Is the Fine-Tuning Evidence for a Multiverse?

Our best current science seems to suggest the laws of physics and the initial conditions of our universe are fine-tuned for the possibility of life. That is to say, for life to be physically possible, certain parameters in basic physics – for example, the strength of gravity, or the mass of the electron – had to have values falling in a certain range, and that range is an incredibly narrow slice of the values those parameters might have had (Leslie 1989: ch. 2, Rees 2000, Davies 2006, Lewis and Barnes 2016). Some philosophers deny that the fine-tuning is evidence of anything in particular, except perhaps our good fortune. But a significant number of scientists and philosophers believe that the fine-tuning is evidence for the multiverse hypothesis, the theory that our universe is just one of a very large number of universes.[1] The basic argument is as follows. If there is just one universe, it's incredibly improbable that the right numbers for life would have come up by chance. But if there are many universes, exemplifying different values in the relevant parameters, then the existence of a fine-tuned universe becomes much more likely.

Some philosophers (Hacking 1987, White 2000/2003) have objected that this line of reasoning commits the *inverse gambler's fallacy*, which consists in inferring from an event with a remarkable outcome that there must be many other events of the same kind, most of which had less remarkable outcomes. Others have countered (Holder 2002, Manson & Thrush 2003, Juhl 2005, Oppy 2006) – call this the 'essentialist response' – that the inverse gambler's fallacy charge depends on the non-obvious assumption that the parameter values that constitute the fine-tuning are *contingent properties* of our universe; that is to say, that in our universe gravity might have had a different strength, electrons a different mass, and so on with respect to the other finely tuned parameters. On a stronger version of the essentialist response, it is argued that the relevant parameter values are in fact essential properties of our universe and hence the inverse gambler's fallacy charge fails. On a weaker version, it is suggested merely that proponents of the inverse gambler's fallacy charge have not offered a positive argument for the thesis that the parameter values are contingent and hence that they have failed to justify a crucial premise of their argument.

Surprisingly, what neither side of this debate of the last few decades has considered is the specific multiverse hypothesis for which there is arguably independent empirical support and which is consequently most often appealed to by many scientists hoping to explain the

[1] Scientists defending this position include Susskind (2005), Greene (2011), Tegmark (2014); philosophers include Leslie (1989), Smart (1989), Parfit (1998), Bradley (2009).

fine-tuning, namely that which is rooted in eternal inflation combined with string theory.[2] I will argue that, on this version of the multiverse, our universe is accidentally fine-tuned, and hence, with respect to the multiverse hypothesis most popular among scientists, the essentialist response to the inverse gambler's fallacy charge fails.

In section I, I will outline the inverse gambler's fallacy charge, primarily as articulated by Roger White. In section II, I will explore the essentialist response, as it has been defended by various philosophers. In section III, I will lay out the much-discussed eternal inflation + string theory multiverse theory, before arguing that, in the context of this specific multiverse theory, the essentialist response fails.

I – The Inverse Gambler's Fallacy Charge

Fine-tuning arguments are not the only way to defend a multiverse hypothesis, but I want here to focus solely on the question of whether the fine-tuning supports the multiverse hypothesis. Hence when I refer to 'multiverse theorists' in what follows, I mean those who appeal to the fine-tuning as evidence for a multiverse hypothesis, considered only in so far as they are defending the multiverse hypothesis in this way.

The inverse gambler's fallacy charge against the multiverse theorist – from now on the 'IGFC' – originates from Ian Hacking (1987), who applied it to John Wheeler's 'oscillating universe' theory. However, Roger White (2000/2003) later gave a particularly detailed form of the objection, arguing that it applies to all forms of the multiverse and not just to the oscillating universe version. I will focus here mostly on White's version of IGFC.

In the regular gambler's fallacy, the gambler has had a long night of bad rolls of the dice: 'Given that it's unlikely that in a long series of rolls there would fail to be at least one double six,' the gambler reasons, 'there's a really good chance I'll get a double six on the next roll!' The fallacy lies in the fact that the chance of getting a double six on the next roll is not made any more likely by the results of previous rolls. In the inverse gambler's fallacy, the gambler walks into a casino to see another player rolling a double six: 'Given that rolling a double six is more likely if one has rolled many times,' the gambler reasons, 'That player must have been playing for a while!' Again, the error arises from the mistaken belief that rolling a six *on a particular occasion* – in this case the occasion the gambler has just witnessed – is rendered more likely by the results of previous rolls.

Hacking and White accuse the multiverse theorist of committing the same fallacy. Just as the gambler sees a remarkable roll of the dice and infers on that basis that there must have been many other, less remarkable rolls, so the multiverse theorist sees the striking fine-

[2] For attempts to account for the fine-tuning in these terms, see Susskind (2005), Greene (2011), Tegmark (2014).

tuning of our universe and thus concludes that there must be many other universes with less striking numbers in their physics. And just as the gambler's inference is unwarranted given that other rolls do not alter the odds that *the roll she witnessed* will be a double six, so the multiverse theorist's inference is unwarranted given that the presence of other universes doesn't make it any more likely that *this universe* will be fine-tuned.

