How Physics Might Undercut Fine-Tuning Arguments

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Abstract: I explore how evidence from physics in favour of multiverse scenarios bears on the fine-tuning argument for the existence of a divine designer. Arguments from apparent fine-tuning of physical parameters to the existence of a multiverse are familiar and disputed; I focus instead on the epistemic consequences of discovering independent evidence from physics for the existence of a multiverse. I will argue that independently-motivated multiverses have the potential to act as undercutting defeaters for the fine-tuning argument, but that whether they in fact do undercut the argument depends on open questions in fundamental physics and cosmology. I will also argue that Everettian quantum mechanics opens up a new route to undercutting fine-tuning arguments, though it is not by itself sufficient to undercut them.

1. The Standard Fine-tuning Dialectic

According to the notorious fine-tuning argument, the evidence of cosmological fine-tuning provides confirmation for the proposition that there is a divine designer. The basic thought is that fine-tuning evidence would be much less surprising if there is a designer than it would be if there is no designer. *Anthropic* reasoning has sometimes been deployed to block the fine-tuning argument, by resisting the thought that fine-tuning evidence would be in any way surprising if there was no designer, and hence denying that there is a disparity in surprisingness. But this response to the fine-tuning argument has been influentially criticized, though: in John Leslie's vivid analogy, you ought to be surprised to find yourself alive after a reliable firing squad has attempted to shoot you (and may reasonably infer some unknown cause of their all missing) even if you wouldn't have been around to be unsurprised if they had successfully carried out their task. A reliable firing squad all missing is just *intrinsically unlikely*. And the problem with the anthropic response is that the occurrence of fine-tuned constants seems likewise to be highly intrinsically unlikely—even though it is not at all unexpected given that such constants are observed. And do not highly intrinsically unlikely events call out for explanation, of the kind offered by the design hypothesis?

Resisting any probability boost to the design hypothesis requires that the occurrence of fine-tuned constants themselves not be intrinsically unlikely. And this is where multiverses have tended to enter the story. Positing a multiverse, containing a universe for every possible combination of constant values, seems to achieve the required result: it is *not* unlikely that somewhere amongst all the universes of the multiverse there is a universe with the right constant values in which there is life.

The problem with this move (according to arguments of Hacking 1987 and White 2000) is that it still seems unlikely that *this very universe* – the one we in fact inhabit – has fine-tuned constant values. After all, most universes in the multiverse do not. As responsible epistemic agents, we know to take into account the whole of our evidence – and our evidence tells us that *this universe is fine-tuned*, not merely that *some universe is fine-tuned.* And this logically stronger evidence seems no less unlikely given a multiverse cosmology than it is given a single universe cosmology. This universe, we may reason, had only a minute chance of ending up with the right constants—so you and I had only a minute chance of existing. At least on the assumption that the universes are causally isolated, the existence or non-existence of lots of other universes doesn't seem to make any difference to the probability that this universe is fine-tuned. So the existence of a multiverse doesn't make the fine-tuning of our universe more probable, and the evidence that our universe is fine-tuned does not support the multiverse hypothesis over the single-universe hypothesis. My understanding is that this argument has been influential in maintaining the credibility of the fine-tuning argument in recent epistemology.

There is of course no consensus. But the focus of the debate has been on whether someone not committed to the existence of a multiverse should regard fine-tuning evidence as supporting a multiverse. I want to ask a different question: if we endorse a multiverse theory on independent grounds, then how is the epistemic import of fine-tuning evidence affected?

2. Multiverse Hypotheses as Undercutting Defeaters

As far as I know, the question of what fine-tuning evidence supports on the supposition that a multiverse exists has not been much explored. One exception is Roger White, who writes as an afterthought to his defence of the position outlined above:

> "the Multiple Universe hypothesis screens off the probabilistic link between the Design hypothesis and the fine-tuning data. Hence if we happened to know, on independent grounds, that there are many universes, the fine-tuning facts would give us little reason to question whether the big bang was an accident, and hence our knowledge of the existence of many universes would render the fine-tuning of our universe unsurprising." (White 2000, p.273-274)

To put White's point in another way: the existence of an appropriate multiverse is an *undercutting defeater* for the design hypothesis. It does not provide direct evidence against the existence of a divine designer, as a rebutting defeater would (perhaps the problem of evil is a candidate rebutting defeater for the fine-tuning argument?); rather the existence of an appropriate multiverse provides evidence that the evidence of fine-tuning does not support the existence of a divine designer.

