LIFE IS EVIDENCE FOR AN INFINITE UNIVERSE

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Abstract

It seems improbable that life would exist in a naturalistic universe. But if the universe were spatially infinite, then seemingly improbable events would be expected to happen; life would be expected to exist. It follows that the existence of life provides evidence that the universe is spatially infinite.

1. Introduction

Is the universe spatially infinite or spatially finite? Are there an infinite number of stars and planets, or only a finite number? I will argue that the very existence of life provides evidence for the hypothesis that the universe is spatially infinite, with an infinite number of stars and planets. (For short, I will call this hypothesis the hypothesis that the universe is infinite.) Specifically, I will argue that (with certain exceptions) the probability one assigns to the proposition that the universe is infinite before one takes into account any evidential connection between the existence of life and the hypothesis that the universe is infinite is lower than the probability one assigns to that proposition once one recognizes that there is such an evidential connection.

Setting aside the existence of life, there is nevertheless a good amount of evidence for the hypothesis that the universe is infinite. For example, empirical measurements of the global curvature of spacetime suggest that spacetime is globally flat, which entails that the universe is spatially infinite. (See for example Bahcall et. al. 1999 for details.) Also, the basic theory of inflationary cosmology is now widely accepted, and inflationary cosmology strongly suggests that the universe is spatially infinite. (See for example Guth 2000, p. 571 or Garriga and Vilenkin 2001 for details.) There is no reason to think that what exists in distant, unobserved regions of space is substantially different from what exists in this region of space, so it is reasonable to infer that stars and planets exist in those regions of space as well. Based on this sort of evidence, one can assign a subjective probability, or degree of belief, to the proposition that the universe is infinite. For me, for example, that subjective probability is around 0.7. But that subjective probability has not taken into account the existence of life; my actual probability assignment for the proposition that the universe is infinite is much higher.

2. The Argument

How can the existence of life have anything to do with whether or not the universe is infinite? The basic argument structure is as follows. Life would be more likely to exist in an infinite universe than a finite universe. Hence, given that life does exist, that provides evidence that the universe is infinite.

When one tries to spell out the argument precisely, though, one runs into prima facie trouble. Let L be the proposition that life exists in the universe, and let I be the proposition that the universe is infinite. For L to count as evidence for I, we must show that $P(I|L) > P(I)$ – that is, the probability of I conditional on L is greater than the unconditional probability of I. It is a basic fact of probability theory that $P(I|L) > P(I)$ iff $P(L|I) > P(L)$. (To see this, note that it follows directly from Bayes' rule that $P(I|L)/P(I) = P(L|I)/P(L)$.) So, it seems that the thesis of this paper is equivalent to the thesis that $P(L|I) > P(L)$.

At this point, there is a potential problem with the argument. We fully believe that we exist, and hence we fully believe that life exists in the universe. It follows that $P(L|I) = P(L) = 1$. Nevertheless, I maintain that L does count as evidence for I. How can that be?

I will first show that there are circumstances where we clearly take the existence of life to count as evidence for a proposition. I will subsequently lay out a general theoretical framework that allows for this sort of evidential relation, and then I will show how it applies to the hypothesis that the universe is infinite. Finally, I will consider three objections to my argument.

Suppose that you find yourself in the presence of a closed box, and in communication with God. God tells you that inside the box is a ball that is either black or white. Since you have no further information about the color of the ball, you decide to assign subjective probability 0.5 to the proposition that the ball is white. Suppose that God then tells you that, to decide whether or not to create life, he used a random number generator to generate a natural number between 1 and 100: if the number 1 was generated, he did not create life and put a black ball in the box, while if any other number was generated, he did create life and put a white ball in the box.

Based on this new understanding of the relationship between the existence of life and the color of the ball, it seems clear that one should revise one's probability for the hypothesis that the ball is white, from 0.5 to 0.99. A natural interpretation of this scenario is that the existence of life counts as evidence for the proposition that the ball is white. This is so even though we already fully believe that life exists.

This is an instance of a general issue in Bayesian epistemology, the problem of old evidence. There are many cases where we have some evidence E such that $P(E) = 1$, and yet we think that E provides epistemic support for some hypothesis H. Perhaps the most famous example is E being the (true) proposition that the precession of the perihelion of Mercury is 5600 seconds of arc per century, and H being general relativity. When general relativity was proposed, people already knew what the amount of the precession of the perihelion of Mercury was, and yet the precession was taken to provide evidence for general relativity. This is one instance of the problem of old evidence.

