On No-Miracles and the Base-Rate Fallacy

Keith Dyck*

Abstract

Colin Howson (2000) contends that the No-Miracles argument fails as an argument in support of scientific realism because it commits the base-rate fallacy. In response, Stathis Psillos (2009) has defended the argument by appealing to cases that involve conditional probabilities but where base-rate information can properly be ignored. Through an examination of these cases, I show that Psillos's defense of the No-Miracles argument is inadequate and that the prospects for a purely probabilistic formulation of the argument are dim. I end by considering whether interpreting the argument as an inference to the best explanation might better serve the scientific realist, concluding that widespread acceptance of such a controversial approach is unlikely.

Introduction

Scientific realists maintain that our best scientific theories are true or approximately true.[1] They often rely on what has become known as the No-Miracles argument in defending this claim. The argument, usually credited to Putnam (1975), holds that "realism is the only philosophy that doesn't make the success of science a miracle" (p. 73).[2] It is generally agreed that science has been highly successful. The only way of adequately accounting for this success, the realist contends, is through an appeal to the approximate truth of our best scientific theories.

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[1]For a full characterization of scientific realism see Psillos (1999) and Chakravartty (2017).

[2]Putnam himself credits the argument to Boyd (1984, p. 49). Inchoate versions of the argument can be seen in Smart (1963, p. 39) and Maxwell (1962, p. 18). The No-Miracles argument is also sometimes called the 'ultimate argument' for scientific realism (see Musgrave (1988), for example).

Colin Howson (2000), however, has disputed the validity of the No-Miracles argument — charging that it is fallacious when understood as an argument concerning conditional probabilities.[3] Taking the titular "miracle" to be an event that is highly improbable, the No-Miracles argument is plausibly formulated as follows:[4]

NM-1: If a particular scientific theory is *not* approximately true, its success would be a chance event that is highly unlikely (i.e. a miracle).

NM-2: If a particular scientific theory *is* approximately true, its success would be highly likely.

NM-3: If a particular scientific theory is successful, it is then likely that it is approximately true. (Following from NM-1 and NM-2.)

NM-4: Our best scientific theories have been successful.

NM-5: Likely, our best scientific theories are approximately true. (Following from NM-3 and NM-4.)[5]

The first three steps of the argument are naturally interpreted as claims concerning conditional probabilities. For a particular scientific theory, take T to stand for the proposition that it is approximately true, take ¬T to stand for the proposition that it is *not* approximately true, and take S to stand for the proposition that it is successful. The initial steps of the argument then become:

NM-1:* $P(S|\neg T)$ is very low.

NM-2:* $P(S|T)$ is very high.

NM-3:* Therefore, $P(T|S)$ is high.[6]

[3] Magnus and Callender (2004) have also argued this point, crediting Howson as the source.

[4] Howson (2000; 2013) attributes this interpretation to Putnam (1975), Popper (1993), Worrall (1985), and Leng (2010).

[5] This formulation is meant to resemble the No-Miracles argument outlined by Howson (2000, p. 36), as well as the paraphrase of Howson's argument provided by Psillos (2009, p. 56).

[6] Psillos (2009, p. 57) presents this as the essential component of Howson's formulation of the No-Miracles argument, with the additional premise that "S is the case." Howson (2013, p. 205) seems to endorse Psillos's rendering, although he drops the Psillos's additional premise as unnecessary for reaching the probabilistic sub-conclusion given by NM*-3.

But, as Howson points out, this sub-argument commits the base-rate fallacy.[7]

To help illustrate, consider a familiar example involving a disease for which there is a highly reliable test. If a person has the disease and is tested, the test returns a positive result 95% of the time and a false-negative result 5% of the time. If a person doesn't have the disease and is tested, it similarly returns a negative result 95% of the time and a false-positive result 5% of the time. The base-rate fallacy is then commonly demonstrated by asking the question: "What is the probability that a randomly selected individual has the disease, given that they have tested positive?" In psychological studies, the most frequent response is 95%. But this answer is correct only under the assumption that exactly 50% of the general population has the disease.[8] If the rate of the disease in the population is actually much lower, the chance that a person who tests positive has the disease will be lower as well (e.g. less than 2% if the base-rate of the disease is 0.1%).[9] Without further information concerning the base-rate of the disease in the general population, no response to the question can correctly be given.

