules or laws that we must abide by, if we are to remain in that society. Such things as 'driving on the left' or 'stopping at a red light' are examples of this kind of knowledge. It is perhaps best called 'procedural knowledge'. Although this knowledge has conceptual content which can be expressed in such propositional form as 'all cars must stop at red lights', it is not the kind of knowledge with which I am concerned. If we are asked to justify or explain a particular instance of this knowledge, we can only do so by referring to concerns outside the actual content of that knowledge. That is, if asked why it is that you stop the car at a red light, it would be unlikely that the explanation you would give would be one involving certain refracted wavelengths falling on your retina, being interpreted by your visual cortex and resulting in leg contractions which stop the car. Instead, you would offer either some general reason 'that its part of the legal highway code' or some moral concern 'because I don't want to hurt anyone'.

The type of knowledge I have in mind is that which we claim offers us explanation of the way the world is. It is a type of propositional knowledge that takes the form of statements such as 'cats miaow whereas dogs bark', or that 'kicking a football makes it move'. *I will call this knowledge 'operational knowledge' as it seems both a result*

of, and a basis for, our operation within the world. It is this type of propositional form that we tend to give to scientific claims about the world. Note that this is not say that all our claims to operational knowledge are obviously reducible to, or dependent upon, scientific claims. On the contrary, scientific claims can be seen on occasion to offer complimentary but quite separate explanations of the world. In terms of the above examples, scientific knowledge might make claims as to the biology of a cat's larynx, and the principles of movement and inertia. The common view of scientific knowledge is that it constitutes some specialised part of this body of operational knowledge. The kind of claims I have in mind could be such things as 'water boils at 100 degrees centigrade' or statements about the relationship between force, mass and motion. Any reliable law-like proposition that scientific research develops I suggest comes under this category.

So let us return to the key question for scientific methodology, which now looks something like this. In what sense, and to what extent, is science able to provide us with such a specialised subset of operational knowledge? On the one hand, science can be seen to provide us with universal laws, which we put to work in both explaining and predicting our individual observations of the world. On the other hand, the business of science can be seen to lie in the questioning of such laws, in showing how to refute them, and thereby taking our operational knowledge closer to the truth of the world. Put crudely, these two approaches to scientific practice are the methods of inductivism and falsificationism respectively. Let us look at inductivism first.

The methodology of induction in science is simple: we note an event or observation repeated again and again across time and we judge this regularity to be something we can depend upon. Each individual observation reinforces our belief in a characteristic of the world that perseveres beyond a specific time and circumstance. For inductivism, collating observations in science leads to the postulation of various scientific laws. On the basis of these laws, I presume both that an observation I may have has been had before, and that it will continue to be observed on other occasions by other people long after I am gone. In other words, these universal scientific laws offer some kind of certainty to my individual observations; what I see on each occasion is grounded by scientific rules. In short, these laws tell me how the world necessarily is, and so give reason for my trust in this inductive process.

So the basic application of our inductive reasoning is two fold: firstly we think we can explain what we *have* seen by the use of universal laws, and secondly, that we can use these established laws in predicting what we *will* see.

There are however, a number of problems with this picture, concerning both the mechanics of this inductive process and the characterisation it gives of scientific knowledge. First and foremost there is the question of whether we are justified in formulating these universal laws simply on the basis of a discrete number of past observations that we have made.

Taking a striking example, that owing to the scientific observation of planetary motion, science can suggest the guaranteed law that 'the sun will rise every day'. Prima facie, just because the sun has risen in the past, it does not mean that it will continue to do so either tomorrow or the next day. There is, as it were, no guarantee that we will ever see the sun rise again. If this is the case, then it is certainly

detrimental to the sense of faith we have in our scientific laws of planetary motions. What we rely upon is the supposition that some kind of necessity has caused the sun to rise in the past and will therefore continue to cause the sun to rise in the future. The problem is that any certainty we think we can obtain from an induced scientific law turns out to be of no more use to us in guaranteeing the truth of the world than any individual observation in itself.