Shortly after Hacking had first introduced the IGFC, John Leslie (1988) and P. J. McGrath (1988) (independently) accused Hacking of ignoring the selection effect introduced by the fact that we couldn't have perceived a universe that was not fine-tuned. Whilst it is trivially true that this selection effect exists, its impact on our evidential situation is more controversial. In support of the fine-tuning argument for the multiverse, McGrath offers the following analogy:

> Jane 1: Jane takes a nap at the beginning of a dice rolling session, in which an unspecified number of players will simultaneously roll a pair of dice just once, on the understanding that she will be awakened if, and only if, a double-six is rolled and not before. Upon waking she infers that there were several players rolling dice.

Initially, this case seems to mirror the selection effect we find in the fine-tuning case. In reality, given that we exist, the universe must have been fine-tuned; in the analogy, given that Jane has been woken, a double six must have been rolled. Moreover, it seems that Jane's inference was correct, as her evidence – the fact that she has been woken and hence a double-six must have been rolled – is more likely on the assumption that there are many players than it is on the assumption that there is only one. By analogy, one might be tempted to conclude that the fact that we observe a finely tuned universe is evidence that there are many universes.

In response, White distinguishes two selection effects:

> *The mere selection effect* – If we exist, there is a fine-tuned universe
> *The converse selection effect* – If there is a fine-tuned universe, we exist.

According to White, the real situation with respect to fine-tuning exemplifies the mere selection effect but does not exemplify the converse selection effect. That's because, on the assumption that there is a multiverse, it could have been that the next universe down was fine-tuned rather than ours, with some other folk existing instead of us. White makes the point vivid by imagining what would have had to be the case for the converse selection effect to obtain. If we were once disembodied spirits, floating around the multiverse looking for a fine-tuned universe to slip into, *then* it would have been the case that: so long as there's a fine-tuned universe, we're going to exist. In the absence of something like that, argues White, we should conclude that there is no converse selection effect.

In the Jane 1 case described above, both mere and converse selection effects obtain. Given that she is woken, someone must have rolled a double six (mere selection effect); and if someone rolled a double six, she would have been woken (converse selection effect). But if White is right that this doesn't match the real world, then, in order to properly assess our evidential situation, we're going to need an analogy that matches the real-world situation in which the mere selection effect holds but not the converse selection effect. Thus, he introduced his own version of the Jane scenario:

> <u>Jane 2</u> – Jane knows that she is one of an unspecified number of sleepers each of which has a unique partner who will roll a pair of dice. Each sleeper will be awakened if and only if her partner rolls a double-six. Upon waking, Jane infers that there are several sleepers and dice rollers.

We now have a case where the mere selection effect holds (given that Jane has been woken, a double six must have been rolled) but not the converse selection effect (just because a double six has been rolled, it doesn't follow that Jane will be woken, as it could have been someone else's partner who rolled a double six). If White is correct that the inverse selection effect doesn't hold in the actual fine-tuning case, then Jane 2 gives a better analogy for the reality of fine-tuning than Jane 1.

Working with Jane 2 as the correct analogy, what can we infer from the evidence of fine-tuning? It seems clear that Jane's inference in Jane 2 is incorrect. The fact that she was woken entails that *her partner* rolled a double six. But whether or not there are other sleeper-partner pairs has no bearing on the likelihood of *her partner* rolling a six. By analogy, White wants to conclude, the fine-tuned evidence gives us no reason to think there are other universes. All we know is that *our universe* is fine-tuned, and whether or not there are other universes has no bearing on the likelihood of our universe being fine-tuned. Assuming there is no converse selection effect, reflection on the above analogies seem to support the IGFC.

Whilst I haven't read this in print, many people have suggested to me in conversation that the Jane thought experiments are problematic because the individual of focus is 'pre-selected' before the dice-rolling takes place. Whether or not this alters things in a problematic way, it is clearly a disanalogy to the real-world fine-tuning situation: in the Jane scenarios, Jane pre-exists the lucky dice-rolling, whereas, in the real-world, we came into existence as a result of the event that corresponds to the lucky dice-rolling, i.e., our universe coming into existence with finely tuned parameters. This potential worry is avoided in the following thought experiment:

> <u>Jane 3</u>: Jane is the product of IVF. One day she discovers that the doctor who performed the IVF which led to her existence rolled dice to see whether to fertilise the egg, determining to do so only if she rolled a double six. Given that she exists, Jane concludes that the doctor must have adopted this decision procedure in the case of many other potential IVFs.

This avoids the worry with the Jane 2 scenarios, as Jane does not pre-exist the dice-rolling, just as we do not pre-exist the fine-tuning. But correcting this disanalogy does not remove Jane's error. Her evidence is that a double six was rolled to decide whether *her* conception would go ahead. How many times the doctor has done this with respect to other potential conceptions has no bearing on how likely a double six was to come up in the case of her conception. Perhaps it would be rational for Jane to infer 'Well if the doctor has done this once, she's probably done it many times.' But that's a different inference: an inference from the fact that the doctor applied this decision procedure, not from the fact that the decision procedure was, against improbable odds, successful. In so far as we're exploring the evidential implications of fine-tuning, we need to focus on what Jane can infer from the fact that the right numbers came up to allow her conception to go ahead.

