SCIENTIFIC REALISM AND EPISTEMOLOGY

1 Introduction

Here are some theses frequently endorsed by scientific realists:

- R1 The theories of mature sciences are very frequently highly successful (where the success of a theory may be articulated in various ways, e.g. the theory passes severe tests, or it makes novel predictions that are confirmed by observation, or it provides a unified explanation of disparate phenomena, etc.).
- R2 The theories of mature sciences are very frequently true or close to the truth. And so, frequently, the entities, often unobservable, posited by the theories of mature sciences exist.
- R3 This success is not accidental. Our belief in theories (or in their approximate truth) is frequently justified and amounts to knowledge.
- R4 The reasoning process by which we come to believe the theories of mature sciences very often is an inference to the best explanation.
- R5 The reason why we should believe R2 is R1. That is the best explanation for the success of the theories of mature sciences is that those theories are very frequently true or nearly true.

Here are two theses endorsed by many anti-realists:

- A1 The apparently well-confirmed theories of mature sciences are very frequently found, in the long run, to be false.
- A2 We should expect current theories to be falsified in due course (by induction on A1).

And here are theses endorsed by some anti-realists:

- A3 We cannot know that a theory involving commitment to unobservable entities is true or close to the truth.
- A4 Inference to the best explanation is not a reliable means of inferring that a theory is true (or approximately true), at least if it involves commitment to unobservable entities.

We might distinguish between pessimistic anti-realists and optimistic anti-realists. The latter, while believing that theories, or at least theories that concern unobservables, cannot obtain truth, nonetheless accept that they can obtain something else worthwhile, for example empirical adequacy. The pessimistic anti-realists hold that science cannot obtain even that. The pessimists will tend to emphasize A1 and A2 whereas the optimists will focus on A3 and A4. The optimists may reject R4, claiming instead that the reasoning processes of science are something other than Inference to the Best Explanation (IBE) that can deliver a worthwhile outcome that

is less than knowledge of the truth of theories. For example, a subjective Bayesian might claim that Bayesian conditionalization can give us rational credences; others may assert that enumerative induction can give us conclusions about laws concerning the phenomena that are increasingly close to the truth.

The purpose of this essay is to consider how these theses are informed by reflections in mainstream epistemology.

2 Inference to the Best Explanation—the problems

Inference to the Best Explanation (IBE, abduction) plays an important part in the realist's argument for the four realist theses articulated above. R4 itself notes that IBE is often the means by which we come to believe in the (at least approximate) truth of scientific theories and the existence of the entities they posit. And so if one believes R2, one must also believe that IBE is frequently a good guide to the truth. Furthermore, R5 itself employs an inference to the best explanation in inferring a general truth about scientific theories (that most of them are nearly true) from a general observation about science (science is generally successful). Correspondingly one flavour of anti-realism (a flavour that accepts the success of science) rejects the value of IBE as a guide to the truth, hence A4.

IBE is an inference procedure that is not exclusive to science (Harman 1965). Prima facie we use IBE to make everyday inferences, for example, concerning where fault in a motor car is, why there is a fresh hole in the lawn this morning, who murdered Lord Edgware, and how Leicester City won the league. Furthermore IBE is seen by a number of mainstream epistemologists as providing the right approach to answering Cartesian scepticism (e.g. Vogel 1990). So the question of the reliability of IBE is not exclusively a concern for epistemological philosophy of science; the efficacy of IBE as truth-tropic inference procedure is of general epistemological interest.

Lipton (2004) identifies a number of general problems for IBE. *Hungerford's objection* states that the evaluation of 'goodness' in deciding which explanation is the best is too subjective to correlate with the truth.[1] *Voltaire's objection* states that IBE assumes that the actual world is the best possible world by explanatory standards; but why should we believe that? And *Underconsideration* raises the concern that we can only select the best of the explanations we have been able to think of, but we may not have considered the actual, true explanation. Lipton provides his own responses to these problems. For example, he holds that Voltaire's problem is just a version of Hume's problem of induction and so does not present a special problem for IBE. That means that this problem should not be the basis of an argument for A4 by, for example, a constructive empiricist, who thinks that there are some good ampliative inferences in science (e.g. uses of enumerative induction) but that IBE is not among them. Lipton's response to Underconsideration exploits the theory-dependence of the reasoning by which we rank hypotheses in order to select the best hypothesis. For example coherence with well-established theories and background beliefs will be one factor in determining how good an explanation is. That process of ranking will not be reliable if the background theories/beliefs are false. So we can assume that if ranking is reliable those background theories/beliefs are often true. And frequently those background theories and beliefs will have been arrived at by IBE. So it must be that IBE does frequently deliver the truth (and a fortiori it cannot be the case that we frequently fail to consider the correct explanation). Lipton

does acknowledge that this argument assumes that the ranking of competing explanations is reliable. However, he says, if we deny this, then again we are back with Hume's problem of induction, rather than with a special problem for IBE.