Howson contends that this same mistake in reasoning is made by proponents of the No-Miracles argument. If the prior probability that a given theory is approximately true is sufficiently low (e.g. $P(T) = 0.001$), the first two premises of the argument can be true (e.g. $P(S|\neg T) = 0.05$ and $P(S|T) = 0.95$) and the argument's sub-conclusion false (e.g. $P(T|S) \approx 0.19$).[10] Without some further premise concerning the prior probability that a theory is approximately true (i.e. the "base-rate" of approximately true theories), the conclusion of the No-Miracles argument is probabilistically unsupported.

Stathis Psillos (2009) has provided arguably the most prominent defense of the No-Miracles argument in the face of Howson's charge. Psillos, however, acknowledges that the supplemental premise Howson takes as vital to the argument's success is not one that the scientific realist can easily provide.

[7]Challenges to the sub-argument's two premises will be set aside for present purposes. Laudan (1981) and Howson (2013), for instance, question whether the mere *approximate* truth of a scientific theory is enough to ensure the very high likelihood of its success.

[8]For a given individual, take D to stand for the proposition that they have the disease and take + to stand for the proposition that they test positive. $P(D|+) = P(+|D)\cdot P(D)/P(+) = P(+|D)\cdot P(D)/(P(+|D)\cdot P(D) + P(+|\neg D)\cdot P(\neg D)) = 0.95\cdot 0.5/(0.95\cdot 0.5 + 0.05\cdot 0.5) = 0.95$.

[9]$P(D|+) = P(+|D)\cdot P(D)/P(+) = P(+|D)\cdot P(D)/(P(+|D)\cdot P(D) + P(+|\neg D)\cdot P(\neg D)) = 0.95\cdot 0.001/(0.95\cdot 0.001 + 0.05\cdot 0.999) \approx 0.0187$.

[10]$P(T|S) = P(S|T)\cdot P(T)/P(S) = P(S|T)\cdot P(T)/(P(S|T)\cdot P(T) + P(S|\neg T)\cdot P(\neg T)) = 0.95\cdot 0.001/(0.95\cdot 0.001 + 0.05\cdot 0.999) \approx 0.0187$.

Measuring the rate of approximately true theories in the general population of scientific theories is, according to Psillos, infeasible due to a lack of precision concerning the argument's central individuating concepts (i.e. theory, success, and approximate truth). Appealing to the principle of indifference in supplying the missing premise is considered but quickly abandoned by Psillos — presumably due to the controversial nature of such an objective Bayesian approach.[11] Howson's own suggestion that the prior probability be supplied based on one's subjective credence concerning the approximate truth of a given theory is also rejected by Psillos as contrary to the argument's objective intent.

Psillos's admission that he cannot convincingly provide the argument's purported missing premise is taken by Howson as tantamount to an acknowledgement of defeat. In his brief rejoinder to Psillos, Howson declares the argument "dead in the water" on probabilistic grounds (Howson 2013, p. 211). What Howson fails to address, however, is Psillos's more involved suggestions as to how the argument could proceed in the absence of such a premise. As Psillos put it, "[r]easoning is much more complex" than Howson is willing to admit (Psillos 2009, p. 68). By appealing to reasoning that appears acceptable in other contexts, he contends that the No-Miracles argument can be convincingly saved as an argument for scientific realism.

In this paper, I will look more closely at Psillos's defense of the No-Miracles argument. In particular, I will focus on his contention that there are cases where seemingly relevant base-rates can safely be ignored in arguments involving conditional probabilities and that the No-Miracles argument provides one such instance. Psillos's claim is worth examining in its own right, but also, as will be discussed, elements of his multipronged approach to rescuing the argument presage more recent realist attempts. I will conclude that Psillos fails to provide an adequate defense of the No-Miracles argument and contend further that attempting to bypass Howson's objection by reformulating the argument as an inference to the best explanation is unlikely to be met with widespread success.

[11] Psillos (2009, p. 60) does maintain that an appeal to the principle of indifference captures the "thrust" of the No-Miracles argument. As Howson (2013, p. 207) points out, it is not completely clear what Psillos means by this contention.

Psillos's Three Cases

In defending the No-Miracles argument, Psillos considers three types of cases where he contends base-rate information can properly be ignored. In the sections that follow, I will present each of these cases in turn and demonstrate how each fails in providing a convincing rebuttal to Howson's objection. Psillos's particular focus is on defending the No-Miracles argument under the assumption that the base-rate of approximately true theories is low. Given the first two premises of the argument (i.e. $P(S|\neg T)$ is very low, and $P(S|T)$ is very high), this is the only scenario where $P(T|S)$ comes out to be low, and thus the only scenario where the argument's realist conclusion is at all threatened.