There is no agreed-upon solution to the problem of old evidence, but one standard type of solution is as follows. (See Glymour (1980, pp. 87-91), Howson (1984, 1985, 1991), Jeffrey (1995), and Barnes (1999) for some discussions of this solution.) Let P^{-} be one's prior probability function, and let P^+ be one's posterior probability function, once one has taken into account that there is a potential connection between E and H. According to this solution to the problem of old evidence, once one learns about the potential connection, one should suppose that one does not fully believe that E, and revise all one's probability assignments accordingly, to generate an ur-probability function P^*. One should then set $P^+(H) = P^*(H|E)$. There are many cases where $P^-(H) = P^*(H)$, since in pretending that one does not fully believe that E, that would generally not influence one's probability for H. In such cases, as long as $P^*(H|E) > P^*(H)$, then $P^+(H) > P^-(H)$, and E counts as evidence for H.

This "ur-probability" solution to the problem of old evidence can be applied to the ball in the box example discussed above. Where W is the proposition that the ball is white, $P^-(W) = 0.5$. When one learns about the potential connection between W and L (the potential connection being a result of God's random number generator), one should generate an ur-probability function supposing one does not know that L. One of the drawbacks of the ur-probability solution is that it is not always clear what values the ur-probabilities should take, especially when one has to make extreme modifications to one's opinion, by for example supposing that one does not know that one exists. Nevertheless, we need to have some way of accounting for how propositions like L can count as evidence, and the ur-probability solution is the best approach available. Applying it to the example under consideration, a natural ur-probability assignment for L is $P^*(L) = 0.5$. It is then the case that $P^-(W) = P^*(W) = 0.5$, and yet $P^+(W) = P^*(W|L) = 0.99$. Since the probability for W increases once one takes into account the connection between W and L, it follows that L provides evidence for W.

I will now apply this ur-probability solution to the problem of old evidence to the case of life and the infinite universe. I will generate an ur-probability function under the supposition that one does not know that L, and I will see whether $P^{+}(I) > P^{-}(I)$.

For me, $P^{-}(I) = P^{*}(I) = 0.7$, since (as mentioned above) 0.7 is the probability I assign to the proposition that the universe is infinite when I have not yet taken into account the potential connection between I and L. To establish a value for $P^{+}(I)$, I will use Bayes' Rule: $P^{+}(I) = P^{*}(I|L) = P^{*}(L|I)\ P^{*}(I) / P^{*}(L)$. To establish a value for $P^{*}(L)$, it helps to note that $P^{*}(L) = P^{*}(L|I)\ P^{*}(I) + P^{*}(L|{\sim}I)\ P^{*}({\sim}I)$. So the crucial question becomes: what are the values for $P^{*}(L|I)$ and $P^{*}(L|{\sim}I)$?

In fact, we don't need to come up with precise values for those quantities. As long as $P^{*}(L|I) > P^{*}(L|{\sim}I)$, we have the desired result that $P^{+}(I) > P^{-}(I)$. This follows because $P^{*}(L)$ is a weighted average of $P^{*}(L|I)$ and $P^{*}(L|{\sim}I)$, so if $P^{*}(L|I) > P^{*}(L|{\sim}I)$, then $P^{*}(L|I) > P^{*}(L)$. If $P^{*}(L|I) > P^{*}(L)$, then $P^{*}(I|L) > P^{*}(I)$. It would then follow that $P^{+}(I) = P^{*}(I|L) > P^{*}(I) = P^{-}(I)$, as desired. I will now show that $P^{*}(L|I)$ is indeed greater than $P^{*}(L|{\sim}I)$.

The proposition ${\sim}I$ encompasses a large possibility space, so to more easily determine the relationship between $P^{*}(L|I)$ and $P^{*}(L|{\sim}I)$, I will specify what the live options are within that possibility space. Specifically, I will suppose that if the universe is finite, then it contains about 10^{80} elementary particles. (It is often claimed by proponents of the hypothesis that the universe is finite that this is the number of particles in the universe; see for example Dembski 1998, 217.) It doesn't matter for my argument what the size of the finite universe is; I just need to specify that it has some particular size, so as to not compare an infinite universe to an arbitrarily large finite universe.