So, Lipton's response to the problems facing IBE is, in effect, that they are not special problems for IBE. Insofar as they are problems they are also problems for any inductivist. If Lipton is right about that, then the position of the optimistic anti-realist is unstable. For that anti-realist must accept that there is some answer to Hume's problem, or else they should not hold that science can yield any worthwhile substitute for truth—even knowledge of the empirical adequacy of theories requires the reliability of enumerative induction. If, however, there is an answer to Hume's problem, and Lipton is right, then there is no epistemological reason to avoid IBE.

3 Hume's problem

In the light of the thought that the problems of IBE reduce to Hume's problem, we should look at the nature of the latter and the most important response to it. The starting point is the observation:

> I1 The conclusion of an inductive argument is not deducible from its premises.

So there is no logical contradiction in asserting the premises of an inductive argument while denying its conclusion.[2] So on what ground should we believe the conclusion of an inductive argument given its premises? One response is to appeal to the general reliability of induction:

> I2 Inductive arguments generally lead to true conclusions from true premises.

But on what ground should we believe I2? It is a general claim, which if it is known at all, is known on the basis of our finding that our inductive reasoning generally works. If it did not generally work—if it did not help us distinguish the safe from the dangerous on the basis of experience—then we would not be around to discuss this question. As Hume points out, this reasoning, from past experience of the success of induction to its general reliability, is itself an inductive argument. And so this attempt to justify our use of induction presupposes that induction is a good way to argue. Consequently that attempt is vitiated by circularity and so provides no justification. Hence our use of induction cannot lead to knowledge:

> $\neg\Diamond$IK It is not possible to gain knowledge by using induction.

Do the objections raised against IBE reduce to Hume's problem? Certainly something like Hume's problem can arise for IBE. It is widely assumed that:

> E1 The conclusion of an inference to the best explanation is not deducible from its premises.

So why should we believe the conclusion of an instance of IBE? As in the case of induction we might need to appeal to IBE's general reliability:

> E2 Inferences to the best explanation generally lead to true or nearly true conclusions from true premises.

To justify E2 we might appeal to the fact that IBE has proven reliable in the past—when we have been able to check the conclusions of many past instances of IBE, they have been found to be true. That argument is an appeal to enumerative induction, and so we have a direct reduction to Hume's problem of induction.

An alternative justification for E2 takes R2 and R4 as premises. Since our theories are mostly true or approximately true and the reasoning processes that deliver them are often instances of IBE, then IBE must generally lead to true or nearly true conclusions from true premises. Why should we believe R2? R5 tells us that we should believe R2 because it is the best explanation of the success of science. So this justification of IBE employs an inference to the best explanation. Furthermore, someone might query the inference from the truth of theories to the reliability of the method that produced them. For even an unreliable method can produce true conclusions on occasion. Still, a better explanation of the truth of the many theories of mature sciences is that they are produced by a reliable method. Hence this route to establishing the reliability of IBE itself depends on a least one prior application of IBE. So the parallel objection will be raised as in Hume's problem, that it uses the very inference procedure that it seeks to justify (Fine 1991: 82).

On the other hand, these are not the problems that Lipton identifies: Underconsideration and Voltaire's objection. It is no part of Hume's problem that we might have failed to consider the full range of possible inductive projections in addition to our preferred one. Voltaire's objection asks for our reason for thinking that the actual world is the *best* by our explanatory standards. And that seems not to have a parallel in Hume's problem. Yes, the inductivist looks as if she is assuming that the world is regular rather than irregular. But she does not seem to have to assume that it is the most regular world or the best world by some standard of regularity. So these problems do not have a parallel in Hume's problem. Furthermore, the characteristic feature of Hume's problem—the apparent circularity of using induction in justifying induction—does not arise in Underconsideration or Voltaire's problem. Nor does it appear that these problems would disappear if we had a solution to Hume's problem.

4 Externalism and reliabilism

What does a solution to Hume's problem look like? The most significant kind of response draws on epistemological externalism. Internalism is the claim that whether a subject is justified in believing that p or knows that p supervenes on the internal states of the subject.[3] Externalism is the denial of internalism. (One could be internalist about justification but externalist about knowledge. For convenience I will consider that internalism about justification and about knowledge together.) One influential version of externalism is reliabilism (Armstrong 1973; Goldman 1975, 1979), of which the following are simple formulations:

> S's belief that p is justified iff S acquired the belief that p by a reliable method.
> S knows that p iff S believes that p, S acquired the belief that p by a reliable method, and it is true that p.[4]

The crucial thing about reliabilism is that the reliability of the belief-forming method in question is an *external* condition. Two subjects may be internally alike, yet the method used by one to form a belief is reliable and that used by the other is

not; the former therefore may be justified in their belief and have knowledge while the latter is not. So whether you know the answer to an arithmetical problem by using a calculator will depend on whether the calculator is functioning reliably. And that will not supervene on your internal states.