Very often when I have raised the Jane 3 case, collocutors have wanted to respond with a slight twist on the case:

> <u>Jane 4</u>: Jane is the product of IVF. One day she discovers that the doctor who performed the IVF which led to her existence rolled dice to see whether to fertilise the egg, determining to do so only if she rolled a double six. Given that she exists, Jane concludes that the doctor must have rolled the dice many times to try to get a double six.

In this case, Jane would be making a correct inference. But this final scenario fails to mirror the inference of multiverse theorists in the real-world fine-tuning case. In the Jane 4 case, Jane infers that the doctor had many rolls of the dice to determine whether her conception would go ahead. That corresponds to us inferring that our universe had multiple shots at having the values of its parameters fixed, such that it proceeded with its expansion only when the fine-tuned constants came up (we might imagine the Guardian of the Cosmos waiting to see if the fine-tuned constants come up, and then allowing the universe to proceed with its expansion). But this is not the inference fine-tuning theorists are making. Rather they are inferring from the fact that the right numbers came up for *our* universe to the hypothesis that there must be many *other* universes where the wrong numbers came up. This corresponds to the bad inference made in the Jane 3 case.

As well as defending his position with analogies similar to those outlined above, White offers a deeper analysis of what's going on here.[3] The core of the issue, for White, is how we ought to construe the evidence of fine-tuning. Two possibilities suggest themselves:

> E = α is life-permitting (where α is our universe).
> E' = Some universe is life-permitting.

White then goes on to argue that E', but not E, raises the probability of the multiverse. He supposes that 'we can partition the space of possible outcomes of a big bang into a finite set of equally probable configurations of initial conditions and fundamental constants: $\{T_1, T_2, \ldots, T_n\}$ (think of the universes as n-sided dice, for a very large n)' such that one of T_1 is the only configuration of initial conditions and fundamental constants required for the possibility of life. For E to be true, there needs to be a universe instantiating T_1, as opposed to any of the other equally possible configurations. If there is just one universe, this is incredibly improbable (1/n); the more universes there are, the more likely it is that one of them will happen to instantiate T_1. In other words, E' is more likely if there is multiverse than if there is only a single universe:

> $P(E'|M) > P(E'|{\sim}M)$ (where M is the hypothesis that there is a multiverse).

However, for E to be true, we need not just any old universe to instantiate T_1, we specifically need α to instantiate T_1. And, according to White, the number of universes distinct from α has no bearing on whether itself will happen to instantiate T_1. As White puts it:

> The events that give rise to universes are not causally related in such a way that the outcome of one renders the outcome of another more or less probable. They are like independent rolls of a die (White 2000: 263).

In other words:

> $P(E|M) = P(\alpha \text{ instantiates } T_1) = 1/n = P(E|{\sim}M)$

Assuming a standard Bayesian conception of evidence as raising of probability, we can conclude that if the evidence of fine-tuning is to be construed as E', then it is evidence for a multiverse; but if the evidence of fine-tuning is given by E, then it is not evidence for a multiverse. If the reasoning thus far is sound, therefore, the crucial question is whether our evidence should be construed as E or E'. At this point, White (2000: 264) brings in the following principle:

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[3] White gives his analysis first, and then goes on to employ some of the Jane thought experiments in discussing the selection effect. I hope my ordering is exegetically more effective.

Total Evidence Requirement (TER): '…in the confirming of hypotheses, we cannot, as a general rule, set aside a specific piece of evidence in favor of a weaker piece' (White 2000: 254).

White (2000: 264) offers the following case in support of TER:

> Suppose I'm wondering why I feel sick today, and someone suggests that perhaps Adam got drunk last night. I object that I have no reason to believe this hypothesis since Adam's drunkenness would not raise the probability of me feeling sick. But, the reply goes, it does raise the probability that someone in the room feels sick, and we know that this is true, since we know that you feel sick, so the fact that someone in the room feels sick is evidence that Adam got drunk. Clearly something is wrong with this reasoning.

What has gone wrong with this reasoning, according to White, is that TER has been disrespected: the stronger evidence – that a specific individual, namely White himself, is feeling sick – has been set aside in favour of a weaker piece of evidence – namely that someone in the room feels sick. White accuses multiverse theorists of the same mistake: setting aside a stronger piece of evidence – that a specific universe, namely α, has been fine-tuned – in favour of a weaker piece of evidence – namely that some universe has been fine-tuned.

There are a number of different objections philosophers have raised to White's argument. Some, for example, have questioned TER (Epstein 2017). In the postscript of the reprint of his article pressing the IGFC, White offers a different theoretical justification for the focus on E rather than E'. Even in the absence of a deeper theoretical analysis, the Jane analogies seem to me to make a good case for construing the evidence of fine-tuning as E rather than E'. In any case, my main focus in this paper is on whether the essentialist response to the IGFC succeeds, and the essentialist response does not question White's contention that the fine-tuning evidence should be construed as 'our universe is fine-tuned' rather than 'a universe is fine-tuned.' I will therefore take for granted in what follows that White is correct on this specific point.

II – The Essentialist Response

The essentialist response to the inverse gambler's fallacy charge questions the following implicit assumption of Hacking and White:

> *The Contingency Assumption* – The parameter values of the laws of physics and initial conditions of our universe – the strength of gravity, the mass of electrons, etc. – are contingent properties of our universe. In other words, these parameters might have had different values, and hence our universe might not have been fine-tuned.