In presenting these cases, Psillos makes extensive use of an example devised by experimental psychologists Tversky and Kahneman (1982):

> CAB: There is one eyewitness to a hit-and-run accident involving a taxicab late at night and that witness reports that the cab she saw was blue. In the city where the accident occurred, 85% of the cabs belong to the Green Cab company and 15% of the cabs belong to the Blue Cab company. In order to check the reliability of the eyewitness, a test is performed where she is asked to identify blue and green cabs under visual conditions similar to those that occurred at the time of the accident. In this test environment, the eyewitness makes correct identifications 80% of the time and is mistaken 20% of the time.

In Tversky and Kahneman's study, test subjects were asked to estimate the probability that the witnessed accident involved a blue cab. Seeming to ignore the given base-rates, they found that the answer typically given was 80%. Using Bayes's Theorem in combination with the information provided in the example, the probabilistically correct answer can be shown to be approximately 41%.[12] Despite the eyewitness's report that the cab involved in the accident was blue, it is actually more likely that it was green.

[12] $P(B|W)$ is the conditional probability that the cab was blue (B) given that the witness reported it was blue (W). $P(B|W) = P(W|B) \cdot P(B)/P(W) = 0.8 \cdot 0.15/(0.8 \cdot 0.15 + 0.2 \cdot 0.85) \approx 0.414$.

Case 1: Relevant Background Information

In presenting the first type of case where base-rate information may safely be ignored, Psillos begins by noting that the witness in the CAB example is likely to have known that there are more green cabs than blue cabs in the city where the accident occurred. This knowledge, according to Psillos, may predispose the witness to identify cabs as green when the perceptual experience is at all ambiguous. Such a disposition is unlikely to show up in the test environment used to estimate rates of error since, in that environment, the witness may reasonably assume that a roughly equal number of green and blue cabs will be presented. Rates of error would then differ in real world situations when compared to those measured in the test environment. It would actually be a mistake, according to Psillos, for the test subjects in Tversky and Kahneman's psychological experiment to blindly reason in a probabilistic manner when confronted with the CAB example rather than taking this background information about dispositions into account. "There is a sense in which the subjects commit a fallacy (since they are asked to reason probabilistically but fail to take account of the base-rates), but there is another sense in which they reason correctly because the salient features of the *case history* can get them closer to the truth" (Psillos 2009, p. 63).

Psillos takes this observation concerning the CAB example to be relevant to a proper assessment of the No-Miracles argument. Granting that the base-rate of approximately true theories is likely to be low, Psillos suggests that "one might well be predisposed to say that a theory T is false, given its success" (Psillos 2009, p. 63). Scientists (who are meant to be analogous to the eyewitness just considered) may be predisposed, based on suspicions that the base-rate of approximately true theories is low, to think that any theory under consideration is *not* likely to be approximately true. Taking this background information into account, "when, then, the eyewitnesses (the scientists, in this case) say that a specific theory T is approximately true (despite that this is unlikely, given the base-rates), they should be trusted — at the expense of the base-rates" (Psillos 2009, p. 63). As in the CAB example, our knowledge of relevant background information may lead us to properly ignore base-rates in considering the No-Miracles argument rather than reaching a conclusion based on the blind application of probabilistic reasoning.

Response to Psillos

The general point that Psillos appears to be making in considering this first case is that a correct conclusion will only be reached using Bayes's Theorem if the probabilities that enter into the calculation are the appropriate ones. In considering the CAB example, Psillos is particularly worried about issues in estimating rates of error for the eyewitness in circumstances similar to those involved in the actual accident. If, due to changes in relevant dispositions, the false-positive and false-negative rates are actually lower than given in the original example, the low base-rate of blue cabs in the city can be overcome such that the eyewitness's testimony should actually be trusted.[13]

While Psillos is right to point out this potential issue, it is unclear how it helps his defense of the No-Miracles argument. In drawing the relevant analogy, he seems to be claiming that scientists believe that most scientific theories are not approximately true. For this reason, scientists are not likely to accept a theory as genuinely successful if its status remains at all unclear. But, in effect, this is simply the claim that, due to the mindset of most scientists, the rate of false-positives is very low in the assessment of the approximate truth of scientific theories. Provided this rate is not zero, however, even a very low rate of false-positives (e.g. $P(S|\neg T) = 0.01$) can be overcome by a sufficiently low prior (e.g. $P(T) = 0.001$), such that the approximate truth of a successful theory is still unlikely (e.g. $P(T|S) \approx 0.09$, given the further assumption that $P(S|T) = 1$).[14] As Psillos himself concedes, there is no clear way to produce an estimate for the base-rate of approximately true theories in the general population. Without such an estimate, there is no way to know if even a very cautious group of scientists will be able to overcome it.