One important motivation (but not the only one) for externalism in epistemological naturalism (Quine 1969; Papineau 1993; Kornblith 2002). The latter aims to understand the epistemic states of an organism (human or otherwise) in terms of its need to interact successfully with its environment. In particular we can explain, in terms of natural selection, why sentient organisms have systems, above all its senses, for gathering and processing information about the organism's environment in a reliable way. The resulting states of the organism are states of knowledge. This perspective is externalist because this explanation appeals only to the reliability of the organism's cognitive systems. This reliability may depend not only on the organism but also on its environment; furthermore this explanation makes no reference to the organism's ability to reflect on and justify its use of those systems. The naturalistically inclined scientific realist will argue that the belief-forming processes of science can be seen as extensions of or additions to the cognitive systems with which the human organism is born.

4.1 Reliabilism and Hume's problem

The pertinence of this to Hume's problem is as follows. In some worlds, the regular worlds where observed regularities tend to hold into the future, using induction will be a reliable method of forming beliefs concerning generalizations (Mellor 1991). In such worlds the users of induction will be justified and will often gain knowledge. So reliabilism implies that *inductive knowledge is possible*:

$\Diamond$IK It is possible to gain knowledge by using induction.

thus denying the sceptical conclusion from Hume's problem, $\neg\Diamond$IK.

One common response to externalist views such as reliabilism is: 'how does one know that the externalist condition is met (for example, that the method in use is indeed reliable)?' The first thing to note is that the very point of externalism is that the subject does not have to be able to answer this question in order for the subject to have knowledge. The subject may be ignorant concerning their belief-forming method—so long as it is reliable, the belief will be knowledge. So the raising of the question cannot be an *objection* to reliabilism or to externalism more generally. That is precisely where the reliabilist and the inductive sceptic part company. The sceptic holds held that the subject must be able to provide a justification for the use of induction in order for it to deliver knowledge. The reliabilist denies this: it suffices for inductive knowledge that induction is reliable; it is not necessary that the subject also has a justified belief that it is reliable.

The question 'how does one know that the external condition is met (for example, that the method in use is indeed reliable)?' might be intended in a different way. It is all very well showing that inductive knowledge is possible. But is it *actual*? Do *our* inductive sciences deliver knowledge? The reliabilist has an answer to this question. Note first of all that a positive response establishes that *inductive knowledge is actual*:

@IK We actually do gain knowledge by using induction.

It is not necessary to show that @IK is true in order to refute inductive scepticism, $\neg\Diamond$IK, since the latter denies that knowledge is *possible*, not merely that we do not *actually* have knowledge. Nonetheless, it is not unreasonable to want to know whether @IK is true. And the reliabilist can argue that @IK can be known to be true. (The reliabilist may parenthetically remind us that her position implies that she is under no obligation to do this, as far as refuting scepticism is concerned.) As Hume envisages, one examines the track record of inductive reasoning. Given its past success, one can argue that inductive reasoning is reliable, and so that when a subject does use induction to gain a true belief she does thereby have knowledge. Is this not circular, as Hume complained, aiming to establish the reliability of induction by using induction? The reliabilist notes that the subject does not *assume* that reliabilism is reliable when using it. She may have not even considered the matter. So this is not like using a proposition as a premise in an argument in order to establish the truth of that very proposition—which is circular. So some externalists distinguish between the latter, *premise*-circularity, and the argument to establish @IK which uses induction as a method or inference rule, which is *rule*-circularity (Braithwaite 1953; van Cleve 1984; Psillos 1999). Externalism denies that rule-circularity is a vicious kind of circularity. If induction is reliable, then it can be used to generate knowledge; and one of the things it can generate knowledge about is the reliability of induction.