Now, imagine dividing up the universe into different spatial regions, each region the same size. (Imagine for example dividing the universe into cubes, each of width one light-year.) Let us restrict our attention to those regions that contain a sufficient number of particles such that it is in principle possible for life to exist in that region. Under the assumption that the universe is finite, there will only be a finite number of those regions, while under the assumption that the universe is infinite, one would expect there to be an infinite number of those regions. For an arbitrary region, what is the ur-probability, call it p, that life arises (at any time) in that region? We know $p < 1$, since ur-probabilities are formed under the assumption that one does not fully believe that life exists. As long as the regions are of large enough size, we should also expect that $p > 0$, since for a given large region there is at least some quantifiable possibility of life arising in that region. As long as whether life arises in any particular region is probabilistically independent of whether it arises in any other region, it follows that the ur-probability of life arising somewhere in the universe is $1 - (1 - p)^n$, where n is the number of regions in the universe. (The probability that life does not arise in a given region is $(1 - p)$; the probability that it does not arise in any region is $(1 - p)^n$; so the probability that it does arise in some region is 1 minus that.) For an infinite universe, this value will be 1, while for a finite universe, it will be less than 1. It follows that $P^*(L|I) > P^*(L|{\sim}I)$, which gives the desired result that $P^+(I) > P^-(I)$.

The assumption that whether life arises in any particular region is probabilistically independent of whether it arises in any other region could be questioned. For example, it could be the case that the infinite universe consists of an infinite number of systems of 10^{80} particles, where each system evolves in the same way. (Let's call this *the recurrence hypothesis, R*.) In that case, the ur-probability of life arising anywhere in the infinite universe is the same as the ur-probability of life arising in the finite universe with 10^{80} particles. But my argument will still go through, as long as one does not assume that the infinite universe *has* to be that way. As long as one assigns a probability less than 1 to the recurrence hypothesis (conditional on the universe being infinite), and probability greater than 0 to the hypothesis that whether life arises in any particular region is (at least to an extent) probabilistically independent of whether it arises in any other region (conditional on the universe being infinite), my argument will go through. $P^*(L|I)$ will be a weighted average of $P^*(L|I \,\&\, R)$ and $P^*(L|I \,\&\, {\sim}R)$, and hence $P^*(L|I)$ will be a weighted average of $P^*(L|{\sim}I)$ and a quantity greater than $P^*(L|{\sim}I)$, and hence $P^*(L|I) > P^*(L|{\sim}I)$.

I have shown that $P^+(I) > P^-(I)$, but I have not shown that $P^+(I) \gg P^-(I)$. Whether that is the case depends on what one's actual ur-probabilities are. For me, $P^*(L|I) \approx 1$, while $P^*(L|{\sim}I) \approx 0$, and hence for me $P^+(I) \approx 1$, while $P^-(I)$ is only 0.7. The reason my ur-probabilities are that way is that, under the assumption that I don't know that life exists, I find the existence of life almost unbelievable. (I am familiar of course with the evolutionary arguments that account for the complexity of life; for me the sticking point is how life arises from non-life.) As a result, I simply would not expect life to arise in a finite universe, even a universe with 10^{80} particles. In an infinite universe, however, the probabilistic resources are much greater, and hence vastly improbable events can be expected to happen. (Richard Dawkins (1996, 6) has said that one could not be an intellectually fulfilled atheist before Darwin; in my opinion one cannot be an intellectually fulfilled atheist until one recognizes that the universe is infinite.)

Of course, many people disagree with my assessment of how probable it is that life arises in a finite universe. Some people even think that it is probable that life would arise many times in our own galaxy. (See for example Dick (1996, 441) for references.) For them, $P^*(L|I) \approx 1$, but

$P^*(L|{\sim}I) \approx 1$ as well. Nevertheless, my argument still goes through, and $P^+(I) > P^-(I)$, even though the difference is very small. From a philosophical point of view, the precise probability shift doesn't matter; what is interesting is that the very existence of life provides some evidence that the universe is infinite.

I will now consider three objections to my argument.