To understand why, let us look to Hume. He stated that when we observe two events to be causally related, say a kick (e_1) causing a ball to move (e_2), what we in fact observe is only a contingent conjunction of two events. That is, the causality that we think we perceive is not actually 'out there in the world' for us to observe. When we see two events and *judge* them to be causally related, it is merely through a habit of the mind, something we project onto the world. A necessary causal link, as such, is not guaranteed. In the relevant parlance, there is no necessity in e_2 following e_1 ; nothing to guarantee that the next occurrence of e_1 will be followed by e_2 .

If we accept this proposal, it is a short step to Hume's general attack on inductive reasoning: that there is nothing in our observation of past or current events that can tell us about the way the future will be.² If we presume otherwise, we are begging the question of the uniformity of nature: that what has always been will (for apparently no good reason) continue to be.

If we return to our example of the sun rising every day and the scientific explanation we propose to give in terms of the causal effects of planetary motions, we can see that the Humean objections take hold in the following way. Whatever scientific explanation I give in terms of the observation of regularities in planetary behaviour, no number of observations gives me the right to postulate a universal law. There is no in-built necessity which we can observe that tells us the planets will always move in such a fashion, and that the sun will thus appear to rise every day. We simply cannot postulate universal laws that tell us the way the world irrefutably is and will always be unless we have reason to trust such generalisations.

Besides which, even if we could trust such universal laws as 'the sun will always rise' it is not even clear how many times we would need to see the sun rise in order to justify first proposing this law. That is, how many 'repeated observations' will suffice for us to be certain that something is going to continue to be the case, either in everyday life or the laboratory? It seems that in this case scientific explanation, although detailed and informative, has no claim to being the irrefutable truth of the matter. Indeed, if scientific method is restricted to induction, it seems our claims to operational knowledge are not as certain as we like to think they are.

These objections give to induction a kind of naïve quality, it being merely a habit of the mind to which we succumb. A method which promises universal pieces of knowledge, but inevitably leaves us open to unwelcome error. If we can do no better than to follow this inductive rationale then we are as naïve as Russell's chicken: fed every day by the farmer, expectant of food in the future, and genuinely surprised by the unforeseen wringing of its neck.³

So much for induction as providing a basis for this scientific operational knowledge. As it stands, this methodology seems far too error prone and dogmatic to be the correct explanation of how we understand the characteristics of the world.

Karl Popper claimed that this naïveté which induction displays is a result of its non-rational or non-logical makeup. Although not irrational, the practice of induction does go beyond what is strictly logical. That is, proposing an ‘all encompassing’ law on the basis of a finite number of observations is thereby to propose knowledge of that which we simply don’t know. If scientific method is to be rational, according to Popper, it must only make claims to knowledge that are logically sound. Science is therefore not in the business of making grand universal laws, but instead should concern itself with the examination of individual observations.

For our present concerns, Popper’s model of falsification can be seen in the following way: when we make claims to operational knowledge, we propose certain non-logical ‘inductive’ laws, and we then rely on science for their *evaluation*. That is, the role of science is different to that proposed by the method of induction. The job of science, according to Popper, is to take these laws which we make through habit or generalisation, and try to prove them wrong. That is, as scientists, we should make it our business to seek out the observation that would falsify our law. Upon observing such a falsifier, we then discard that particular universal law and move on to another one. This, in short, is his technique of ‘falsification’. In this way, science ‘prunes’ our claims of operational knowledge in the most efficient and logical way possible; finding one falsifier is an easier task than seeking out every affirmative case of a universal law. Indeed, as Popper asserts, the latter may be something we cannot even do:

any conclusion drawn (from this process of induction) may always turn out to be false: no matter how many instances of white swans we may have observed, this does not justify the conclusion that all swans are white.⁴

If we are to accept this model, then the role of science is to show us how we are being inaccurate in our claims to knowledge about the world. That is, if I believe that ‘all swans are white’, and a Popperian shows me a black swan, then my explanation of the way the world is will stand to be improved by my discarding of this universal claim.