4.2 Reliabilism and IBE

Do reliabilism and the reliabilist solution to Hume's problem help with the problems of IBE? First, reliabilism tells us that if IBE is a reliable means of generating true beliefs, then it will give us knowledge. Do the sceptical worries addressed above give us reason to think that IBE cannot be reliable? *Hungerford's objection* says that our standards of explanatory goodness are too subjective to be a reliable guide to the truth. If that objection is correct, then it looks as if IBE is not in fact reliable. Is there any possible world where IBE, with subjective goodness, is reliable? That's unclear; at least it would be an odd sort of world where the subjective standards of that world were a good guide to the truth. *Voltaire's objection* says that for IBE to lead us to the truth, our world would have to be the best possible world by explanatory standards—and that seems implausible. Implausible but not impossible. Some world is the best by explanatory standards and in that world IBE is reliable (and perhaps it is sufficiently reliable in some other nearly-best worlds). *Underconsideration* says that we cannot be sure that we have thought of the correct explanation among those we are ranking. The reliabilist's initial response here will be that if scientists (or others) are good at generating potential explanations, so that they reliably do include the correct explanation among those they consider, then IBE's reliability will not be compromised on this count. Reliabilism requires only that our practice of IBE *is* reliable in this respect. Reliabilism does not require that for knowledge we must also have an argument to show that we always consider the correct explanation. However, some have argued that there are additional reasons to think that our practice of IBE is not reliable in this respect, since in the past we have clearly failed to consider potential explanations that at a later date we do consider, and then in fact take to be true. For example, Newton did not consider anything like Einstein's theory of space, time, and gravity when devising his own explanation of celestial and terrestrial motion. Stanford (2006) gives further examples of more recent theories and greater theoretical differences between established theories and later successors that had not previously been considered.

So the best one can say is that there is *some* world where IBE is reliable, in which case in that world IBE will lead to knowledge. That refutes the sceptic who espouses abductive scepticism:

$\neg\Diamond$AK It is not possible to gain knowledge by using inference to the best explanation.

Hence:

$\Diamond$AK It is possible to gain knowledge by using inference to the best explanation.

is true.

On the other hand, the three objections do seem to cast doubt on the actuality of abductive knowledge:

@AK We actually gain knowledge by using inference to the best explanation.

(@AK entails E2 or something close to it.) While it is possible that we inhabit an explanatorily optimal world, Voltaire's objection maintained that this just looks to be unlikely. Why should we have that good fortune when there are many worlds where the best explanations are often not true? Turning to Underconsideration, it is possible that scientists are always able to think up a range of possible explanations that includes the actual explanation. But one might doubt that they actually always do so. For, as mentioned, there is evidence that when looking for explanations of the evidence, scientists have not always been good at generating hypotheses that later scientists come to regard as correct. So these problems do not establish $\neg\Diamond$AK but they would establish a weaker form of abductive scepticism:

$\neg$@AK We do not actually gain knowledge by using inference to the best explanation.

To reject the argument for $\neg$@AK it is not necessary to establish the truth of @AK. One might be able to undermine the reasons for thinking that @AK is implausible without having to gather evidence that that shows @AK to be true. Since $\neg$@AK is a contingent claim and Underconsideration is supported in part by empirical data, then it is likely that arguments to undermine support for $\neg$@AK will themselves use empirical data. They may well do that while falling short of providing evidence and argument that would show @AK to be true.

5 Observation and evidence

So far I have considered blanket scepticism with regard to IBE (and enumerative induction). But one might think that IBE can be reliable in some circumstances but not in others. This might allow for an optimistic scepticism: science, by IBE, can achieve some worthwhile epistemic goals but not some kinds of knowledge.

Van Fraassen's constructive empiricism (1980) comes close to saying something like this.[5] IBE may be good for giving us knowledge about theories that wholly concern observable features of the world. On the other hand, when IBE is applied to theories with content concerning the unobservable, we cannot be sure of its reliability.

The underdetermination argument seeks to establish that any attempt to theorize about the unobservable cannot lead to substantive knowledge about the unobservable (whether by IBE or some other route). It is not immediately obvious why

the observable/unobservable boundary should also mark a boundary between the reliability of IBE and its unreliability. According to the underdetermination argument, this is because our evidence concerns the observable. For any such set of evidence there will be many competing theories that entail the very same evidence. So that evidence cannot provide a reason for holding one of those theories be true and rejecting the others as false.

This argument makes two assumptions:

S There is no more to evidential support than that the evidence be entailed by the hypothesis in question.

and:

E=O All our evidence is observational.

The standard response to this familiar underdetermination argument is to reject S. The hypothetico-deductive model of confirmation may endorse S but that model is discredited. A central advantage of IBE is that it can allow for degrees of evidential support. Two hypotheses might both entail and explain the same evidence but one will explain that evidence better than the other does. For example, one of the ways in which one explanation can be better than another is that it is simpler or more elegant than the other. So the evidence may support one hypothesis more than it supports the other, because the former is simpler or provides a more elegant explanation than the latter.

The underdetermination argument has affinities to the problem of induction, insofar as the latter starts by pointing out that our evidence, which concerns the past, is consistent with numerous ways in which the future can develop, including ways in which past patterns break down. One difference between the two arguments is that the inductive justification of induction looks plausible, initially at least. Some of our inductive predictions can be verified, and so we can see whether induction has a good track record. On the other hand, the unobservable does not become observable.[6] So we cannot verify our past inferences concerning the unobservable. We are able to assess the track record of IBE when the latter generates conclusions that themselves wholly concern the observable. But we cannot assess its track record regarding unobservables. Unlike the inductive justification of induction, we do not have an evidence base for the inductive justification of IBE as applied to unobservables.