There does seem to be a second possible interpretation of Psillos's first case. Psillos writes that "[i]f we take the base-rates into account, we may get at the correct probability of a theory's (chosen at *random*) being approximately true." Scientists, however, do not just randomly select theories for empirical testing. Rather, theories are only subject to testing if they have first been identified as potential candidates by scientists employing what can

[13] As a concrete example, assume $P(W|B)$ is actually 1 and $P(W|\neg B)$ is actually 0.05 in late-night situations. Taking $P(B)$ to be 0.15 as originally specified: $P(B|W) = P(W|B) \cdot P(B)/P(W) = 1.00 \cdot 0.15/(1.00 \cdot 0.15 + 0.05 \cdot 0.85) \approx 0.78$. This is significantly higher than the originally calculated value of approximately 0.41.

[14] $P(T|S) = P(S|T) \cdot P(T)/P(S) = 1.00 \cdot 0.001/(1.00 \cdot 0.001 + 0.01 \cdot 0.999) \approx 0.09$.

be broadly characterized as the scientific method. According to this line of thinking, the base-rate appropriate to the No-Miracles argument should be the rate of approximately true theories in the limited population of theories selected by scientists, not the rate of approximately true theories in the population of theories in general. In fact, several recent attempts at rescuing the No-Miracles argument take this exact position (Menke 2014; Henderson 2017; Dawid and Hartmann 2018). Henderson (2017), for instance, writes that "the base rate fallacy allegation relies on an assumption of random sampling of individuals from the population which cannot be made in the case of the no miracles argument" (p. 1295).

The problem with this approach is that we are once again confronted with a base-rate that is unknown. Since the very point of the No-Miracles argument is to establish which scientific theories are likely to be approximately true, we are in a poor position to directly estimate this new base-rate in a non-circular manner. Estimating the base-rate indirectly, however, seems at least possible. If the rate of success of theories selected using the scientific method were known (i.e. $P(S)$), $P(T)$ could be calculated using the law of total probability and already assumed value for $P(S|T)$ and $P(S|\neg T)$.[15] In fact, as Dawid and Hartmann (2018) have recently shown, $P(T|S)$ is guaranteed to be greater than 0.5 — a plausible threshold for the success of the No-Miracles argument — if $P(S)$ is more than twice $P(S|\neg T)$.

Given the premise that "our best scientific theories have been successful" (i.e. NM-4), it may seem that the No-Miracles argument already presupposes that the rate of success among theories selected by scientists is high.[16] This, however, is not the case. Since success is generally a prerequisite for a theory to be considered among our best, the very high rate of past success for theories we currently take to be our best can provide little evidence as to their approximate truth. What is needed in support of the No-Miracles argument is the rate of success of all theories selected by scientists for further testing, not the rate only among those theories that did in fact succeed. That this more inclusive rate of success is more than twice the value of $P(S|\neg T)$ is far from obvious. Perhaps an appeal to historical data could be made, but, as Psillos points out, issues concerning theory individuation, the measure of

[15] The law of total probability states $P(S) = P(S|T) \cdot P(T) + P(S|\neg T) \cdot P(\neg T)$. Given that $P(\neg T) = 1 - P(T)$, it can easily be shown that $P(T) = (P(S) - P(S|\neg T))/(P(S|T) - P(S|\neg T))$.