We may use the familiar analogy of misleading lighting. An object looks red to us (a fine-tuned universe looks designed) so we conclude that it is red (so we conclude there is a divine designer); but, once we are informed that the object is being illuminated with red light (once we are informed that there is a multiverse), we recognize that we now ought to revert to our prior expectations about the object's colour (we now ought to revert to our prior expectation about whether there is a divine designer). Information about the misleading lighting screens off the evidential relevance of our perceptual experience to the object's colour. (Information about the existence of the multiverse screens off the evidential relevance of the fine-tuning evidence to the existence of a divine designer.)

There are interesting open questions about exactly how undercutting defeat works, raised in recent work by Maria Lasonen-Aarnio, Scott Sturgeon and others. Does it work by providing reasons for positive higher-order beliefs about causal or other explanatory relationships between the posited phenomenon and our possession of the evidence that seems to count in favour of that phenomenon? Or does it work purely by pruning away features of our epistemic states, without itself providing us with any positive reason for belief in any proposition? On the former model, the independent evidence *that there is a multiverse* provides new positive reason to believe the higher-order thesis: *that the evidence that this universe is fine-tuned fails to support the thesis that there is a divine designer.* On the latter model, the independent evidence that there is a multiverse merely cuts away some structure within our epistemic states, eliminating the link between fine-tuning and divine design. But we need not pursue these questions here; what concerns us is which sorts of multiverses are capable of acting as undercutting defeaters and why, not the mechanism by which this undercutting defeat operates.

Before we look in more detail at the kinds of multiverses for which there might be independent evidence, and assess whether they really do act as undercutting defeaters for the evidence from fine-tuning, it is worth observing that the posit a multiverse for fine-tuning-independent reasons does not eliminate the evidential import of fine-tuning altogether. Even if evidence of fine-tuning does not support the multiverse hypothesis, and even if the multiverse hypothesis screens off the support the fine-tuning evidence provides for the existence of a divine designer, the evidence of fine-tuning may support other surprising conclusions. By analogy, your having an experience as of a red object may support some potentially surprising conclusions even if it does not support the misleading-lighting hypothesis, and even if the misleading-lighting hypothesis screens off its support for the red-object

hypothesis. For example, it may support the hypothesis that the inhabitant of the room likes the colour red, or it may support the hypothesis that you can see in colour. So: what should multiverse proponents regard as the evidential import of fine-tuning evidence?

My first observation is that it depends on which kind of multiverse is posited. Physicists do not posit multiplicities of universes first and ask questions about those universes later (though this impression might be gained from certain philosophical work on the topic). Rather, they posit certain kinematical structures and dynamical laws in order to explain observed physical phenomena, and then ask questions about whether these physical posits give rise to multiplicities of universes. There is no general argument to be found in physics for the existence of a multiverse of some kind or other; there are only arguments for multiverses that are realized in physically specific ways.

3. Which Multiverses Can Undercut Fine-Tuning?

Max Tegmark's classification of multiverses into levels (Tegmark 2003) is coarse-grained, but it's a useful starting point:

- Level 1: Multiplicity of regions of a single spacetime, spatio-temporally distant from one another. All regions share the same physical constants.
- Level 2: Multiplicity of regions of a single spacetime, spatio-temporally distant from one another. Regions differ in their physical constants.
- Level 3: Multiplicity of quantum-mechanical worlds, as envisaged by proponents of many-worlds quantum mechanics.
- Level 4: Multiplicity of complete possible physical realities, as envisaged by proponents of David Lewis's modal realism.