A reliabilist may complain, as we have seen, that regarding both inductive scepticism and the underdetermination argument, the demand for a justification is misplaced. For a method (induction, IBE) to deliver knowledge, the subject does not have to know about the reliability of the method employed; it is sufficient that the method *be* reliable. However, the reliabilist also thinks that an inductive justification of induction is possible, even if it is not necessary (for inductive knowledge). It is (*prima facie*) an asymmetry between the two cases that there is not an inductive justification of IBE as applied to unobservables.

While S is the standard target of responses to the underdetermination argument, rather less attention has been given to E=O. This premise is an assumption of van Fraassen's constructive empiricism as well as of the underdetermination argument. This premise is also often rejected by realists, often for reasons stemming from an empiricist general epistemology (*cf.* Maher 1996; Schurz 2014: 23). Which propositions are evidence propositions? According to Williamson (1997) and Bird (2016) one's evidence propositions are just what one knows. In the light of this, the premise

E=O is asserting that all one's knowledge is observational. That proposition, however, is precisely what the underdetermination argument seeks to establish. So the realist ought not concede E=O. Furthermore, scientists' use of the term 'evidence' does not restrict it to the observational—at least not in any sense of 'observational' that is helpful to the anti-realist (Bogen and Woodward 1988). For example, when scientists at CERN report evidence regarding theories relating to the standard model of particle physics, the reports concern the behaviour of sub-atomic particles in certain conditions. They say things such as, 'Indirect evidence for the Higgs coupling to the top quark, an up-type quark and the heaviest elementary particle known to date, is implied by an overall agreement of the gluon-gluon fusion production channel cross-section with the standard model prediction' (The CMS Collaboration 2014). Here the evidence is the value of an abstract theoretical quantity (the cross-section) relating to a sequence of particle interactions and decay events. For van Fraassen and other anti-realists, what is observable is what is perceptible (without artificial aids). So what the scientists regard as evidence is not observational in van Fraassen's sense. Now, it is also true that the same scientists are comfortable with talking about *observing* gluon-gluon fusion. In that sense what they say about evidence does not contradict E=O. In which case neither evidence nor observation have any close relation to perception. If sub-atomic particles are observable, then A3 loses its interest—there isn't much left to be anti-realist about.

6 On scepticism and realism—what can the arguments show?

6.1 Sceptical arguments and realism

The Cartesian sceptic argues that even if in fact a subject's perceptual beliefs are true, they cannot amount to knowledge because the subject cannot distinguish them from corresponding false beliefs (since the evil demon could have implanted erroneous but seemingly veridical experiences). The point of current interest is that this is an apriori argument that seeks to establish a necessary conclusion:

$\neg\Diamond$PK Perceptual knowledge is not possible.

The reliabilist response regards the argument as invalid, since according to the reliabilist the sceptic uses a mistaken (internalist) conception of knowledge. So the first thing that the reliabilist establishes is:

The sceptic's argument for $\neg\Diamond$PK is invalid.

This does not itself show that $\neg\Diamond$PK is false—perhaps there are other, valid arguments for that conclusion. However, the realibilist hopes to do better. There are possible worlds where perceptual belief formation is reliable, and so according to her analysis, subjects do have perceptual knowledge in that world. Hence:

$\Diamond$PK Perceptual knowledge is possible ($\neg\Diamond$PK is false).

This refutes the sceptic. But it does not establish:

@PK Perceptual knowledge is actual.

@PK is clearly a contingent claim that could only be established by aposteriori means. Establishing @PK is not something that could be achieved by purely apriori, philosophical reasoning. So although there can be prima face reasonable purely philosophical (apriori) arguments for $\neg\Diamond$PK and $\Diamond$PK, there is no such argument for @PK. If one were to try to establish @PK one's empirical, aposteriori investigation would most likely need to use perception. So that attempt would involve using perception to try to show that perception is actually reliable and so actually produces knowledge. While sceptics will complain that this is circular, we have already seen that the reliabilist has an answer—that this would be rule circularity and not premise circularity and so not a case of begging the question.

The position as regards the debate between the anti-realist and realist over IBE is largely the same, with a slight difference. As we saw, the strong abductive sceptic maintains:

$\neg\Diamond$AK It is not possible to gain knowledge by using inference to the best explanation.

A reliabilist may reject the argument for $\neg\Diamond$AK by rejecting its internalist assumptions. The reliabilist will argue that $\neg\Diamond$AK must be false because there is *some* world where IBE is reliable. The reliabilist thereby takes herself to have established, by apriori means, the negation of $\neg\Diamond$AK:

$\Diamond$AK It is possible to gain knowledge by using inference to the best explanation.

