

# Underdetermination and Rational Choice of Theories

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**Abstract** The underdetermination of theory by data argument (UD) is traditionally construed as an argument that tells us that we ought to favour an anti-realist position over a realist position. I argue that when UD is constructed as an argument saying that theory choice is to proceed between theories that are empirically equivalent and adequate to the phenomena up until now, the argument will not favour constructive empiricism over realism. A constructive empiricist cannot account for why scientists are reasonable in expecting one theory to be empirically adequate rather than another, given the criteria he suggests for theory choice.

**Keywords** Theory choice · Constructive empiricism · Underdetermination of theory by data · Inference to the best explanation

## The Challenge Posed by Underdetermination of Theory by Data Argument

Scientific realism (SR) is often characterised as the view that scientific theories are truth-apt (semantic SR), that they aim at truth (axiological SR) and that they describe a mind-independent reality (metaphysical SR). Moreover, scientific realists hold that we are rationally warranted in believing that our best scientific theories are true (epistemic SR).

Arguably one of the strongest arguments against scientific realism is the underdetermination of theory by data argument (UD). UD comes in varying strengths, but I take it to have the following basic formulation:

- 1) At any time, any scientific theory has empirically equivalent competitors.
- 2) If theories are empirically equivalent, then there is equally good reason to believe that either is true.

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- 3) Therefore, belief in any particular theory at any given time is arbitrary, not founded on rational considerations.

The reason that UD poses a serious challenge to SR is as follows. To show that we are justified in our beliefs about unobservable entities, realists must show that the reasons that we have for our beliefs are somehow privileged. If one theory  $T_1$  asserts that some unobservable entity  $E$  has a property  $P$ , and another theory  $T_2$  asserts that  $E$  has a property  $Q$  that is incompatible with  $P$ , and the empirical evidence supports  $T_1$  and  $T_2$  to an equal degree, we must explain why we have reason for believing that one of the theories is true rather than another. If we have equal reason for believing both  $T_1$  and  $T_2$ , belief in either of these theories would seem arbitrary, and it would seem that we have no reason for believing that either  $T_1$  or  $T_2$  is true. This would be incompatible with SR understood epistemically. Since the first premise of UD tells us that *all* scientific theories have empirically equivalent competitors at any time, it follows that epistemic realism will not be tenable for any theory at any time.

UD has been the subject of much debate, mostly concerning the possibility of developing a realist response to UD. But what has been largely overlooked is how the argument (under at least one construal) poses a serious challenge to more sophisticated anti-realist positions such as constructive empiricism (CE). CE tells us that the aim of science is not to produce scientific theories that are true; rather, the aim is to produce scientific theories that are empirically adequate. A theory is empirically adequate if and only if its observational claims are true with regard to the observable phenomena; if and only if it ‘saves the phenomena’. The phenomena includes all past present and future phenomena. Therefore, believing that a theory is empirically adequate involves an ampliative move. I will argue that UD presents a problem for this ampliative move<sup>1</sup>.

The dispute between a constructive empiricist and a realist is, except for the question of what science aims at, best framed as a debate over whether we are justified in our beliefs about unobservables. The epistemological formulation of realism tells us that we are rationally warranted in believing that our best scientific theories are true. A constructive empiricist would disagree. UD raises the following question: How can a constructive empiricist proceed when faced with alternative empirically equivalent theories which agree on the available evidence but disagree for future instances? Unless the constructive empiricist produces some account of or procedure for selecting rationally among such alternatives, he will struggle to provide us with a basis for rational expectation of future observable events. In order to clarify the dialectic I will first display some realist responses to UD.