[16] Henderson (2017), for instance, takes for granted that the theories selected by science have a "a high overall proportion of success" (p. 1300).

success, and the meaning of approximate truth would have to be satisfactorily settled, as would questions concerning the appropriate domain and historical time frame to be used. The contentious nature of the debate surrounding the use of historical data in support of the pessimistic meta-induction indicates that forming a general consensus concerning these matters is unlikely.[17]

A further concern with this approach is that providing the historical rate of success for scientific theories is not enough to rescue the No-Miracles argument. Since the argument relies on $P(S)$ being significantly higher than $P(S|\neg T)$, a convincing estimate for the latter would also be needed. But, notice that the meaning of $P(S|\neg T)$ has changed when compared to the argument's original framing. While even the anti-realist may be willing to concede that an arbitrarily selected theory that is not approximately true is highly unlikely to succeed, this is far less obvious when considering the limited set of theories produced using the scientific method. There seems to be good reason to think — due to the elimination of clearly inferior theories, for instance — that $P(S|\neg T)$ will at least be higher than in the original case. An additional appeal to historical data could be made, but now estimates for two parameters (i.e. both $P(S)$ and $P(T|\neg S)$) would need to be produced. Menke (2014) suggests that this could be done by focusing exclusively on scientific theories historically subject to multiple tests for success, but this introduces even further complications in terms of determining which historical tests should be considered independent.[18] This second interpretation of Psillos's first case also fails as a convincing reply to Howson.

[17] Laudan (1981) provides the canonical version of the argument, also commonly referred to as the 'pessimistic induction.' Laudan famously states that "for every highly successful theory in the past of science which we now believe to be a genuinely referring theory, one could find half a dozen once successful theories which we now regard as substantially non-referring" (p. 35).

[18] To illustrate the controversial nature of appealing to historical cases in support of scientific realism, consider the following: Menke (2014) uses the 19th century wave theory of light as an example of a theory that can be established to be approximately true based on its success under repeated testing. Laudan (1981) uses this same theory as an example of a theory that we now hold to be not approximately true, based on it incorrectly positing the existence of an optical aether.

Case 2: Explanatory Considerations

Psillos also uses the CAB example to illustrate a second type of case where he thinks base-rate information can properly be ignored. Recall that in Tversky and Kahneman's original study, test subjects ignored the fact that 85% of the cabs in the city were green and 15% of the cabs in the city were blue when considering whether to trust the eyewitness's account. As Psillos points out, however, a slight modification to the study produced very different results. In CAUSAL CAB, a second example devised by Tversky and Kahneman, the CAB example is altered to specify that there are an equal number of green and blue cabs in the city and a new detail is added that 85% of the *cab related accidents* in the city involve green cabs while 15% of the *cab related accidents* involve blue cabs (Tversky and Kahneman 1982, p. 157).[19] When presented with the CAUSAL CAB example, test subjects now started to factor in the relevant base-rates in determining whether it was a green or blue cab that was involved in the witnessed accident.

Psillos contends that the reason that test subjects now started incorporating this information into their assessment was not an increased desire to get the probabilities right — they presumably wanted to get the probabilities right when considering the original CAB example as well — but rather because they thought that the base-rate information "was *causally relevant* to the issue at hand" (Psillos 2009, p. 64). And, as Psillos puts it, "causally relevant information has a better chance to lead to true beliefs" (Psillos 2009, p. 64). Since the CAUSAL CAB example strongly implies that a given green cab is more likely to cause an accident than a given blue cab, the high base-rate of accidents involving green cabs was seen by test subjects as relevant to the question of the color of the cab responsible for the witnessed accident.

Psillos takes Tversky and Kahneman's experimental result to provide insight as to how we ought to reason in the case of the No-Miracles argument. Taking reasoning about causation to essentially be reasoning about explanation, Psillos suggests that we only ought to use base-rate information in deciding whether a successful theory should be considered approximately true if it is explanatorily relevant to such a determination. The issue then be-

[19]Psillos (2009) states that "the subjects are told that 85 per cent of the car accidents are caused by *blue* cabs and 15 per cent by *green* cabs" (p. 64, emphasis mine). In fact, as stated above, Tversky and Kahneman's example involves *green* cabs causing 85% of the car accidents and *blue* cabs causing 15%. I assume that Psillos's error is merely typographical.

comes distinguishing explanatorily relevant base-rates, such as the ones seen in CAUSAL CAB, from base-rates that are merely 'incidental' in nature.

Psillos again focuses on the situation where the base-rate of approximately true theories is low. He writes that "[i]f falsity did explain success, then, clearly, the small base-rate for truth would undermine belief in a connection between success and approximate truth" (Psillos 2009, p. 64). If both a theory *not* being approximately true and a theory being approximately true provided explanations for success, then the low base-rate of approximately true theories would be explanatorily relevant, favoring the former over the latter. However, according to Psillos, this is not the case and "falsity does *not* explain success" (Psillos 2009, p. 64). Since a theory being approximately true is the only explanation available for a theory's success, the low base-rate of approximately true theories is explanatorily irrelevant to determining what should be believed concerning a successful theory. The low base-rate of approximately true theories can then safely be ignored.