To the best of my knowledge, this issue was first raised by Rodney D. Holder (2002).[4] In White's formalism, the Contingency Assumption is the assumption that T_1 (the configuration of initial conditions and fundamental constants required for the possibility of life) is a contingent property of α (our universe). Rejecting this assumption, Holder explores what happens if we 'start from the more logical tack that our universe by definition possesses as its essential properties those represented by T_1' and further that T_1 could not be instantiated more than once (Holder 2002: 305-6). In other words, Holder works from the assumption that the instantiation of T_1 is necessary and sufficient for the existence of α. Given that all sides agree that the multiverse hypothesis raises the probability that T_1 will be instantiated, Holder's assumption entails that the multiverse hypothesis raises the probability that α exists. Support for the multiverse is secured and the IGFC fails.

However, Holder's argument against the Contingency Assumption is obscure:

> By defining α as a rigid designator of our universe, White is committing a modal fallacy when he goes on to assert that α might not have been life-permitting. Indeed, instead of rigidly designating our universe, on White's treatment α might as well denote any randomly chosen universe – in fact, it would seem that this is exactly what α does represent (Holder 2002: 305).

Holder seems to be implicitly assuming that if 'α' is a rigid designator, it must pick out our universe is terms of some of its properties, and that the only properties that could play this role are those expressed by T_1. Hence, thinks Holder, given that White is clearly not taking T_1 to enter into the reference-fixing condition of 'α' – for if it did, our universe would instantiate T_1 by definition – White is inconsistent in asserting that 'α' is a rigid designator.

There are two problems with this argument. Firstly, Holder seems to be ignoring the possibility that we pick out our universe at least partly by *demonstration*: by, as it were, pointing at the physical world around us, and perhaps specifying that 'the universe' is everything connected in space and time to the thing pointed at.[5] It would then be a question of metaphysics, not language, what are the essential properties of the thing thus demonstrated. Secondly, even if we do pick out the universe by description, it doesn't follow that the description determines the essence of the referent. Perhaps we pick out α as *the actual thing that instantiates T_1*. Just as there are possible worlds in which water exists

[4] I am deeply indebted to Manson's 2021 literature survey on the IGFC for bringing together the four papers considered here.

[5] One might worry that there is something peculiar about referring to the universe by demonstration, given that we can't point to anything distinct from the universe. However, it's not clear to me that this objection is correctly identifying a necessary condition for demonstrative reference: I can demonstratively refer to my own mind despite the fact that I can't 'inwardly point' at anybody else's mind. I will not here explore this concern in too much detail, given the availability of the descriptive alternative outlined above.

without instantiating the properties we use to pick it out in the actual world – being colourless and odourless, falling from sky, etc. – so it could be that there are possible worlds in which our universe exists without the properties we use to pick it out in the actual world. Given these two possibilities, we certainly cannot infer from the thesis that 'α' is a rigid designator to the thesis that T_1 is an essential property of α.

In a publication one year later, Manson and Thrush (2003) again raised the issue of (what I'm calling) the Contingency Assumption, this time by pointing out that there are at least some theories of the identity conditions of a universe which, if true, cast doubt on it. They consider, for example, the view that each set of possible parameters defines a cosmic essence, with the cosmic essence of our universe constituted of T_1. On this understanding of what a universe is, Holder would be correct that the instantiation of T_1 is necessary and sufficient for the existence of our universe, and the IGFC would fail. Crucially, however, Manson and Thrush are not arguing that the Contingency Assumption is false. Their point is rather that there is a gap in the argument of Hacking and White; if their argument is to have force, they need to demonstrate – not just assume – the Contingency Assumption.

Another two years later, a paper by Cory Juhl (2005) argues that the inverse gambler's fallacy charge fails whether or not the Contingency Assumption is true. Juhl interprets the Contingency Assumption as the metaphysical view that our universe is essentially defined by its *haecceity*, i.e., its non-qualitative particularity or *thisness*. If, contra the Contingency Assumption, our universe is essentially defined by the parameter values of its laws and initial conditions, then the inverse gambler's fallacy charge fails for the reasons discussed above. But even if, in line with the Contingency Assumption, our universe is essentially defined by its haecceity, then we still find support for the multiverse hypothesis, according to Juhl. This is because the instantiation of α's haecceity is much more likely on the assumption that there are many universes than it is on the assumption that there is only one universe.

One striking thing about Juhl's argument is that he accepts that the putative support for the multiverse does not derive from the fact that our universe is fine-tuned. This is clear in so far as that support derives from the multiverse hypothesis making it more likely that α's haecceity is instantiated: given that α's haecceity is logically and metaphysically independent of T_1, the probability of T_1 being instantiated has no bearing on the probability of α being instantiated. However, even in so far as support for the multiverse arises from the fact that α instantiates T_1, Juhl still holds that it is not relevant that T_1 represents the fine-tuning of the universe for life:

> …appeal to fine-tuning in particular is not required in order to yield justified inference…. Fine-tunedness for life is simply one among many equally improbable ways the laws and initial conditions might have turned out…Thus one might say that it is not fine-tuning per se that does the work in the inference. (Juhl 2005: 344)

Thus, according to Juhl even if the initial conditions and constants of our universe had not turned out to be fine-tuned for life, so long as it is improbable that the parameters of physics should have the values they do – which presumably it would be so long as those parameters could have had a wide range of other values – we get support for the multiverse hypothesis, as it is much more likely that the improbable actual values will come up if there are many universes than if there is only one. This seems to make support for the multiverse too easy. For almost all of the scientists and philosophers who are drawn to the multiverse explanation for reasons in this vicinity, their motivation is to explain the striking fact that our universe is fine-tuned for life. In my judgement, the fact that, on Juhl's account, the fine-tuning for life totally drops out of the picture is a reason to suppose that Juhl has made some kind of error.