The claims just considered concern the possibility of knowledge from IBE. We also considered the opposing claims, *weak abductive scepticism* and *abductive possibilism* concerning the actuality of knowledge from IBE:

$\neg$@AK We do not actually gain knowledge by using inference to the best explanation.

and:

@AK We actually gain knowledge by using inference to the best explanation.

Both of these are contingent propositions and we cannot expect purely philosophical (apriori) arguments to establish either. We saw that Voltaire's objection and Underconsideration gave grounds that non-deductively support $\neg$@AK and so reject @AK. A scientific realist might want to do two things in response. First, she may wish to resist these arguments for $\neg$@AK and against @AK. This is a defensive move; if successful the conclusion is that realism has not been refuted. Secondly, she may wish to establish @AK as true. However, note that these aims are not only distinct, the second is far more demanding than the first. The first is just a matter of showing that the anti-realist's argument for $\neg$@AK is defective. The weak abductive sceptic thinks that it is implausible that we gain knowledge from IBE. The realist need only show that despite the anti-realist's argument, there is some plausible way, consistent with what we know about the world, that IBE delivers knowledge. It is quite another thing for the realist to show that this way is actual, that we do in fact gain knowledge with IBE. More generally, there is a considerable difference between the *modest* realist and the *ambitious* realist. The modest realist's aim is to resist anti-realist arguments for propositions such as A2–A4 that reject claims to scientific knowledge or the truth/verisimilitude of scientific theories. The ambitious realist wants to argue in favour propositions such as R2–R3 asserting that we do get to the truth or close to it with our theories and that we do generate scientific knowledge.

6.2 Ambitious realism

The ambitious realist tries to establish R2 and R3 via R5—the best explanation of the success of the mature sciences is the (near) truth of their theories. This is the *No Miracles Argument* (Putnam 1975: 73). A more sophisticated version of the argument is developed by Boyd (1981: 617–18) and Psillos (1999: 78–81). This argues that our theory-laden methods are highly successful in experiments, tests, and other applications. So these methods are instrumentally reliable. And the best explanation of this reliability is the truth of the theories with which those methods are laden (the truth of the causal claims that underly the reliability of the methods).

What would it take for the ambitious realist to succeed? This is a contentious question. From one perspective the task is enormous. R2 is a contingent claim. Although it is simply stated, it indirectly makes a very considerable claim about the world. For the theories of the mature sciences individually make substantive contingent claims. To say that such a theory is true is to repeat or endorse the claims it makes. And to say that all theories of a mature science are true is therefore to repeat or endorse very many substantive claims about the world. (This is only slightly reduced in force by downsizing realism to say that *most* theories are at least *close to the truth*.) How could one make such a claim without at least reviewing and endorsing the detailed evidence and arguments of the scientists?

On the other hand, it might be reasonable to endorse someone's claims without examining their basis in detail, if one has a reason for thinking that they are generally reliable—if, for example, we know that the are the sort of person who only ever asserts what they have strong reason to believe. In the case of scientific realism, we might think that there is something in common among the theories of the mature sciences that makes them reliable. That might be, perhaps, the scientific method. One might, for example, think of the scientific method as a set of rules that tells one, given any hypothesis, what evidence one needs in order for the hypothesis to be likely to be true. So if a scientist conscientiously applies the scientific method and acquires the appropriate evidence, then her theories are likely to be true. But this looks to be too simplistic a picture of the way that science works. It does not seem to allow for IBE. According to IBE, how well evidence e supports hypothesis h depends on what the rival hypotheses to h are. It is implausible that those rivals could always be generated methodically. So it is difficult to see how *rules* could tell us what evidence supports h in such a case. Furthermore, whether e supports h will typically depend on the truth of various background theories. This might be accommodated by the rules of method. But then it would not be possible to tell whether a scientist was using the method in a reliable way without investigating the truth of her background theories. So it is doubtful whether there is anything like the scientific method that will do what the ambitious scientific realist wants of it, *viz.* for it to be such that (i) it is highly general across science, (ii) one can tell without extensive scientific investigation that its use will tend to lead to the truth, (iii) one can tell fairly easily that it is in fact being used in a reliable way across a lot of science. It does not look as if anything fulfils these desiderata. IBE itself does not. For the standards of explanatory goodness are not fixed and uniform across time and across scientific disciplines (*cf.* Kuhn 1977). What counts as a simple or elegant explanation in physics will look very different from a simple explanation in physiology. And it will differ between Aristotelian physics and quantum physics. And any application of IBE also depends on background assumptions, whose truth may vary from field to field. So we should not think that there is a single thing, inference to the best expla-

nation, that is the same in its applications across all science. The use of IBE might be reliable in one field but not in another.

In summary, for the ambitious realist's claim about science in general to succeed, she must either consider all the first-order arguments of the scientists and endorse their claims. Or she must find some relevant feature that is common to the mature sciences, and which she has reason to think would render them reliable. The first is too ambitious; and in any case it does not seem a job for a philosopher—assessing first-order science is a scientist's job. And the second is chimerical.