Psillos provides two examples to help illustrate this point. In the first example, the likelihood of a successful theory being approximately true is high (e.g. $P(T|S) \approx 0.957$) despite the base-rate of approximately true theories being low (e.g. $P(T) = 0.1$, hence $P(\neg T) = 0.9$).[20] Since the only explanation for a theory's success is that it is approximately true, the high base-rate of not approximately true theories should in no way undermine our belief that a successful theory is approximately true. Psillos contrasts this first example with a second. Here, the base-rate of approximately true theories is even lower than in the previous example (e.g. $P(T) = 0.001$, hence $P(\neg T) = 0.999$) and the likelihood of a successful theory being approximately true comes out to be low as well (e.g. $P(T|S) \approx 0.165$).[21] Concerning this second example, Psillos writes that "despite the low base-rate [i.e. P(T)], a certain successful theory may be deemed approximately true. Its posterior probability [i.e. P(T|S)] may be low, but this will be attributed to the rareness

[20]Assuming additionally that $P(S|\neg T)$ is very low (e.g. $P(S|\neg T) = 0.005$) and $P(S|T)$ is very high (e.g. $P(S|T) = 0.99$): $P(T|S) = P(S|T) \cdot P(T)/P(S) = 0.99 \cdot 0.1/(0.99 \cdot 0.1 + 0.005 \cdot 0.9) \approx 0.957$. Psillos actually specifies in his example that $P(S|\neg T) = 0.05$, $P(\neg T) = 0.9$, and $P(S) = 0.99$. Blindly plugging these numbers into Bayes's Theorem: $P(\neg T|S) = P(S|\neg T) \cdot P(\neg T)/P(S) = 0.05 \cdot 0.9/.99 \approx 0.0455$. This isn't vital to the point that he is trying to make, but Psillos fails to notice that the example he provides is incoherent. Since $P(S) = P(S|T) \cdot P(T) + P(S|\neg T) \cdot P(\neg T)$, the specified values would result in $P(S|T) = (0.99 - 0.05 \cdot 0.9)/0.1 = 9.45$.

[21]Keeping $P(S|\neg T) = 0.005$ and $P(S|T) = 0.99$: $P(T|S) = P(S|T) \cdot P(T)/P(S) = 0.99 \cdot 0.001/(0.99 \cdot 0.001 + 0.005 \cdot 0.999) \approx 0.165$.

of truth and not to any fault of the individual theory" (Psillos 2009, p. 64). Approximately true theories may be uncommon, but it is only if a theory is approximately true that its success can actually be explained. The low base-rate of approximately true theories should then not factor into our reasoning and a successful theory should be taken to be approximately true despite the calculated value of $P(T|S)$ being low.

Since successful theories should be considered approximately true regardless of whether the probability of a successful theory being approximately true is calculated to be high or low, the base-rate of approximately true theories is then irrelevant to the conclusion of the No-Miracles argument.

Response to Psillos

Psillos's argument in considering this second case is problematic for at least two reasons. First, he seems to be confusing the results of a psychological experiment meant to show how humans actually reason with normative claims about how we *ought* to reason. As Tversky and Kahneman (1982) point out with regards to a related pair of examples, "[f]rom a normative standpoint [...] the causal and the incidental base rates in these examples should have roughly comparable effects" (p. 156). The fact that test subjects treated explanatory and non-explanatory base-rates differently does not provide convincing evidence for thinking that they ought to be treated differently.

The second problem with Psillos's view is that it has consequences that are scientifically unacceptable. Consider the earlier discussed disease example with both the rate of false-positives and the rate of false-negatives specified to be 5%. Now add the further detail that the base-rate of the disease in the general population is only 0.1%. It seems clear that having the disease explains a positive test result, while not having the disease does not.[22] Given that the base-rate of the disease in the general population is low, Psillos's method of evaluation would seem to yield the verdict that the base-rate involved in this example is not explanatorily relevant. This is analogous to Psillos's contention that the base-rate of approximately true theories is not explanatorily relevant if it is low because it does not reflect the fact that it is only approximate truth that can explain a theory's success. Consistent with Psillos's treatment of the base-rates involved in the No-Miracles argument,

[22] $P(+|D)$ being high and $P(+|\neg D)$ being low mirrors this fact.

the low base-rate of disease in the general population should then be ignored. But this means that an individual who tests positive should be taken to have the disease despite there being a less than 2% chance that this is actually the case. This is surely an assessment that no reputable epidemiologist would accept. If, as realists generally contend, science is our best guide to truth, we should reject this kind of reasoning when it comes to the No-Miracles argument as well.