A realist may challenge either or both assumptions 1 and 2 of UD. 1 (the existence of alternatives) comes in varying strengths. If all the available evidence up until the present,  $t_{\text{now}}$ , leaves the choice open between two theories,  $T_1$  and  $T_2$ , then  $T_1$  and  $T_2$  are weakly empirically equivalent and may differ with regard to their empirical adequacy in the future. This situation does not pose a serious threat to a scientific realist. If such a situation were to obtain a realist could recommend either that we withhold judgement and await future evidence, or else that we decide

<sup>1</sup>Ladyman et al. (1997) discuss a related issue, namely whether CE can admit a version of IBE. I will later show how my points differ from their discussion.

between  $T_1$  and  $T_2$  according to how inference to the best explanation (IBE) favours one theory over another. The latter recommendation entails a denial of 2 (there is equal reason for believing all empirically equivalent theories). A realist holds that hypotheses have so-called '*super-empirical* virtues' that is, qualities that we take to count in favour of their truth. Anti-realists may argue that realists thereby beg the question against those who holds the view that empirical data is the only evidence that can count in favour of a scientific hypothesis. But realists may argue in the same way against anti-realists. A defence of a realist position may employ '*super-empirical* virtues' and 2 just amounts to the claim that there is no such thing<sup>2</sup>.

If a scientist is presented with a range of empirically equivalent theories and his aim is to pick out the one that is empirically adequate, how is he to proceed? Realists will choose to appeal to IBE at this point, but what should a constructive empiricist say? He must show that the scientist in question is reasonable (in choosing one theory over other alternatives) relative to forming empirically adequate theories (which is the aim of science according to CE). CE has a different approach to explanatory virtues from that of a scientific realist but he also has a different approach to rationality. I will now go on to present what it means to be reasonable according to CE, and after this I will discuss what virtues constructive empiricists consider relevant for theory selection and show why a constructive empiricist cannot employ a response to UD that is analogous to the one employed by the realist.

## New Epistemology

In order to discuss what it means to be reasonable according to CE, we need to look at an epistemology suited for CE. To this end, I will briefly present van Fraassen's 'new epistemology'. As a word of warning, I should say that we cannot equate van Fraassen's view of epistemology with his constructive empiricist position. CE is essentially a view about what science is, and does not commit one to holding any particular position in epistemology. There are, of course, constraints provided by the

<sup>2</sup>The strongest version of UD tells us that that there are cases of strong empirical equivalence. Two theories are strongly empirically equivalent if they are mutually incompatible but have the same empirical content all the same. Furthermore, no empirical facts past, present or future will give us evidence for choosing one over the other. In cases like this I think there are different strategies open to a realist in countering UD. If for example two theories are equally supported by the evidence but one theory accommodates the evidence post hoc and the other predicts it, realists would argue; that a theory has novel predictions would count in its favour. (There is a wide discussion of whether evidence post hoc. can ever count in a theory's favour or not, see for example Psillos (1999), for a discussion of so-called use-novelty). In cases where two theories are equally supported by the evidence, and each theory is supported to an equal extent by old and new evidence in turn, the most common strategy for a realist will be to adopt an explanationist strategy and postulate the existence of *super-empirical* values. Even though this is arguably a question-begging procedure, it is my opinion that the debate between realists and anti-realist leaves it open who has the burden of proof in this case. Even though the realist will not convince any prospective anti-realists by doing so, she can at least do so while being internally consistent. There is a large body of literature on this, arguing in favour of realism; see for example Devitt (2002, 2005). For an argument that what shall count as evidence in the future is contingent (thereby denying the premise that all evidence is equal between the two theories) see Laudan and Leplin (1991). For an argument saying that the strongest versions of UD are produced by 'semantic trickery' see Hoefer and Rosenberg (1994). Finally, for an argument against the points made by Laudan and Leplin and Hoefer and Rosenberg see Kukla (1998).

constructive empiricist position that will make some choices more attractive than others. Van Fraassen's new epistemology is well suited to an empiricist position and I assume that van Fraassen thinks that CE is to be supplemented with an epistemology of this kind. When I speak of CE in the future I will take this to mean CE wedded to voluntarism in epistemology<sup>3</sup>.

According to van Fraassen, 'rationality' is a permissive notion. In other words, you are rational in accepting any belief whatsoever as long as it is not inconsistent with any beliefs you hold.