Level 1 multiverses would be spatially infinite universes, which are ergodic in the sense that everything happens somewhere: all physically possible dynamical processes are to be found somewhere within such a universe. If you imagine travelling far enough within a Level 1 multiverse, you will eventually come across another region of space with indiscernible contents to our own region—*for any arbitrarily large region of space around us that one may want to consider*. For the limiting case of an indiscernible Hubble volume to our own—that is, for everything that it's in principle possible to have causal contact with—Tegmark estimates one would expect to travel $10^{10^{115}}$ metres before finding one. Still, if we live in a Level 1 multiverse, such duplicate Hubble volumes are out there somewhere. Various theories of cosmic inflation seem to predict such a universe; the details will not matter for our purposes, however.

This is because belief in the existence of a level 1 multiverse would not, after all, screen off the evidential relevance of a fine-tuned universe to the existence of a divine designer.

Why not? Because all regions in a Level 1 multiverse have the same values of the constants that are at issue in the fine-tuning argument. Either all regions have constant values congenial to life (even though not all of them will actually contain life, of course) or no regions do. Evidently, since we exist, if we do live in a Level 1 multiverse then we live in one in which all of the worlds have suitable constant values for life. The existence of such a Level 1 multiverse would seem to call out for explanation in just the same way that a single fine-tuned Hubble volume would; even if a fine-tuned multiverse is no less likely than a fine-tuned universe, it certainly does not seem any more likely. So the fine-tuning evidence remains highly surprising even on the supposition that we live in a Level 1 multiverse, and the existence of such a multiverse is not an undercutting defeater for the fine-tuning argument for a design designer.

Level 2 multiverses are a different story. While they are like Level 1 multiverses in that they consist in single infinite spacetimes with different phenomena in different regions, Level 2 multiverses have different values of the constants in different regions—and typically they are also be assumed to be ergodic in our rough sense: all physically possible states of affairs—including all physically possible combinations of constants—occurs somewhere in some region of the multiverse. Hence level 2 multiverses are capable of acting as undercutting defeaters for the support provided by fine-tuning evidence for a divine designer. If there is a Level 2 multiverse, then there are certain to be infinitely many different regions of spacetime that have appropriate constant values for life, and—given that we ourselves are alive—it is no surprise that we observe a region of that kind. Whether Bradley or White is right in their assessment of the nature of the maximal relevant evidence—that *this* universe is suitable for life, or that *we* inhabit a universe suitable for life—there is guaranteed in a Level 2 multiverse to be universe that is indiscernible from this one, so our maximal relevant evidence is guaranteed to be received somewhere. That we receive it is accordingly neither unsurprising nor unlikely given that there exists a Level 2 multiverse.

By construction, Level 1 multiverses do not undercut the fine-tuning argument and Level 2 multiverses do. It is part of what it is to be a Level 1 multiverse that constants do not vary across regions, and part of what it is to be a Level 2 multiverses that constants do so vary. The non-trivial question that remains is whether we have any reason to think we live in a Level 2 multiverse, and hence any reason to think that the fine-tuning argument really is undercut.

While the theories of cosmic inflation that lead to a Level 1 multiverse are relatively mainstream, the theories that generate Level 2 multiverses are much more speculative. A variety of mechanisms for generating such multiverses have been considered—for example, Linde's chaotic inflation model

(Linde 1986) (also known as eternal inflation) and Smolin's cosmological natural selection model (Smolin 1992) but each proposed mechanis, goes well beyond the orthodox Lambda-CDM cosmology that is currently favoured by most cosmologists. I think it is safe to say that nobody yet knows for sure whether there is a Level 2 multiverse, and accordingly nobody yet knows for sure whether the support that fine-tuning provides for a divine designer is in fact undercut.

Our situation is thus like that someone who has seen an object that looks red, but has been warned that misleading lighting is a live possibility. On the supposition that there is misleading lighting, the evidential support of the red appearances for the thesis that the object is red is undercut; on the supposition that there is not misleading lighting, that evidential support is not undercut. In such a circumstance it is presumably rational to reduce one's confidence that the object is in fact red below the level of confidence usually associated with red appearances when no suspicions have been raised, but to maintain that confidence above one's base-line expectation that the object is red prior to any observation of it whatever. Likewise, the evidence of fine-tuning ought to raise our confidence that there is a divine designer above the baseline, but this confidence ought to stay below the level that the fine-tuning evidence would establish in the absence of any suspicions of a multiverse. The more confidence we have in a Level 2 multiverse, the more confident we should have that the fine-tuning evidence is undercut and the closer our confidence in a divine designer should be to its baseline level.