3. Dembski's Objection

As far as I know, the exact thesis I am arguing for has never before been defended in detail in the literature. Nevertheless, some of the reasoning in my argument is familiar, and has been attacked. Specifically, I will focus on an objection of William Dembski's.[1] He writes:

> It is illegitimate to take an event, decide in advance that it must be due to chance, and then propose numerous probabilistic resources because otherwise chance would be implausible. This is the inflationary fallacy, and it is utterly bogus. (Dembski 1998, 215)

Dembski would presumably claim that, when I argue that we should increase the probability we assign to the proposition that the universe is infinite because the existence of life would be implausible in a finite universe, I am engaging in this fallacy.

Dembski is a theist, and believes that the existence of life should be accounted for via design, not chance. He calls the purported fallacy "the inflationary fallacy" because the cosmological theory of inflation allows for an infinite number of probabilistic resources. (Dembski seems to think that the only reason physicists postulate inflation is to increase the

[1]Here I focus on Dembski (1998). Dembski develops this line of reasoning in other works as well (such as Dembski 2003), but the basic points remain the same.

probabilistic resources available to account for events like the origin of life. This is false, but I will not pursue the issue here.)

Dembski does not say in this passage why it is illegitimate to decide in advance that an event must be due to chance (though the passage of his I discuss below can perhaps be viewed as an argument for that claim). I believe that it can be rational to decide in advance that an event must be due to chance. For example, an atheist could believe that the concept of an supernatural intelligent designer of life is incoherent, and hence assign probability 0 to the proposition that the origin of life is due to design. From a subjective probability standpoint, there is nothing wrong with deciding in advance (in the sense of having prior probability 0 for the proposition) that an event is due to chance, as long as all of one's probability assignments are coherent.

Dembski does not consider the simple hypothesis that the universe is spatially infinite, but instead discusses more complicated proposals that "inflate our probabilistic resources" (1998, 215). He considers "posited entities" like "the bubble universes of inflationary cosmology, the many worlds of quantum physics, and the possible worlds of metaphysics". He writes:

> there is something deeply unsatisfying about positing these entities simply because chance requires it. In each case the posited entities are causally isolated from our space-time manifold. Hence the only evidence in their favor is their ability to render chance plausible. This is pushing inference to the best explanation too far. It is legitimate to posit an entity to explain a phenomenon only if the entity is at least in principle capable of interacting with the phenomenon. But entities posited simply to inflate probabilistic resources are utterly inert and self-contained. They do not interact with our space-time

manifold. They exist solely to make chance intelligible. (Dembski 1998, pp. 215-6)

There are a number of confusions in this passage; after clearing up the confusions I will discuss the argument that remains.

The first confusion is that Dembski thinks that we cannot get evidence for entities that are causally isolated from our spacetime manifold (other than the evidence that they render chance plausible). I will show that this is false, both by thought experiment and by appeal to scientific practice. First, consider the ball in the box example discussed above, but suppose that God puts the box in a region of spacetime that is causally disconnected from ours. Our evidence that the ball is white is independent of the location of the box. Second, consider scientific practice. It is standardly thought that evidence can provide confirmation for a theory as a whole. A theory can entail that causally isolated entities exist, but as long as the theory also has implications for causally connected entities, we can get confirmation for the theory.

The second confusion is that Dembski seems to think that the argument in favor of the posited entities based on their rendering chance plausible is an argument utilizing inference to the best explanation. In fact, this need not be the case. The argument I gave in the sections above, for example, makes no reference to competing explanations; it is simply an application of Bayesian reasoning and the ur-probability solution to the problem of old evidence. In fact, I would not want to use inference to the best explanation in such an argument; I am convinced by Bas van Fraassen (1989, pp. 160-9) that inference to the best explanation is probabilistically incoherent.

The third confusion is in the penultimate sentence of the quoted passage: Dembski says that entities posited simply to inflate probabilistic resources are utterly inert and self-contained.

While I am willing to grant that this is true for the posited entities Dembski discusses, this need not be the case for all entities posited to inflate probabilistic resources. For example, a spatially infinite universe could be posited to inflate probabilistic resources, but the various regions of this universe are not causally inert and are not self-contained. In an infinite universe, as long as the rate of expansion of the universe is or will be small enough, one can in principle travel to arbitrarily far regions of the universe, thus showing that the regions of the universe are not causally inert and are not self-contained.