Is it rational to believe in angels or electrons? I construe the term *rational*, as applied to opinion here, as a term of *permission* rather than of *obligation*. To say that you are rational in your opinions does *not* mean that your opinions are rationally compelled – that any rational person with the same experience as yourself would have to agree. It is not irrational to “go beyond the evidence,” and belief in angels or electrons or the truth in molecular biology does not *ipso facto* make one irrational. The constraints or bounds on rationality leave much underdetermined—*rationality is but bridled irrationality*. (Van Fraassen 1985, p. 248)

The notion of rationality that van Fraassen is working with is weak. We can best understand the notion of rationality in relation to its counterpart; one is rational if one is not irrational. Irrationality is defined in the following way:

(...) the paradigm of irrationality is to form or organize your actions, decisions, or opinions so as to hinder needlessly your chances of vindication. (Van Fraassen 1985, p.248)

It is rational to believe (have an opinion about) anything that one is not rationally compelled to disbelieve. The rational way to change your beliefs (opinions) includes any that remain within the bounds of rationality – which may be very broad. Van Fraassen thinks that the problem with traditional epistemological accounts is that they are restrictive, saying that you should not hold a certain belief unless it was acquired by a reliable method or by deduction. In fact, the very notion of ‘belief’ is problematic: for semantic reasons, to believe something is to believe that thing to be true. Instead, van Fraassen has introduced the notions of opinion and acceptance. We can, according to his account, *accept a theory* without saying that it is true. However, as the above citation suggests, there is in fact evidence in van Fraassen's writing that he thinks that we can still have beliefs (or opinions) about unobservables without being irrational for that reason, but science doesn't require this.

<sup>3</sup>Traditionally, voluntarism is the view that having a belief is within the control of a person. Our epistemic life is conceived of as involving certain subjective choices. Van Fraassen's voluntarism does not however entail that someone can believe anything they want. There are certain constraints that van Fraassen calls ‘epistemic policies’. “If we choose an epistemic policy to govern under what conditions and how far, we will go beyond the evidence in our beliefs, we will be setting down certain boundaries” (van Fraassen 1985, p. 254). These policies are not however derived from the empirical evidence that we have got, rather they are endorsed by virtue of us having certain commitments. This is more fully explored in van Fraassen (2002), where having such commitments is spelled out in terms of one taking a stance. If CE can be defended while combined with a different view in epistemology some of the points that I will go on to raise will not apply. However, it is not easy to work out what other kind of position in epistemology CE could be combined with. Van Fraassen has made the distinction between belief and acceptance central to CE and voluntarism is perfect for spelling out how we are to understand acceptance.

## Being Reasonable and Pragmatic Virtues

Suppose we scientists are presented with a surprising fact and a number of hypotheses. Suppose further that we form an infinite number of possible explanatory hypotheses, each of which is weakly empirically adequate (a hypothesis is weakly empirically adequate if and only if it saves all the phenomena known at the moment). To further strengthen the example suppose that the hypotheses differ with regard to their long-term predictions for the future. We are thus in a position of underdetermination of theory by data. How should we choose between them?

According to CE ‘we are not *rationally compelled* to choose any of these hypotheses’. According to van Fraassen’s voluntarist epistemology, we would not be irrational in choosing any particular hypothesis (assuming that they are all weakly empirically adequate) rather than another; we are not rationally compelled to believe any *one* of them. But ultimately van Fraassen has to give reasons as to why we should choose certain hypotheses over others and why are we reasonable in expecting one hypothesis over another to be empirically adequate in the future<sup>4</sup>.

The measure that the constructive empiricist wishes to appeal to in terms of evaluating theories is a *pragmatic* standard. The following citation displays the virtues that a constructive empiricist suggests might help us choose some hypotheses over others.