6.3 The pessimistic induction

The anti-realist ought not take too much heart from this failure of ambitious realism. For her view, if founded on the pessimistic induction, may suffer from a parallel problem. From the premise, A1, that past, well-confirmed theories of the mature sciences are frequently refuted, the PMI makes an inference, A2, to the falsity of their current theories.[7] However, as Goodman's (1954) new riddle of induction reminds us, we should only endorse inductive reasoning of this sort if the properties involved in the induction are projectible.[8] Is 'well-confirmed theory of a mature science' a projectible property? It is not obvious that it is. For one thing, the sciences change and develop—a very mature science is not the same as a recently matured science. Likewise standards of confirmation vary, and tend to become more stringent over time. So the well-confirmed theories of current very well matured sciences may not be sufficiently similar to the failed theories that make up the evidence for the pessimistic induction. Just as the ambitious realist hoped to trade on the virtues of the scientific method (or something similar) as the common basis for the success of science, the anti-realist might hope that the vices of something like the scientific method will underpin the pessimistic induction. If there were a single scientific method in use throughout (mature) science, and unchanging over time, then one might reasonably infer from the failure of previous theories generated or confirmed by it, to the probable failure of current and future theories.

While there might not be anything like the scientific *method* that is common to all mature science, past and present, the anti-realist may wish to base her argument on something weaker than a method, but which nonetheless might be thought to explain the (alleged) consistent failure of science. This brings us back to the problems of Inference to the Best Explanation. If IBE were in widespread use among the mature sciences for the justification of their theories, then epistemic inadequacies in IBE would explain past failures and predict future ones. The modest realist can draw upon the very same argument just posed against the ambitious realist: the relevant features of IBE are not constant across all sciences and all times. Standards of explanatory goodness used to rank competing hypotheses will vary. Likewise scientists' ability to generate competing hypotheses may differ between fields and eras. Just as this variation and change are reasons to reject any proposal that IBE is reliable across all science, it will undermine the claim that it is unreliable across all science.

7 Conclusion

In this essay I have touched on the following themes:

- The centrality of IBE to debates concerning realism.

- Internalism versus externalism in epistemology.
- Coming to know the reliability of induction and IBE using induction and IBE.
- Whether the observable/unobservable distinction marks a significant epistemological boundary.
- The dialectic of the realism versus anti-realism debate.
- Modest versus ambitious realism.

I conclude by tying these together.

At the heart of many debates surrounding scientific realism we tend to find Inference to the best explanation. For example, IBE is held to be an ampliative form of inference—the conclusions of an inference to the best explanation are not deducible from its premises.[9] The standard reason given for this assumption is that our evidence concerns the observable while theories often refer to the unobservable. Any such inference must be ampliative. Indeed, the value of IBE, on this view, is precisely that it allows us to make inferences about the existence of unobservable atoms and molecules, for example, on the basis of what we observe in our experiments. Because such an inference is ampliative, the evidence will underdetermine the choice of theory. But must our evidence be always observational? While philosophers of science often take that for granted, some non-empiricist epistemologists deny that claim. Rejecting that claim also removes a premise from the underdetermination argument.

Inference to the best explanation is central to the discussion of scientific realism for two reasons. First, because IBE characterizes the reasoning of much of science, at least of the theoretically more interesting parts. And, secondly, because the No Miracles Argument itself employs an inference to the best explanation. The anti-realist therefore has a number of options:

- Argue that there are certain flaws in IBE that render it unable or unlikely to deliver the truth (such as Hungerford's objection, Voltaire's objection, and Underconsideration).
- Argue that realist's use of IBE in the No Miracles Argument is viciously circular.
- Argue that the poor track record of science (shown by the eventual refutation of theories) gives us reason to expect the future failure of science.

The third of these, the Pessimistic Meta-Induction, does not mention IBE. Nonetheless, it can support the attack on IBE in two related ways. First, it provides evidence that IBE is unreliable. On numerous occasions it has led to false conclusions. And if it is unreliable, it cannot lead to knowledge, even on those occasions when the scientific theory in question is in fact true. Secondly, when successful theories are refuted the are frequently replaced by theories that had not been previously conceived of. That suggests that one of the sources of unreliability is Underconsideration.