Now that I have cleared up the confusions, I will consider the argument that remains. The argument is that it's bad to posit entities simply because chance requires it. Saying that chance "requires" something is too strong, but I think that the ostensibly bad argument Dembski is hinting at with that claim is as follows: the hypothesis that the event in question is due to chance is highly implausible under the supposition that the posited entities do not exist, and that provides evidence that one of the posited entities does exist. In other words, Dembski rejects arguments of the form: this event seems to be improbable, but if X were the case the event would be probable; therefore we should think it more probable than we did before that X is the case. I can agree with Dembski to an extent: not all arguments of that form are good ones. Nevertheless, some are. One example of a good argument of that form is the general relativity one discussed in section three. The event of the perihelion of Mercury precessing in the way that it does was an improbable event; people didn't know how to account for it. If general relativity were true, the event would be probable; we would expect the perihelion to precess in the way that it does. Thus, people took the precession of the perihelion as evidence for general relativity, and thought it more probable than they did before that general relativity was true. Dembski has not said anything that would make us think that the form of reasoning that is utilized in this general relativity argument is a bad one. Since my argument for the thesis that life provides evidence for an infinite universe uses that same form of reasoning, I conclude that Dembski's objection is unsuccessful.

4. The Theistic Objection

Now I will briefly discuss a second objection to the main argument of this paper. This objection is related to Dembski's objection, in that it is inspired by theistic considerations, but it is nevertheless a distinct objection. As we will see, this objection is somewhat successful, and demonstrates a limitation of my argument.

I argued above that $P^*(L|I) > P^*(L|{\sim}I)$, but in fact there are prima facie reasonable ur-probability functions where this is not the case. Consider a theist who fully believes that God exists, and fully believes that God has control over whether or not life exists. When this theist supposes that she does not know that life exists, she would evaluate how likely she thinks it is that God would create life. The crucial point is that this value would be independent of whether the theist thinks God would create an infinite or finite universe: $P^*(L) = P^*(L|I) = P^*(L|{\sim}I)$. For this theist, then, $P^+(I) = P^-(I)$; life is not evidence for an infinite universe.

We should not be surprised by this result; there is always a prior probability function such that what counts as an evidential relation for most people doesn't count for someone with that prior probability function. Whether that prior probability function is reasonable or not is another matter; I will leave it to the reader to judge whether assigning probability 1 to the existence of God is reasonable.

Note that, if one has credence less than 1 for the existence of God, even if that credence is high, then my argument still goes through. This person's $P^+(I)$ would be a weighted average of the posterior probability for *I* assuming that God exists and the posterior probability for *I* assuming that God does not exist. In other words, $P^+(I) = P^+(I|G)\, P^+(G) + P^+(I|{\sim}G)\, P^+({\sim}G)$. Given the discussion above regarding the theist, $P^+(I|G) = P^-(I|G)$, while the main argument of the paper establishes that $P^+(I|{\sim}G) > P^-(I|{\sim}G)$. We can suppose that, before taking into account the possible evidential connection between life and the infinite universe, the person saw no connection between the existence of God and the universe being infinite: $P^-(I) = P^-(I|G) = P^-(I|{\sim}G)$. It follows that $P^+(I)$ is a weighted average of $P^+(I|G)$, which equals $P^-(I)$, and $P^+(I|{\sim}G)$, which is greater than $P^-(I)$. Hence $P^+(I) > P^-(I)$, which is the desired result.

5. The "This Region" Objection

The third and final objection I will consider is one that I have come up with on my own, but it is inspired by the literature on the fine-tuning argument. Specifically, this objection, what I will call the "this region" objection, parallels the "this universe" objection to the many-universes fine-tuning argument. I will argue that both the "this universe" objection and the "this region" objection are unsuccessful.

First, I will explain the many-universes fine-tuning argument. A premise of the argument is that the fundamental constants of the universe (such as the masses of the fundamental particles and the strength ratios between the fundamental forces) are finely tuned for life, in that if the constants had slightly different values life could not exist. If this universe is all that exists, it would be very unlikely for the universe to have life-permitting fundamental constants by chance.