Briefly then the answer is that the other virtues claimed for a theory are pragmatic virtues. In so far as they go beyond consistency, empirical adequacy, and empirical strength, they do not concern the relation between the theory and the world, but rather the use and usefulness of the theory; they provide reasons to prefer the theory independently of questions of truth. (Van Fraassen 1980, p. 88)

Van Fraassen believes that the problematic state of underdetermination of empirically equivalent theories can be resolved at the practical level, because we get some guidance as how to proceed. We are to choose the theory that displays the most pragmatic virtues; van Fraassen suggests that one good example of a pragmatic virtue is explanation. However, according to a constructive empiricist, explanation is not special in the epistemic sense suggested by a realist.

The *epistemic* merits a theory may have or must have to figure in good explanations are not *sui generis*; they are just the merits it had in being empirically adequate, of significant empirical strength and so forth. This does not mean that something is automatically a good explanation if it has those merits; what more it needs is the pragmatic aspect of explanation<sup>5</sup>. But in the pursuit of explanation we pursue *a fortiori* those more basic merits, which is what makes the pursuit of explanation of value to the scientific enterprise as

<sup>4</sup>It should be noted at this point that acceptance is not to be thought of as being binary. Acceptance can be qualified — it is a matter of degree, where the degree to which one accepts a hypothesis is proportional to the evidence one has in favour of it.

<sup>5</sup>According to van Fraassen, the context determines which scientific factors are explanatorily relevant. However as the context is always relative to the specific interests and goals of the person in question explanation cannot be epistemically relevant.

such. [...] it might be arguable that, for purely pragmatic (that is, person- and context related) reasons, the pursuit of explanatory power is the best means to serve the central aims of science. (Van Fraassen 1980, pp.88–89)

We are not meant to choose theories by a criterion of how we believe the world most likely is in relation to our data of observables. Instead, we should go by a criterion of explanation, one that on van Fraassen's account is characterised by being context-dependent and dependent on the people who are asking the questions. Nevertheless, as we can see from this quotation, when we pursue explanatory power, we also pursue empirical adequacy. This is because something has to be empirically adequate to count as a good explanation.

It might seem as if van Fraassen wants to allow for IBE as long as it is employed on the level of observables only. This, at least, seems to be implied if the appeal to explanation always takes place when theories are at least empirically adequate. However, this reading is wrong (see Ladyman et al. (1997)). Van Fraassen should not be interpreted as embracing the application of IBE to either the unobservable or the observable domain. However, perhaps van Fraassen believes that we can employ something like inference to the best explanation, but not for the *same* reasons as those employed by the realist.

So, when we choose between theories with an appeal to explanation, we will be choosing the explanation that is pragmatically best. Van Fraassen's version of inference to the best explanation will then be an inference based on pragmatic reasons that are context-dependent. Maybe it is unfair to call whatever it is that van Fraassen is suggesting an instance of IBE, but it is definitely a functional equivalent of IBE in the respect that it helps us choose between scientific hypotheses by means of some set criterion. The realist employs a criterion that he says provides us with epistemic reasons for choosing one theory over others; in contrast, the constructive empiricist cites a criterion that will give us pragmatic reasons. In this way, van Fraassen can still help himself to a version of IBE. Let us call it 'Choice of the Best Explanation' (CBE). Could CBE help us accommodate the intuition that our choice between hypotheses is guided?<sup>6</sup>

If we are to believe that CBE helps us in forming reasonable expectations on a constructive empiricist account, we are going to have some expectations about how the world will behave under certain circumstances. Presumably, a constructive empiricist believes our expectations are reasonable only in so far as they concern the

<sup>6</sup>At this point it should be mentioned that according to van Fraassen, being rational is not necessarily a matter of following rules. Therefore it is open to him to object to a reference to intuition at this point, that that by itself does not introduce the need for rules. We may sometimes go beyond what is evident to us at a particular time without that involving any rule based principle, and yet be entirely rational. (I wish to thank an anonymous referee for this Journal for pointing this reply out to me). I think this is a reply that is entirely consistent with the constructive empiricist tradition, but in so far as we form expectations about the future, it is very hard to make sense of the idea that such expectations would be formed if we did not believe that certain regularities obtained. If it is indeed granted that such regularities obtain, it would be tempting to assume that our expectations are formed on the basis of inferences that we assume correspond to these regularities in one way or another (regardless of whether they actually do so). If one holds a view according to which it is reasonable to hold certain expectations about the future, without relying on any rule based reasoning, it seems to undermine the very idea of it ever being more reasonable to expect anything rather than something else.