Science isn’t in the business of being constitutive of our operational knowledge, it is to be understood as that which evaluates and refines it. What we commonly think of, as scientific claims to knowledge, are only tenuous hypotheses proposed with the intention of proving them wrong.

There are however, some strange consequences of this Popperian methodology. They become obvious when we ask what happens when one of our universal laws happens to be right. That is, what if I claim ‘all ravens are black’ and they *are* in fact all black? For Popper, we can never have this claim confirmed. Due to its very nature as a universal law it will always go beyond what we have the right to assert.

If we never see a non-black raven this does nothing to help our claim. If we only ever see black ravens, this does not help to strengthen our claim either. In fact, for Popper, the best we can hope for is that a given claim is corroborated at one instance in time,

it can remain the best theory we have whilst it sits in the probationary wings, awaiting its refutation. In sum, a universal law can never be judged to be right - even if it is - as in *principle* we may always discover a falsifier. Intuitively, this just seems in direct conflict with our understanding of what knowledge is. That is, we want it to be something substantial and dependable, not something that is only useful to us in one restricted time and circumstance. When we set out to explain the subset of operational knowledge claims that we commonly know to be 'scientific knowledge' we did not intend to discard its status as knowledge altogether.

Nevertheless, if we maintain that our operational knowledge consists of sets of universal statements about the world then Popper's revelations are right to question the status of this as 'knowledge'. If Popper is right, then all we can ever know with logical certainty is that on one occasion we have proved a universal law to be wrong.

So where does this leave our question as to what scientific knowledge consists in? As it stands, we have two answers, depending on which methodology of science we choose to favour. According to inductivism, we have a type of operational knowledge which takes the form of universal scientific laws that we induce from observing repeated instances of a phenomenon. These laws seem to give the sense of certainty that we require from knowledge, that what we are claiming to know has some grounding above and beyond the individual case that we perceive here and now. However in light of Humean and Popperian thought, such certainty seems to be purely illusory. On the other hand, falsificationism tells us that scientific knowledge consists in telling us about what is not the case, it is the process of showing how and why these laws fall short of a correct explanation of the world. As a consequence however, we cannot claim to have certainty in any positive claim about the world. *Prima facie*, it seems that neither of these options is immediately attractive. We seem to either be allowed a body of scientific knowledge which is logically flawed, or we have a rather paradoxical type of knowledge which only consists of judgements of what is *not* the case. In neither case does our common sense view of scientific knowledge demonstrate any kind of justifiable reliability.

Arguably, what seems to be the problem is the pivotal role both methodologies give to the idea of a universal law. By taking opposing stances as to the possible truth of a universal law it seems inductivists fail to accommodate the possibility of falsifying instances, whereas falsificationists rule out the possibility of substantive knowledge of any universal law. Does it really have to be the case that we either know something to always be the case, throughout time and space, or, on the other hand, that we simply can only know for certain what we don't know?

Perhaps what we need to ask is whether our claims to knowledge need have this 'universal' character. Instead let us consider a statement such as 'I know the sun will probably rise tomorrow based on what I have experienced'. What is the difference between this and a universal law like 'the sun will always rise'? Well, in the former I acknowledge that my experience is playing a role in my judgement. That is, I clearly admit to using a reference class that is limited in scope both in terms of the number of observations it depends upon, and the time scale over which they were obtained. What we are accommodating for is the *possibility* of error. Whilst we may claim to know something on the basis of the information we have, this is not the same as claiming that the state of the world will never deviate from how the scientific community has

hitherto described it. This would mean that our body of scientific knowledge is not claiming to present universal truths, but only suggests that we can accommodate our observations of the world so far under certain probabilistic claims.