4. Everettian Multiverses as Undercutting Defeaters?

I now want to turn to the main target of this discussion: the consequences of the existence of a Level 3 multiverse for the evidential force of fine-tuning evidence. The Level 3 multiverse is the multiverse of Everettian quantum mechanics, otherwise known as the many-worlds interpretation. There is a universe—or what I will call an Everett world—for every physically possible course of events. But unlike Level 1 and Level 2 multiverses, the universes of the Level 3 multiverse are not different regions within a single infinite spacetime. Rather, they each inhabit their own spacetime: Everett worlds, if you need a spatial metaphor, should be thought of as superimposed upon one another, rather than as laid out in a mosaic pattern is in the Level 1 and 2 multiverses. If there is at least one Level 2 multiverse and Everettian quantum mechanics is correct, then there is a huge plurality of Level 2 multiverses: each Everett world contains a Level 2 multiverse.

There is an open metaphysical question in the foundations of Everettian quantum mechanics concerning the mereological relations amongst Everett worlds. The more familiar 'splitting worlds' view posits mereological *overlap* of worlds: on this picture, different Everett worlds share initial

segments in common. To use a ligneous metaphor, the overlapping multiverse looks like a branching tree. The less familiar 'parallel worlds' view posits no mereological overlap: worlds *diverge*, by having duplicate initial segments and non-duplicate later segments. To extend the ligneous metaphor, a diverging multiverse is a bundle of separate branches. For a discussion of the distinction between overlap and divergence, and a defence of divergence on grounds related to the interpretation of objective probability, see Wilson (2012).

The distinction between overlap and divergence is orthogonal to our present concern, however. This is because which qualitative possibilities are realized in the Everettian multiverse does not depend on how these qualitative possibilities are mereologically structured. Whether divergence or overlap is correct, there either are Everett worlds containing a variety of combinations of constant values or there are not. If there are such worlds, then the Everettian multiverse undercuts the evidential import of fine-tuning for a divine designer. If there are not such worlds, then the Everettian multiverse does not undercut the fine-tuning argument. That is not to say that the distinction between overlap and divergence more generally might be relevant to the epistemological predicament of Everettian agents; see Wilson (forthcoming) for a presentation and rebuttal of an argument that overlap leads to a massive Doomsday effect. But a multiverse's ability to undercut the fine-tuning argument depends only on the existence of worlds in it with appropriate constant values; it doesn't matter for purposes of assessing the fine-tuning argument how these worlds are arranged.

What does matter for our purposes, then, is whether the worlds of a Level 3 multiverse include worlds in which there are a suitable variety of combinations of constant values to make it unsurprising that there are life-permitting combinations. It is characteristic of Everettian multiverses that they include worlds corresponding to all physically possible outcomes of indeterministic quantum-mechanical processes. That is, if there is a quantum-mechanical chance of some outcome—*no matter how small*—then there is an Everett world in which that outcome occurs. Hence our question becomes: is there a quantum-mechanical chance, no matter how small, of the constant values taking all of the combinations needed to make the existence of a world with life-permitting constant values unsurprising. Are there indeterministic dynamical processes that assign non-zero quantum-mechanical chances both to combinations of constant values that are life-permitting and to combinations that are not, such that the overall range of constants permitted is of a kind that is not suggestive of divine design?