At this point it is useful consider the aims of the various participants in this debate. The anti-realist is a sceptic, though the degree and kind of scepticism varies. The most extreme anti-realist will (like the Cartesian sceptic) claim that scientific knowledge is not possible. To achieve knowledge by using IBE would require having a justification for IBE. But no justification is available that does not beg the question. For example, to provide such a justification one might try to use the No Miracles Argument to show that IBE does lead to the truth. But this, the extreme anti-realist will say, is viciously circular, for this NMA itself employs IBE: this is justifying IBE by using IBE. We can think of Voltaire's objection and Underconsideration as objections

from the extreme anti-realist along these lines. The anti-realist will say that in order to use IBE to gain knowledge, one must show that the actual world is the explanatory best of possible worlds and show that we do conceive of the the true explanation among those potential explanations we actively consider. But how could we show that without begging the question? Such a justification of IBE is not possible, and so knowledge from IBE is not possible either.

Now the epistemological internalism–externalism debate becomes relevant. According to a typical externalist position, such as reliabilism, it is not necessary that the knowing subject should be able to justify the belief-forming methods she uses. If the method is in fact reliable, that will suffice for knowledge. Since IBE could be reliable in a propitious world, a subject using IBE in such as world gets to know. The externalist view of knowledge thus claims to refute the extreme sceptic: knowledge from IBE is possible after all. Furthermore—and this is an additional point, not required for the former point—one of the things IBE can lead to knowledge about is the reliability of IBE itself. That reasoning is not viciously circular, since it is rule-circular not premise-circular.

Extreme anti-realists are epistemological internalists; they say that scientific knowledge is not possible. A less extreme version of anti-realism will argue that even if knowledge from IBE is possible, there are good reasons for thinking that it is not actual. The moderate anti-realist does not need to be an internalist. Above I said that Voltaire's objection and Underconsideration understood as extreme anti-realist arguments. However, they may also be used by the moderate anti-realist in a way that consistent with externalism (just as the PMI is consistent with externalism). Because it is a more moderate form of scepticism, moderate anti-realism is less easy for a realist to refute than extreme anti-realism—an appeal to epistemological externalism will not suffice.

The moderate anti-realist will argue then that the conditions that would make scientific knowledge possible are not in fact found in the actual world. Their argument will thus have a contingent element to it. How should the realist respond? Here we distinguish between the ambitious and the modest realist. The ambitious realist wants to show that the relevant conditions are actual—we therefore do have scientific knowledge when we use IBE. A modest realist aims only to undermine the anti-realist's arguments. That can be shown by arguing that certain conditions that would allow for knowledge are not in fact ruled out by the anti-realist's arguments or by other contingent evidence. The modest realist can argue for this conclusion without also arguing for the stronger claim that such conditions actually obtain.

One reason for preferring modest realism is the worry that ambitious realism is overly ambitious. It aims, in effect, to endorse most of the findings of the mature sciences. That could reasonably be achieved only be identifying some belief-forming method common to the mature sciences and showing that method to be highly reliable. But is there such a method? Even if IBE is common to much science, it does not seem to be sufficiently method-like that we can be confident that its uses in disparate (mature) sciences amounts to the same thing, such that we can endorse its reliability in all or most of those sciences. If that is correct, there isn't a global second-order argument for realism (*cf.* Magnus and Callender 2004). The most the realist can hope for is to defeat each global argument from the anti-realist. Still, the same lack of a common belief-forming method will also undermine the reasonableness of the Pessimistic Meta-Induction. Maybe what we are left with is principally the first-order examination of the scientists' methods and arguments; but that looks like more of a job for a scientist than for a philosopher.

Notes

[1]I will not be discussing Hungerford's objection in this article at any length.

[2]This is not the same as saying—as is frequently said—that it is possible for the premises of an inductive argument to be true and the conclusion false. For the problem of induction remains even if the inductive conclusions are (aposteriori) necessary truths (e.g. all water is composed of H_2O).

[3]This is not the only way of defining internalism (Pappas 2014). A slightly different one maintains that justification depends only on mental states. Mental states (for many externalists, e.g. Williamson 1995) may themselves be conditions external to the subject, though internalists will typically have an internalist conception of all mental states. Another characterisation of the central internalist claim is: justification depends only on what is directly accessible (by introspection or reflection) to the subject.

[4]Reliabilism in this form (and others) faces objections. The most obvious objection is that since the two reliabilist claims together entail that knowledge is justified true belief, this reliabilism does not escape the Gettier counterexamples.

[5]Strictly, constructive empiricism is principally a view about the goal of science (that goal is empirical adequacy, not truth). However, it is difficult to see why this is a plausible goal without some degree of scepticism about the unobservable. Van Fraassen (1989) seems to adopt a stronger scepticism about IBE.

[6]According to views such as van Fraassen's, where observation is unaided perception.

[7]For discussion see Poincaré 1943: 160; Laudan 1981.

[8]Goodman and subsequent authors have focussed on the consequent property *green* or *grue* in 'all emeralds are green/grue', but similar concerns arise for the base of antecedent property, *emerald* in this case.

[9]But see Bird (2005) for a non-ampliative account of IBE. The problems discussed above would be rather less pressing if IBE were not ampliative.

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