Nevertheless there are objections to this type of suggestion. The first of which concerns the risk of invoking what Popper calls pseudo-science.⁵ From a Popperian standpoint, universal laws are not only the targets of scientific attack, they are a necessary part of scientific practice. That is, the problem with non-universal or 'probable' statements like the one I proposed above is that they do not admit of conditions in which they can be falsified, and hence ultimately, be rejected. If a statement cannot be falsified then it simply isn't scientific, and is merely a piece of 'psuedoscience'. However, this objection is not as damaging as it first appears. We can still find a valuable role for falsification even when we disregard universal laws. When we say something has always been the case and therefore it is *probable* that it will continue to be that way, evidence showing cases both where this is realised *and* where it is rejected are of the utmost importance to us. The first type of evidence strengthens the probability of a claim to knowledge and the second type weakens it. The difference in relation to Popper's account is that falsifying evidence is used to develop theories and not simply as a means with which to categorically discard them.

From a philosophical standpoint perhaps the more compelling objection that we should consider regarding these probabilistic knowledge claims is the relationship between knowledge and truth. When we held in place that knowledge existed in the form of universal laws it was easy to imagine how a given piece of knowledge was either true or false: it depended quite simply on whether the law was right or wrong. However, in terms of these 'probabilistic' scientific claims I have introduced, it is not immediately clear that we can claim to know with such certainty whether they admit of categorical truth or falsity. That is, it is hard to see when we would reject a law as false. Even if we find a falsifier, it is hard to judge when its occurrence is improbable enough to warrant rejection of that law.

In other words, it is arguably a consequence of abandoning the idea of a universal law that we no longer have a black and white picture of when we have truth. However, even if this is the case, this is not to say that we cannot have knowledge. Truth and knowledge are not the same thing. We certainly like to think of truth as something definitive or categorical, and it is for this reason that I suggest truth to provide something like a normative condition for scientific knowledge. It is the job of science to refine theories in the face of evidence until they thereby come closer to what we call truth. This suggestion seems favourable with regard to the phenomenological aspect of knowledge, as although we would never claim knowledge of something that we suspected to be false, we are still prepared to rectify or adjust our claims to knowledge in the face of new evidence. In fact, in reality we accept that knowledge is 'not a precise conception' and that 'it merges into "probable opinion."' ⁶

Besides, it is a further point that being 'true' in itself is not the only support a piece of knowledge can have. As Russell stated:

A body of individually probable opinions, if they are mutually coherent, become more probable than any one of them would be individually. It is in this way that many scientific hypotheses acquire their probability.⁷

Although this ‘coherence’ of knowledge claims with one another cannot guarantee that any of them are actually true, it still offers a kind of structural support. That is, although science may not provide definitively true knowledge, it does offer an internally supportive network of claims from which explanations and propositions can be extracted and put to use.

Arguably, science is in the business of working toward the truth, and if we had it already science would be redundant. I think we can accept that our claims to scientific knowledge are true only in the face of what has been experienced so far. Although scientific method may not produce infallible claims to knowledge, it must be borne in mind that it is only a *potential* for error that we admit. This does not equate to our being in a state of constant uncertainty. On the contrary, it seems that a degree of error is something we would be wise to admit. Or, as Russell put it: all our knowledge of truths is infected with *some* degree of doubt, and a theory which ignored this fact would be plainly wrong.⁸

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References

Hume, D. *A Treatise of Human Nature* (2001). Oxford University Press: Oxford.

Popper, K. (1959). *The Logic of Scientific Discovery*. Basic Books: New York.

Popper, K. (1963). *Conjectures and Refutations*. Routledge & Kegan Paul: London.

Russell, B. (1912) *The Problems of Philosophy*. (2001 edition) Oxford University Press: Oxford

¹ I should add that I don't wish to beg the question against Wittgensteinian concerns of whether behaviour is rule governed or rule guided, either term will do for my purposes here.

² Although the arguments against necessary connection of cause and effect and the problem of induction are often discussed separately, it suffices for our purposes to deal with them as striking the same target. For the original discussions see *Treatise of Human Nature* Book 1, Part 3, especially §6 & §14.

³ See Russell (2001 edition) p.35

⁴ See Popper (1959) p.27

⁵ For a full presentation of Popper's views see Popper (1963) pp.33-39.

⁶ Both of these quotes are from Russell (2001 edition) p. 78

⁷ Ibid p. 81

⁸ Ibid p. 78