A toy example may help clarify matters. Suppose that only one constant (better called a parameter) is involved—call it Z—and suppose that parameter Z may take any integer value from 1 to 100. Only a Z value of 77 is compatible with life. A Z value of 77 is observed. *Prima facie*, this whole body of evidence tends in the context of a single-universe cosmology to support the hypothesis

of a divine designer who selected 77 as the value for Z. Now suppose that Everettian quantum mechanics is correct, and that there exists a quantum-mechanically indeterministic process which determines the value of Z. There will then be Everett worlds with each of the physically possible values of Z. Now consider four different hypotheses about the indeterministic process which fixes the value of Z:

- Process A: The quantum probability of Z taking value 4 is 50%, and the quantum probability of Z taking value 77 is 50%. All other values get zero probability.
- Process B: The quantum probability of Z taking value n is 0.01% for each integer n from 1 to 100 *except for n=77*; the quantum probability of Z taking value 77 is 99.01%.
- Process C: The quantum probability of Z taking value n is 1% for each integer n from 1 to 100.
- Process D: The quantum probability of Z taking value n is (n/50.5)% for each integer n from 1 to 100.

Which of these processes gives rise to an Everettian multiverse capable of undercutting the toy fine-tuning argument based on the value of Z?

Process A does not give rise to a suitable multiverse. Even though it guarantees that there will be an Everett world with a life-conducive value of Z, this is not enough to undercut the support that is provided for the divine designer hypothesis. This is because life-conducive constant values continue to play an unexplained and unexpected role in the theory. On the supposition that two specific values of n play an unexplained and basic role in the theory, it remains very unlikely that 77 will be one of these values, and hence that life will be possible at all in our toy multiverse; given an even prior probability distribution over which pair of Z values are physically possible, the probability of one of these values being 77 is only 2%. So there would still be a significant boost in this toy scenario for the divine design hypothesis.

Process B also does not give rise to a suitable multiverse. Although all values of n are now rendered physically possible, so there will be an Everett world with each of the values, there is still something distinguished and special about the life-supporting value of Z: it is nearly 1000 times more likely than any other value of Z, and there is no explanation for this fact within the theory. So there would still be a significant boost in this toy scenario for the divine design hypothesis.

Process C does give rise to a suitable multiverse. The particular Z value that is conducive to life does not play any special role in the theory; it is not distinguished in any way from the other constant values, so there is no basis for the hypothesis that a divine designer had any hand in so distinguishing

it. If we were informed that Process B was part of the physics of our toy multiverse, then the toy argument for a divine designer from the apparent fine-tuning of Z would be undercut.

Process D also does give rise to a suitable multiverse. As with Process C, the particular Z value that is conducive to life does not play any special role in the theory. The probability distribution over Z values may not be uniform, but nor is it tilted in particular towards life-conducive Z values. What makes a universe more likely to be the outcome of the initial chance process, in this scenario, is just higher Z value. It is true that the life-supporting Z value is towards the higher end of the spectrum, but—as far as I can see—this fact by itself provides no particular boost to the divine designer hypothesis.

Note that given Process A and B, the Everettian multiverse does not fail to undercut the divine designer hypothesis because a divine designer is needed to explain why the actual world we observe has suitable constants. Rather, Processes A and B seem to invite the hypothesis of a divine designer to explain why the theory itself has certain properties that are correlated with life-conduciveness. The probabilification of a divine designer is not based on the observed constant values being unlikely except if there is a divine designer, but instead is based on the way in which these observed constant values are selected by an underlying causal mechanism being unlikely except if there is a divine designer. That alters the nature of the fine-tuning argument, but it does not change the ultimate upshot: a probability boost for a divine designer.

So: which of these types of scenario is actual, if Everettian quantum mechanics is correct and we are in fact living in an Everettian multiverse? The somewhat deflationary provisional conclusion of this paper is that it is simply too early to tell for sure. We do not know enough about the physics of the very early universe to know whether there were any dynamical processes relevant to the fixing of parameter values the early universe. However, there is potential for progress over the coming decades in quantum gravity research to shed some light on these questions.

Candidate approaches to quantum gravity do already include appropriate candidate dynamical processes: string landscape models as proposed by e.g. Susskind (2005), following Bousso and Polchinski (2000), provide one possible form that parameter-fixing dynamical processes could take. As I understand the string landscape scenario, a unitary quantum process leads to an extremely complex superposition of the different possible compactifications of a Calabi-Yau manifold, with probabilities attached to each compactification; hence, in an Everettian implementation of this quantum chance process there would be Everett worlds corresponding to all possible compactifications. Such a multiverse makes fine-tuning evidence entirely unsurprising. Likewise, in other approaches to quantum gravity, it can reasonably be expected that some cosmological parameters may have their values dynamically determined; time will tell.