In any case, the basic argument Juhl is pushing is pressed, in a bit more detail, in Graham Oppy's discussion of fine-tuning in his (2006) book of the following year. If we are to suppose that the parameter values of our universe are non-essential features of it, then Oppy suggests we should suppose that there are $H_1,\ldots,H_m$ equally probable haecceities, in addition to the $T_1, T_2,\ldots, T_m$ possible parameter values, yielding m x n possible universes: each one corresponding to one of $H_1,\ldots,H_m$ instantiating one of $T_1, T_2,\ldots, T_n$. Assuming our universe exists, the probability that it will be fine-tuned is 1/n. But for our universe to exist and be fine-tuned it first needs to exist, and for it to exist, its haecceity needs to exist. Given that there are m equally probable haecceities, on the assumption that only one universe exists, there is a 1/m chance that that universe will be α. The more universe haecceities there are, the more likely it is that α's haecceity will be instantiated; to take the extreme case, if m non-identical universe haecceities exist, then the probability that α exists is 1.

On the other hand, if the parameter values of our physics are essential to α, then Oppy thinks we should equate the probability of α existing with the probability that its configuration of initial conditions and fundamental constants are instantiated. He justifies this via an appeal to the identity of indiscernibles to support the thesis that each universe instantiates only one of $T_1, T_2,\ldots, T_n$. It follows from these assumptions that, if there is only one universe, the probability that our (fine-tuned) universe exists is 1/n. The more universes there are, the more likely it becomes that our fine-tuned universe will exist; in the extreme case: if there are n universes, the probability that our (fine-tuned) universe will exist is 1.

In contrast to Juhl, Oppy doesn't explicitly say that, on his account, there would be support for the multiverse regardless of whether our universe is fine-tuned. And it would be consistent with what Oppy does say to hold that much of the support for the multiverse hypothesis comes from the fact that our universe is fine-tuned. However, it is equally clear that, on his account of the evidential situation, if the Contingency Assumption is true, there is significant support for the multiverse hypothesis that is totally independent of the fine-tuning. Suppose that, as science develops, we discover that our universe is not in fact fine-tuned. Nonetheless, we can take as our evidence simply that α exists, and consider how likely that evidence is on the single universe hypothesis and on the multiverse hypothesis. According to Oppy's interpretation of the Contingency Assumption: on the multiverse hypothesis, there is a 1/m chance that α's haecceity will exist; whereas the more universes there are, the better those odds become, culminating in a probability of 1 if there are m universes. Thus, *no matter how our universe turns out*, we will have significant support for the multiverse hypothesis. I suggest we should take this implication to be a reductio ad absurdum of Oppy's (and Juhl's) account of the evidential situation given the Contingency Assumption.[6]

If their account is wrong, wherein lies the error? I suggest we locate it in Oppy's assumption, perhaps also implicitly made by Juhl, that there is a finite number of haecceities. What could possibly limit the number of possible haecceities to a certain finite number? Surely, if there is one haecceity, then there are infinite. In that case, no matter how many finite universes there are, the probability that α will exist is the same: $1/\infty$. In other words, the postulation of a large but finite number of universes does not increase the probability that our universe exists.

What about the hypothesis that every haecceity exists, call this 'the maxiverse hypothesis'? Does the existence of α not support the maxiverse hypothesis? After all, on the single universe hypothesis, the probability that α exists is $1/\infty$, while on the maxiverse hypothesis, the probability that α exists is 1. What greater evidential support could one ask for than an infinite Bayes factor? However, the maxiverse hypothesis entails the existence of α simply because it *explicitly includes* the existence of α, as well as lots of other stuff. Nobody thinks the evidence E_1 that I had breakfast this morning gives us good grounds for accepting the hypothesis H_1 that I had breakfast this morning and there are unicorns: H_1 is merely E_1 conjoined with a random postulation not at all supported by E_1. Similarly, the evidence E_2 that α exists does not provide good grounds for accepting the maxiverse hypothesis, as the maxiverse hypothesis is merely E_2 conjoined with a huge number of random postulations not at all supported by E_2.