observable. Van Fraassen concurs: “*we do form expectations of the future, which are reasonable and yet do go beyond what is now evident to us – and that is allowed within the bounds of rationality*” (van Fraassen 1985, p.280). In a case where all our theories are weakly empirically adequate, we cannot assume that each of them will provide us with reasonable expectance of equal strength. When we go on to choose between them, the criterion that we employ ought to reflect our interest in forming empirically adequate theories and our criterion of choice should ensure that we are reasonable in expecting that we do choose empirically adequate theories. However, the criterion suggested by van Fraassen counts as explanation only in light of his pragmatic theory of explanation.

### Choosing Between Weakly Empirically Adequate Theories

Let us now consider the options open to someone who is to choose between empirically equivalent theories. I propose that there are four options:

- i) No choice is made
- ii) A choice is made for pragmatic reasons
- iii) A choice is made for epistemic reasons
- iv) A choice is made for no reason at all

In option i) the decision is postponed, so we will not decide until we get further evidence which will help us choose one theory over another. Insofar as we are looking for an answer to how we should choose between weakly empirically adequate theories (to remind the reader, a theory is weakly empirically adequate if and only if it saves all the phenomena known at the moment), i) is not helpful. Furthermore, I assume that it is common ground that we want to make progress and in this sense the option described in i) is unwanted because we are not progressing towards the aim of science when no decision is made. However I do not take this to constitute a serious problem. Other research could take place in parallel, and we are therefore not facing a complete standstill of *all* science, but everything else being equal option i) is not an attractive option.

Option ii) may seem tempting, but why should we believe that pragmatic considerations are epistemically guiding with regard to how the world (at the observable level) is going to be? Notice that this is a problem for CE because a constructive empiricist needs a principle for theory selection that is consistent with CE, and also accounts for why scientists are rational when choosing certain theories over others when the theories we choose from are all weakly empirically adequate. It could be argued that there is no problem here according to van Fraassen’s account of rationality. Choosing by a pragmatic standard is consistent with CE and is as rational as can be. However, my point is the following: presumably scientists choose a certain theory because they believe that theory to be more likely to be empirically adequate than any other. As the aim for a constructive empiricist is empirical adequacy, this ought to be reflected in the criterion for theory choice that CE suggests. In the case where the theories that we choose between are all weakly empirically equivalent, we would expect the scientist to choose one theory over another because he takes that theory to possess virtues that makes it more likely



(from the scientist's point of view) to be empirically adequate than any other theory. What we are lacking on a constructive empiricist account is some way of linking pragmatic considerations with the aim of scientists to choose theories that are empirically adequate<sup>7</sup>. It is simply not clear how pragmatic value is a guide to empirical adequacy.

But, someone might argue, this misses the point of pragmatism: the empiricist adopts this criterion *because* (according to the constructive empiricist) it is useful in helping us to choose empirically adequate theories. So, in this sense, pragmatic virtues are guides to how the world is and is going to be at the observable level. There are two problems with this response.

First, if 'usefulness' is to be understood as 'useful for arriving at empirically adequate theories', we have a situation where explanation is epistemically guiding at the observable level – it leads to empirically adequate theories. So, a realist and a constructive empiricist only differ in so far as a realist takes explanation to be epistemically guiding at both the observable and the unobservable level, whereas a constructive empiricist wants to say that explanation is only guiding at the observable level<sup>8</sup>. But a realist is not invoking anything particularly different in his use of explanation when it is employed at the unobservable level rather than at the observable level. He is, in other words, employing explanation as epistemologically guiding in a uniform fashion. So, a constructive empiricist now owes us an explanation of why he treats explanation differently when it is employed at the observable level from how he treats explanation when employed at the unobservable level. It is one thing to argue for there being a level of observation that coincides with how human physiology happens to be; it is quite another to argue for how theoretical virtues should only apply at the observable level. A similar point has been argued elaborately by Psillos (1996, 1997). In response to Psillos (1996), Ladyman et al. (1997) makes it clear that van Fraassen does not intend to embrace a version of IBE that is constrained at the level of observables, and seem prepared to embrace the