Fortunately, we can draw some epistemic lessons from the preceding discussion even in the absence of a well-confirmed theory of quantum gravity. If neither the activity of a dynamical process of the Process C/Process D sort, nor the design of a divine designer, was responsible for the actual constant values, then our evidence of fine-tuning looks extremely unlikely even on the assumption that Everettian quantum mechanics is correct. So on the assumption that there is an Everettian multiverse, and taking into account the fine-tuned constant values that are actually observed, there is strong support for the disjunctive hypothesis that *either* a life-neutral dynamical process akin to Process C and D fixed the values of the constants in our own (region of our) Everett world *or* a divine designer was involved in the setting of the distribution of constant values across all Everett worlds.

Although I have argued that convinced Everettians ought to be very confident in the above disjunction, it remains open for other doxastic commitments to tip the balance likelihood towards one or other of these disjuncts. For example, an Everettian with very low prior in the existence of a divine designer is likely to be strongly confident in the life-neutral-constant-fixing-dynamical-process disjunct, while an Everettian with prior theistic commitments is likely to be more confident in the divine-designer disjunct. But this is well within the bounds of reasonable disagreement.

5. Conclusion

The main lesson I would like to draw from this discussion is that close attention to specific fundamental cosmological hypotheses, and in particular to candidate dynamical processes that might give rise to variation in constant value, is necessary to settle the status of the fine-tuning argument. The fine-tuning argument may be undercut by future cosmological discoveries in two main ways. Either future physics may unearth evidence of a Level 2 multiverse, or future physics may unearth evidence of life-neutral dynamical processes that operate to fix constant values and, in conjunction with Everettian quantum mechanics, generate a Level 3 multiverse with different constant values in different Everett worlds.

Everettian quantum mechanics, while not itself undercutting the fine-tuning argument, does at least provide a cosmological framework suitable to host dynamical processes by which the fine-tuning argument might be undercut. This potential route to undercutting the fine-tuning argument is distinct from (though compatible with) to the route to undercutting the fine-tuning argument that goes via a Level 2 multiverse. A suitable dynamical parameter-fixing process need not give rise to a Level 2 multiverse in order to undercut the fine-tuning argument - though it might well give rise to one, for example if the string landscape hypothesis is combined with Everettian quantum mechanics). Hence, there is at least one additional route to undercutting the fine-tuning argument that is available to

Everettians but not to non-Everettians. Perhaps surprisingly, choice between interpretations of quantum mechanics turns out to be evidentially relevant to the existence of a divine designer.

References

Bousso, Raphael. & Joseph Polchinski (2000). "Quantization of four-form fluxes and dynamical neutralization of the cosmological constant", *Journal of High-Energy Physics* 06, 006.

Bradley, Darren (2012). "Four Problems About Self-Locating Belief", *Philosophical Review* 121(2): 149-177.

Hacking, Ian (1987). "The Inverse Gambler's Fallacy: the Argument from Design. The Anthropic Principle Applied to Wheeler Universes", *Mind* 96(383): 331-340.

Linde, Andrei (1986). "Eternally Existing Self-Reproducing Chaotic Inflationary Universe", *Physics Letters B* 175(4): 395-400.

Smolin, Lee (1997). *The Life of the Cosmos*. Oxford University Press.

Susskind, Leonard (2005). *The Cosmic Landscape: String Theory and the Illusion of Intelligent Design*. Little, Brown.

Tegmark, Max (2003). "Parallel Universes", in *Science and Ultimate Reality: From Quantum to Cosmos*, eds. J.D. Barrow, P.C.W. Davies, & C.L. Harper. Cambridge: Cambridge University Press.

White, Roger (2000). "Fine-Tuning and Multiple Universes", *Noûs* 34(2): 260–276.

Wilson, Alastair (2012). "Everettian Quantum Mechanics Without Branching Time", *Synthèse* 188(1): 67-84.

-- (2017). "The Quantum Doomsday Argument", *The British Journal for the Philosophy of Science* 68(2): 597-615.