To be fair, a similar charge has been made against attempts to draw evidential support from fine-tuning (McGrew, McGrew & Vestrup 2001; Colyvan, Garfield & Priest 2005). If the range of possible values of a given parameter is infinite, either because there is no upper

[6] It is worth noting that later in the chapter, Oppy concedes that the IGVC is 'clearly right in the case in which we suppose that there is a "cosmic roll of the dice" that fixes the values of the relevant parameters at some time t in the early history of the universe' (Oppy 2006: 223). I will argue in the next section this is exactly what we do find in the version of the multiverse hypothesis most popular among scientists as a way of trying to account for the fine-tuning. However, Oppy then goes on to suggest the IGVC might be avoided if we construe the evidence of fine-tuning as 'the fact that this cosmic fine-tuning data are presented to me for consideration.' I find it very hard to see how this would make a difference. As Oppy later considers, the IGVC would still seem to apply, as the multiverse doesn't raise the probability that *I* – as opposed to someone else – would be subject to a presentation of the fine-tuning data. Oppy responds to this worry by pointing out that there are *many* observers subject to a presentation of the fine-tuning data. But I can't see how a move from the first-person singular to the first-person plural changes anything: the multiverse hypothesis doesn't raise the probability that *we* – as opposed to some other observers – will be subject to a presentation of the fine-tuning data, any more than it raises the probability that *I* will be subject to a presentation of the fine-tuning data. Along the way, Oppy considers an analogy of someone reading about a lottery winner in a newspaper: 'If few lottery tickets are purchased, then it is extraordinarily unlikely that readers of the newspaper report will learn that there was a winning ticket (Oppy 2006: 226).' But in this case – also in the similar golfing analogy he gives – there is plausibly an inverse selection effect, as whoever won the lottery the newspaper would have printed their name.

limit or because there is an infinite range of possible values between any two points on the scale, then the probability that the parameter will be fine-tuned looks to be $1/\infty$, no matter how broad the fine-tuned range of possible values is. If this charge succeeds, then any empirical evidence regarding how apparently narrow the fine-tuned range for any given parameter is will turn out to be irrelevant; no matter how broad the range is, so long as it's finite, the probability of its being fine-tuned will be the same.

However, there are responses that can be made to this worry about the evidential import of fine-tuning. It is not obviously obligatory to consider the entire range of possible parameter values, if there is a narrower range that is fairly natural and non-arbitrary. Robin Collins (2009: 4.4), for example, argues for the following two theses:

(A) it is reasonable to focus on the 'epistemically illuminated' range, i.e., the range of parameter values for which we can assess whether or not they are life-permitting,
(B) the epistemically illuminated range is finite, because, for example, our current physical theories apply only below certain energy levels.

We can ensure this focus by building into our background knowledge that our universe is a member of a certain finite set of possible universes: the set of all universes with physical laws and initial conditions indiscernible from P – where 'P' rigidly designates α's actual physical laws and initial conditions – except for having different parameter values from the epistemically illuminated range, such that, for any possible combination of parameter values from the epistemically illuminated range, there is a universe in the set that exemplifies that possible combination. Thus, effectively, we are not asking 'How likely is a life-sustaining universe (from all of the possible universes there might have been')?', but rather 'Given that our universe is in such and such finite set of possible universes (where the set is natural and non-arbitrary), how likely is it that our universe would be life-sustaining?'

As Collins notes, John Leslie has previously defended something like this approach with the following analogy:

> If a tiny group of flies is surrounded by a largish fly-free wall area then whether a bullet hits a fly in the group will be very sensitive to the direction in which the firer's rifle points, even if other very different areas of the wall are thick with flies. So it is sufficient to consider a local area of possible universes, e.g., those produced by slight changes in gravity's strength .... It certainly needn't be claimed that Life and Intelligence could exist only if certain force strengths, particle masses, etc. fell within certain narrow ranges … All that need be claimed is that a lifeless universe would have resulted from fairly minor changes in the forces etc. with which we are familiar. (Leslie: 1989:138-9; quoted in Collins 2009: 4.4).

Of course, one may not be satisfied with this way of accounting for the probabilities involved in fine-tuning arguments, and it is not within the business of the paper to defend it. For our purposes, we need only note that no such strategy is available when trying to ask how likely is it that the haecceity of our universe would be instantiated. Precisely because haecceities are featureless, there is no way of drawing a natural and non-arbitrary division among them. We are stuck with the probability of $1/\infty$.

Let's start to bring all of this together. We have explored three ways of interpreting the essentialist response:

1. Holder: The IGFC fails because it relies on the Contingency Assumption and the Contingency Assumption is false.
2. Manson and Thrush: The IGFC, as presented by Hacking and White, is incomplete as it relies on an assumption that Hacking and White have not defended, namely the Contingency Assumption.
3. Juhl and Oppy: The IGFC fails, as we gain support for 'α is fine-tuned' whether or not the Contingency Assumption is true.

I have argued above for the following two claims:

- Holder's response fails as his argument against the Contingency Assumption is unsound,
- Juhl's and Oppy's responses fail, as 'α is fine-tuned' does not raise the probability of the multiverse if the Contingency Assumption is true (or more cautiously: Juhl's and Oppy's attempts to show that it does fail).

This leaves Manson and Thrush's version of the Essentialist Response. So understood, the essentialist response is not a refutation of the IGFC but a challenge: give us a reason for accepting the Contingency Assumption. In the next section I will argue that this form of the essentialist response is ineffective when the version of the multiverse under consideration is the one most favoured by the scientific community for explaining fine-tuning.