<sup>7</sup>Van Fraassen argued (1980) that we can explain the success of science by appeal to how theories come to be successful by natural selection. "Only the successful theories survive [...]" (van Fraassen 1980, p. 40). In this way it may be argued that van Fraassen has in fact coined a connection between pragmatic considerations and the aim of scientists. But as has been argued by Leplin (1997) (among others) the competition amongst theories does not satisfy some of the conditions necessary for a process of Darwinian selection to take place. Leplin sets out an analogy with tennis-playing abilities of Wimbledon finalists. The question we want to answer is: how come Wimbledon finalists are so good at tennis? We can interpret this question in two ways. If we want to know why it is in general that Wimbledon players are so good at tennis, we can cite the selection criteria for getting into the tournament. That answer though, does not tell us why individual finalists like Becker and Agassi are so good at tennis. In order to answer the latter question we have to cite the relevant properties of those particular players, which may involve training and genetics. The analogy with the Darwinian account of success of theories is the following. The Darwinian account may explain how we come to be in possession of successful theories, but it does not have anything to say about what it is about our particular successful theories, that make them successful.

<sup>8</sup>Van Fraassen (1980) argued that IBE could perhaps be used at the observable level, but this is denied in Ladyman et al. (1997) that is a response to Psillos (1996) arguing that accepting IBE for observables but not for unobservable lead to inconsistency. Psillos (1997) argues that denying that IBE is reliable at even the observable level will force constructive empiricism into scepticism.



kind of scepticism that follows from this point. This is also stressed by Psillos (1997)<sup>9</sup>.

Second, even though a scientist knows that the kind of explanation that he will be seeking is different from one situation to the next (as explanation is context- and person-relative according to van Fraassen) he can rest assured that if a theory possesses good explanatory value it will be empirically adequate. But this is only the case, because of what van Fraassen has written into the concept of ‘a good’ explanation. “The epistemic merits a theory may have or must have to figure in good explanations are not *sui generis*; they are just the merits it had in being empirically adequate (...).” (van Fraassen 1980, p. 88.). But now we see the problem: we cannot take it for granted, where we are evaluating theories that are weakly empirically adequate, that a theory being a good explanation means that it is also an empirically adequate theory. Whether it is an empirically adequate theory is exactly what we were wondering about. If an explanation is only a good explanation insofar as it is empirically adequate, the consequence in this example is that we do not know whether any of the theories are good explainers.

Option iii) is not really a viable strategy for a constructive empiricist, but it is for a realist. A realist is going to suggest that we employ IBE to help us choose one of the many theories, and he can consistently suggest that we do this, because he takes IBE to be a principle that employs a criterion for ranking theories, that provides us with some epistemic guidance.

Finally, we should consider option iv) (choice for no reason). By employing the conception of rationality offered by a constructive empiricist, it is open to him to argue that a scientist can choose any theory out of a group of empirically equivalent theories and the choice will count as rational. I assume that a constructive empiricist will agree that it is preferable if our choice of one theory over another reflects the aim of picking empirically adequate theories over other non-adequate ones. A constructive empiricist, however, could plausibly argue that in some cases we are just not in such a fortunate position as to have our choices reflect our principle aim. According to voluntarism, it will not be unreasonable for a scientist to choose whichever hypothesis he wishes to, unless it undermines his chances of vindication.