While the specific suggestion Psillos makes for incorporating explanation into the No-Miracles argument does not seem to work, perhaps the second case Psillos considers is meant to gesture more generally at an interpretation of the No-Miracles argument as an inference to the best explanation. To paraphrase Lipton (2003), the contention would be that we should look to the 'loveliest' explanation of the success of science, not just the likeliest. This is a possibility I will more fully explore in this paper's conclusion.

Case 3: Justice and Fairness

Psillos presents one final type of case where he thinks it may be proper to ignore base-rates. He again returns to the original CAB example, but now adds a wrinkle where this same scenario plays out multiple times. After each accident, the involved victim files a lawsuit against each of the two cab companies that could potentially be involved, with the only evidence provided in each case being the statistical information specified in the example and the testimony of the one eyewitness. If the courts reached their judgments based purely on an application of Bayes's Theorem, the Green Cab company would be found financially liable in every single one of the cases — despite actually being responsible only 59% of the time. According to Psillos, this would be a mistake and "[f]airness and justice seem to give us *some* reason to ignore the base-rates" (Psillos 2009, p. 65).

Returning to the No-Miracles argument, Psillos sees the community of scientists serving a role analogous to the courts in the modified CAB example just considered. Psillos contends that "[i]f scientists acted as the imagined judges above, they would be unfair and unjust to their own theories" (Psillos 2009, p. 65). If the base-rate of approximately true theories was low and exclusively probabilistic reasoning was used, then all successful theories would be deemed not approximately true. According to Psillos, this would be unjust and unfair. This provides at least some reason for taking successful theories to be approximately true, regardless of the actual base-rates involved.

Response to Psillos

In evaluating Psillos's argument, it is worth briefly examining the source of the intuition that the Green Cab company would be unjustly treated if it was found guilty in every case brought against it. In the Anglo-American tradition, the keystone of criminal justice is that a defendant is 'innocent until proven guilty.'[23] This corresponds to a systematic attempt to lower the rate of false convictions at the expense of allowing some guilty defendants to escape unpunished.[24] In civil cases, such as the ones involved in Psillos's example, the closely related 'presumed non-culpable' standard is in effect.

What Psillos fails to notice, however, is that this standard should apply in cases brought against the Blue Cab company as well. If base-rate information were ignored and the eyewitness was simply trusted, it would seem that the Blue Cab company would be found guilty in each case brought against it, despite being responsible less than half of the time. This would certainly be as much of an injustice as the one perpetrated against the Green Cab company. Considerations of justice and fairness would then indicate that one absolutely *should* take base-rate information into account in cases involving the Blue Cab company, with not guilty verdicts handed down in each instance.

When court cases involving the Blue Cab company are also considered, it doesn't appear that the modified CAB example Psillos is appealing to in support of the No-Miracles argument actually helps his position. Psillos takes blue cabs to correspond to approximately true theories and green cabs to correspond to not approximately true theories. If guilty verdicts should not be handed down in court cases involving either — something that justice and fairness seems to demand — this would correspond to our best scientific theories being judged neither approximately true nor *not* approximately true. In effect, this is the admission that the No-Miracles argument, when factors of justice and fairness are considered, does not provide a positive argument for scientific realism.

Psillos may well reject this response and claim that this is not the analogy he wants to draw. Instead, he may contend that misjudging an approximately

[23]This is sometimes referred to as the 'golden thread' of criminal law.

[24]Whether the criminal justice system actually succeeds in doing this is, of course, highly debatable.

true theory to be *not* approximately true is an injustice that must be avoided, while misjudging a *not* approximately true theory to be approximately true is no injustice at all. Returning to the CAB example, this is in effect the claim that the Green Cab company should be presumed non-culpable, while no such assumption, or maybe even the reverse assumption, should be applied in cases involving the Blue Cab company. This difference in the treatment of the two companies seems clearly unjust and unfair. Psillos would need to provide an explanation for why this type of asymmetric treatment is not similarly inappropriate when considering the No-Miracles argument.