III – The Inflationary Multiverse

In what follows I will lay out the specific details of the multiverse hypothesis most often appealed to by scientists attempting to account for fine-tuning, namely that rooted in eternal inflation and string theory.[7] I will then turn to the question of whether the Contingency Assumption is true on this theory.

Cosmological Inflation (Guth 1981, 2000) is the theory that the early universe enjoyed a period of exponential expansion before moving to a slower rate of expansion. This inflationary period is posited to explain the large-scale structure of the current universe, for example, the fact that the universe is flat and that the cosmic microwave background radiation is evenly distributed. *Eternal* inflation (Steinhardt 1983, Vilenkin 1983) is a form of cosmological inflation according to which the inflationary period never ends for space as a whole, although it ends for regions of space. What we think of as 'our universe' is in fact just a region of space in which inflation has come to an end. According to eternal inflation, there are many such non-inflationary regions, or 'bubble universes,' separating by exponentially

[7] Everettian 'many worlds' theories are also very popular, but less appealed to as an explanation of fine-tuning. Having said that, there are some attempts to deal with fine-tuning via Everettianism (Wilson 2020). It's an interesting question whether such views would avoid the IGFC, but one outside the scope of this paper.

inflating space. Some physicists (Guth 2001) believe that once inflation is combined with quantum theory, eternal inflation is all but inevitable because of quantum fluctuations.

A crucial point that is often not explicitly made in discussions of fine-tuning is that eternal inflation alone does not account for the fine-tuning. That's because eternal inflation is consistent with the parameters of physics being the same in all bubble universes, and if the parameters of physics were the same in all bubble universes, we would be left with the highly surprising fact that all bubble universes are fine-tuned. The puzzle of fine-tuning would remain untouched.

This is where string theory comes in. According to string theory, the fundamental constituents of reality are not particles but one-dimensional strings. Each string is located at a single point in spacetime, housed in a high-dimensional shape in which most of the dimensions are 'curled up.' The facts of physics, including the parameters we are concerned with in fine-tuning discussions, are fixed by the patterns of vibrations of the strings, which are in turn determined by the high-dimensional shapes in which the strings vibrate.

In fact, there is a very big number – around 10^{500} – of high-dimensional shapes which could in principle house the strings, each corresponding to a different possible universe with different kinds of particles and forces. This set of possibilia is referred to as the 'string landscape.' This opens up the theoretical possibility that different bubble universes might exemplify different options from the string landscape. We can call the theory that posits this theoretical possibility 'landscape eternal inflation.' Proponents of this theory speculate (Tegmark 2014: Ch. 6) that the high energies that exist during inflation are able to mould, somewhat randomly, the high-dimensional shapes contained in different regions of spacetime; as a result, different bubbles emerge from inflation with different particles and forces.

A second point often not make explicit in these discussions is that there are no empirical grounds for moving from eternal inflation to landscape eternal inflation. String theory is highly speculative. Moreover, even if we accept string theory, there is no empirical reason to think that different possibilities in the landscape are actually instantiated. It is quite coherent to suppose that eternal inflation and string theory are both true, but that each bubble universe contains exactly the same particles and forces, because each point in the entire multiverse contains the same high-dimensional shape. Call the theory expressing this possibility 'homogenous eternal inflation.' There is no empirical reason to favour landscape eternal inflation over the simpler theory of homogenous eternal inflation, and all things being equal simpler theories are to be preferred.

Or rather, there is no empirical reason to favour landscape eternal inflation over homogenous eternal inflation *other than the fine-tuning* we observe in our universe. The reason some scientists take seriously landscape – as opposed to homogenous – eternal inflation is because it seems to provide a nice explanation of fine-tuning. If different particles and forces exist in different bubbles, such that a wide range of different parameter values show up in the physics of different bubbles, then it perhaps becomes not so surprising that our universe would happen, just by chance, to have fine-tuned parameters.[8]

In so far as scientists take *landscape* (as opposed to homogenous) eternal inflation seriously, then, it is because they believe that the fine-tuning provides evidential support for the move from homogenous eternal inflation to landscape eternal inflation. However, assuming White is correct that the relevant evidence is that *our universe* is fine-tuned – which in the context of eternal inflation is understood as the evidence that *our bubble* is fine-tuned – the crucial question is whether or not the assumption of landscape eternal inflation raises the probability that our bubble is fine-tuned.

Having outlined landscape eternal inflation, I turn now to the question of whether the Contingency Assumption is true on this theory. According to the Contingency Assumption, the parameters contained in the laws and initial conditions of our universe might have had different values. In the context of assuming landscape eternal inflation 'our universe' means not the whole of physical reality but our bubble universe. In other words, our question is whether or not the parameters contained in the laws that specifically describe our bubble universe, and the initial conditions of our bubble universe, might have been different. In what follows I will be hypothetically assuming landscape inflation theory, in order to explore its implications, and hence will take 'α' to refer to our bubble universe.