This reply looks cogent but it can be blocked by strengthening the situation. If we assume that the goal of the scientist is to arrive at empirically adequate theories, then it will matter in practice how we choose, because scientists do not have an unlimited amount of funding for the purpose of testing theories. If the case is such that there is a multitude of weakly empirically adequate theories, it will of course matter which one he chooses. So, option iv) may look like a live option in theory, but it wouldn’t be a viable option in reality. By randomly choosing any one theory for no reason at all, the scientist will in effect sabotage his own chances of vindication in the long run.

Assume now that none of these practical problems exist. Let us then evaluate the claim that a scientist is not sabotaging himself when choosing one empirically

<sup>9</sup>As is clear from Ladyman et al. (1997), three of the four authors of that article see this as a problem for van Fraassen. See Psillos (1997) for a full discussion of this.

equivalent theory over another. If we go back to the conclusion of UD ([The Challenge Posed by Underdetermination of Theory by Data Argument](#)), we see that what is at stake in that argument is an issue of rationality:

- 3) Therefore, belief in any theory at any given time will be arbitrary and not founded on rational considerations. Theory choice is underdetermined.

In 3, it is assumed that we ought to avoid choosing arbitrarily and for reasons that are not rationally founded. If this argument is advocated by a constructive empiricist to show that a realist is irrational if he chooses arbitrarily, he is clearly begging the question against a realist. A constructive empiricist does not abide by these standards of rationality and therefore cannot impose stronger demands upon a realist position. If the aim is to show that a realist is irrational from his own point of view, then the argument fails too, as a realist can consistently allow himself the use of IBE which helps him in the situation under consideration.

From the point of view of a constructive empiricist, it does not matter which theory we choose, so long as the choice is between empirically adequate theories – the aim of science according to a constructive empiricist is to provide empirically adequate theories. But when we choose between weakly empirically adequate theories where one may be empirically adequate and the other ones are not, constructive empiricism offers no guidance as to what qualities we should look for in theories that may indicate to us that one theory is more likely to be empirically adequate than another. From the point of view of the person choosing, the situation where he chooses an empirically adequate theory will be indistinguishable from a situation where he doesn't. This is a strange result, but when CE is wedded to voluntarism in epistemology it follows.

It has been argued that a realist can reply to UD in a way that is at least internally consistent with SR. The aim of science according to SR is truth, and the way we choose between weakly empirically adequate theories according to realists is a way that reflects that our choice is guided by that aim. This is possible because we choose the hypothesis that maximises the so called empirical virtues, which according to realists are good indicators of truth. When it comes to constructive empiricism the situation is different. Constructive empiricism is defined as the position that says that the aim of science is to give us empirically adequate theories. If a theory is empirically adequate it means that it will be adequate to the phenomena in the past present and the future. Therefore, from the point of view of a constructive empiricist scientist who has to choose between weakly empirically adequate theories in the present, the aim will be to choose the theory that will continue to be adequate to the phenomena in the future. When choosing between theories constructive empiricists recommend that we choose the theory that maximises pragmatic virtues. But in order for this procedure of choice to be consistent with the proclaimed aim of science according to constructive empiricism, the maximisation of pragmatic values should be guiding with regard to empirical adequacy. This is problematic for a constructive empiricist. Either it will mean that pragmatic virtues like explanation are epistemically guiding with regard to the observable, in which case constructive empiricism is drawing an unfounded distinction between explanation being epistemically guiding at the observable level and not at the level of unobservables. Or, it means that we choose for reasons unrelated to the proclaimed aim of science

according to constructive empiricism. In conclusion, scientific realists have the resources to answer a version of UD that challenges us to show that scientists proceed in a rational way when choosing between weakly empirically adequate theories, whereas constructive empiricists do not. Unless the concept of rationality is redefined such that whether or not an action is reasonable, is independent of whether it promotes ones explicit aim and, in addition, suggests that one is only irrational when sabotaging ones chances vindication. However, when we employ this weakened notion of rationality it has two consequences. First of all, UD is no longer an argument of any threat to SR, and second, it is not clear that we could proceed to choose between theories without it having practical consequences for whether we would be vindicated in our aim (of getting empirically adequate theories), in which case constructive empiricist scientists would be irrational even by their own lights.

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