In fact, it seems highly questionable whether concerns over justice and fairness should impact the No-Miracles argument at all. The type of justice that Psillos seems concerned with in the modified CAB example is compensatory justice. The injustice that Psillos wants to avoid is the harm that would be done to the company owners if they were forced to pay compensation for an accident the company was not actually involved in. But, in the case of scientific theories, who exactly is harmed? It can't be the theories themselves, since they don't seem to be the types of things that are capable of suffering harm. The scientists involved in coming up with the theories in the first place, or perhaps those that endorse them as approximately true, would seem to be the only individuals that could potentially be damaged by an incorrect judgment as to a theory's approximate truth. Psillos's argument would then be that we should judge our current best scientific theories to be approximately true to prevent reputational harm to scientists, or perhaps harm to their self-esteem. But if this is right, then this harm should presumably always be of concern in epistemic matters involving science. For instance, it would seem that considerations of justice and fairness should factor against the publication of results that disprove an existing scientific theory, since scientists who currently endorse that theory could potentially be harmed. Also, we should be reluctant to propose new theories that might displace old theories, since the reputation and self-worth of the scientists who came up with the current theories may be negatively impacted. But these types of considerations sound epistemically inappropriate and downright unscientific. If realists are as concerned about truth as Psillos claims they are, there would seem to be no reason for considerations of this type to factor into what should be purely epistemic evaluations.

Conclusion

Psillos is then unsuccessful in his defense of the No-Miracles argument. His failure highlights the difficulties faced by scientific realists wanting to directly engage with Howson's probabilisitic formulation of the argument. It is worth briefly considering whether the realist might be better served by an approach that attempts to sidestep Howson's rendering of the argument altogether. Taking the 'miracle' referred to in the argument to be an event that is unexplained rather than one that is unlikely, the No-Miracles argument could be reformulated as an inference to the best explanation. The conclusion that our best scientific theories are approximately true would be reached based on the fact that approximate truth provides the best explanation for their success. This is an interpretation that Howson does not even consider and one that Psillos explicitly endorses elsewhere.[25]

There are two main concerns with this approach. First, it is far from clear how explanations should be judged and ranked. Most proponents of this style of argument rely on explanatory virtues that are poorly defined and generally appeal to the actual practice of science in defending these virtues as indicators of truth. However, this appeal to science seems to rely on the assumption that science actually produces explanations that are true — the very issue the No-Miracles argument is meant to settle.[26] Second, if the mechanism for picking the best explanation is made explicit, there are two possibilities. If the resulting No-Miracles argument does *not* respect the rules for Bayesian updating, it will be subject to a diachronic Dutch book argument.[27] Alternatively, if the resulting No-Miracles argument does fit within the Bayesian framework, explanatory considerations would have to be used to justify why P(T) should not be taken to be too low.[28] It is unclear

[25] See Psillos (2009, p. 68) for instance. Boyd (1984) and Worrall (2007) have also endorsed this interpretation of the No-Miracles argument.

[26] Fine (1984) was the first to point out the potential circularity involved in interpreting the No-Miracles argument as an inference to the best explanation.

[27] Teller (1973) provides the first presentation of the diachronic Dutch book argument, which he credits to David Lewis. Van Fraassen (1989, ch. 7) uses a Dutch book argument to criticize the use of inference to the best explanation. See Douven (2017) for a potential response to van Fraassen.

[28] See Lipton (2003, ch. 7) for a discussion of how inference to the best explanation could be made compatible with Bayesian updating. Worrall (2007, p. 146) suggests that our intuitive judgment that a given scientific theory is particularly simple or unifying should give rise to a reasonably high prior.

how this could be done in a way that will be generally accepted.

These concerns point to the cost of abandoning the probabilisitic No-Miracles argument. Many philosophers – anti-realists chief among them – will dismiss the suggestion that a probabilistically unsupported conclusion should be accepted based on explanatory considerations alone. Attempts to bypass Howson's formulation of the argument will then result in a version of the No-Miracles argument that is unconvincing to the committed anti-realist. Perhaps the more modest goal of persuading at least some of those who are undecided as to their position in the realism/anti-realism debate could be achieved, but this is far from the full victory that proponents of the No-Miracles argument had hoped for.

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