Assessing this question requires forming a view as to what essentially defines a bubble universe in landscape eternal inflation. Although Manson and Thrush do not consider eternal inflation in any detail, they do suggest that 'with cosmogenic models whereby universes grow out of inflating "bubbles" in a pre-existing hyperspace, perhaps the bubbles can be distinguished in terms of their positions in this hyperspace' (Manson & Thrush 2003: 77). This does indeed seem to be the most plausible view about the essence of bubbles in eternal inflation. Just as it's plausible following Kripke (1980) that I am essentially defined in terms of the sperm and egg from which I originated, so it's plausible that our bubble universe is essentially defined in terms of the region of space which stopped inflating to create this bubble. Call LEI combined with this view about the essence of bubbles in 'EO-LEI' (EO for 'essential origins').[9]

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[8] Although White disputes that the fine-tuning is evidence for the multiverse, he accepts that if we assume – perhaps on independent evidence – that there is a multiverse (of the right kind), the fine-tuning is not surprising. Section VI of White 2000 offers an account of what makes an event surprising.

[9] Manson and Thrush (2003:77) say that this kind of multiverse raises the question of what determines the identity conditions of regions in the larger space. It doesn't seem to me that we need to answer this question in order have grounds for holding that the identity conditions of the bubbles are determined by their location

According to EO-LEI, our bubble ends up not being essentially fine-tuned. For recall, on LEI, random processes fixed the high-dimensional shapes contained in the region of space that became our universe when it stopped inflating. Those random processes happened to result in α having fine-tuned parameters, but those random processes might easily have rendered α non-fine-tuned. And crucially, at the time those random processes were moulding the high-dimensional shapes which would ultimately determine the physics in α, how many *other* regions of space were being randomly moulded had absolutely no bearing on how likely it was that the region of space that would become α would turn out fine-tuned. Although White is not working with a specific scientific model of the multiverse, the assumptions he makes about universe formation fit perfectly with EO-LEI:

> The events which give rise to universes are not causally related in such a way that the outcome of one renders the outcome of another more or less probable. They are like independent rolls of a die (White 2000: 263).

Could we not combine LEI with the 'cosmic essence' view of Manson and Thrush outlined earlier? On this view (call it 'CE-LEI' for 'cosmic essence' LEI), α is entirely essentially defined by its parameter-values. Call the region of space which stopped inflating to become our universe 'the seed.' CE-LEI entails the following two propositions:

> P1: In another possible world in which random processes had moulded the seed to have different parameter-values, a universe non-identical with α would have resulted.
> P2: Any bubble universe (actual or merely possible) with the same physics as α is identical with α.

P2 is implausible. Just because another bubble universe ends up having the same physics as ours, that clearly doesn't make it numerically identical to our universe. Despite having the same physics, these bubbles have different locations in the multiverse, and, by Leibniz's law, identical things cannot have different properties.[10]

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in the larger space. Moreover, either an account in terms of the relational properties of a given region, or one involving the postulation of haecceities at regions or points, would seem to be adequate.

[10] One option would be to adopt analogous strategies to those endurantists adopt to avoid the problem of temporary intrinsics (Lewis 1986: 202-4, Haslanger 1989, Macbride 2001). For example, one could hold that a single universe instantiates all of its properties not simpliciter but relative to a location in the multiverse. This would allow a single universe to be multiply located in the style of a Catholic saint. But one would need motivation for introducing all this metaphysical baggage, and the motivation shouldn't be avoiding the IGFC. One should rather work out the most plausible version of a given multiverse hypothesis and then assess whether or not the essentialist response succeeds, relative to that hypothesis.

What about a hybrid of EO-LEI and CE-LEI? According to H-LEI – 'H' for 'hybrid' – α is essentially defined *both* by its location in the multiverse *and* by its parameter-values. Hence, P1 is true but P2 is false. On EO-LEI, we can take it that the seed is identical with α: a single entity merely changes state as its high-dimensional shapes are fixed and it stops inflating. On H-LEI, however, the seed and α cannot be identical, which can be demonstrated in the following:

1. Assuming H-LEI, in any non-actual world in which the universe α^* which results from the seed has different physics, α is not identical with α^* (this follows from P1).
2. Given that α is not identical with α^*, the seed cannot be identical with both α and α^* (by the transitivity of identity).
3. Either the seed is identical with both α and α^* or it is identical with neither α nor α^* (it would be arbitrary to say it's identical to one but not the other).
4. Therefore, the seed is identical with neither α nor α^*.

Thus, on H-LEI, we say either that the seed ceases to exist to be replaced α, or (more plausibly) the seed continues to exist but comes to constitute a new entity α. This is an ad hoc multiplication of entities. By far the more natural assumption is that the seed *becomes* α, as an embryo becomes, in the fullness of time, an adult. The only motivation I can see for holding otherwise is to avoid the IGFC. But this would get things the wrong way around. We should be trying to work out the most plausible view as to what essentially defines α and *then* judging whether the IGFC applies, rather than fixing the game by allowing our desire to avoid this objection to shape our view of what essentially defines α.

Conclusion

I have not considered every response that has been raised to the inverse gambler's fallacy charge, nor every version of the multiverse hypothesis. I have rather focused on the version of the multiverse most popular with scientists attempting to account for fine-tuning – landscape eternal inflation – and considered whether, on this version of the multiverse, the essentialist response to the inverse gambler's fallacy charge is successful. I hope to have shown that it is not. The many proponents of landscape eternal inflation should either find an alternative response to the inverse gambler's fallacy charge or accept that their view is not supported by the evidence of fine-tuning.

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