But if many (perhaps an infinite number) of universes exist, with different fundamental constants obtaining in the different universes, it would be likely that at least one of the universes is life-permitting. The conclusion is that one should shift one's probability assignments in favor of the hypothesis that there are many universes. Where *E* is the proposition that this universe is life-permitting, and *M* the proposition that there are many universes, the conclusion is that $P(M|E) > P(M)$; the fact that this universe is life-permitting is evidence that there are many universes.[2]

There is a standard objection to this argument, which has been promulgated by Hacking (1987), Olding (1991, 123), Dowe (1999), and in most detail by White (2000, 2003). This objection, dubbed the "this universe" objection by Manson and Thrush (2003), runs roughly as follows. Whether other universes exist or not does not affect how likely it is that this universe, the universe we are in, is life-permitting. If that is right, then $P(E|M) = P(E)$. It follows that $P(M|E) = P(M)$; that this universe is life-permitting provides no evidence for the many-universes hypothesis.

White (2003, 233) makes clear that the proposition that *some* universe is life-permitting, *E*', does provide evidence for the many-universes hypothesis, since the more universes there are, the more likely it is that one of them is life-permitting. That is, $P(M|E') > P(M)$. But White says that we have to consider the total evidence available to us, and we know more than just *E'*, we know *E*. Since *E* entails *E'*, $P(M|E \& E') = P(M|E)$, and White maintains that $P(M|E) = P(M)$.

[2]Note that the main argument of this paper is not at all the same as the many-universes fine-tuning argument. For example, my argument has nothing to do with the range of life-permitting fundamental constants, whereas the many-universes fine-tuning argument does. Also, my argument is about just one universe, where the fundamental constants are assumed to be the same throughout the universe; the many-universes fine-tuning argument is about multiple universes, where different fundamental constants obtain in different universes.

One can give an objection which parallels the “this universe” objection to my argument that life is evidence for an infinite universe. The objection, which I will call the “this region” objection, is as follows. It is true that we know *L*, life exists in the universe. But that is not our total evidence, for we also know *T*, that life exists in *this* region of the universe, the region that we are in. One can grant that $P^*(I|L) > P^*(I)$, but nevertheless maintain that when one takes into account our total evidence *T*, $P^*(I|L \& T) = P^*(I|T) = P^*(I)$. The reason that $P^*(I|L \& T) = P^*(I|T)$ is that *T* entails *L*, and the reason that $P^*(I|T) = P^*(I)$ is that whether this region contains life is independent of whether other regions contain life. It follows that once we take into account our total evidence *T* we do not get a probability shift in favor of *I*. This is the conclusion of the “this region” objection.

Because of the close parallel between the “this universe” objection and the “this region” objection, my reply will pertain to both. Even if my reply is unsuccessful, it does not follow that the “this universe” objection and the “this region” objection are right; there are other criticisms of the “this universe” objection in the literature, which would carry over to the “this region” objection: see for example Bostrom 2002, pp. 20-3, Holder 2002, and Manson and Thrush 2003. (An evaluation of these other criticisms is outside the scope of this paper; for my main argument to go through all I need is one successful reply to the “this region” objection.)

As a precursor to my reply, note that both the proponents of the many-universes fine-tuning argument and the proponents of “this universe” objection are presumably relying on something like the ur-probability solution to the problem of old evidence, even though none of them makes that explicit. The reason this is presumably the case is that, if they were only utilizing actual probabilities, then it would be obvious that $P(E|M) = P(E)$, and hence $P(M|E) =$

$P(M)$; the reason it would be obvious is that our actual probability assignments are such that $P(E|M) = P(E) = 1$.

When one puts the many-worlds fine-tuning argument in the framework of the ur-probability solution, one can more easily see what goes wrong with the "this universe" objection. Since the main argument of this paper has already been given in the framework of the ur-probability solution, I will focus on the "this region" objection. It should be clear how my reply carries over to the "this universe" objection.

The problem with the "this region" objection is that illicit information is built into one of the very propositions under consideration when one is formulating one's ur-probability function. Specifically, the problem arises when one attempts to evaluate conditional ur-probabilities involving T, that *this* region of the universe contains life. To formulate ur-probabilities, one assumes that one does not know whether any region contains life. One cannot then treat the region we find ourselves in as being privileged; it has to be treated like any other region of the universe. It follows that one cannot evaluate a conditional probability involving a proposition like T, which refers to *this* region, using one's ur-probability function.

Since one cannot legitimately formulate probabilities like $P^*(I|T)$, then one cannot get $P^+(I)$ by setting it equal to $P^*(I|T)$. In moving from ur-probabilities to actual probabilities, one does not learn that *this* region contains life, since one was not reasoning about *this* region in formulating ur-probabilities. Instead, what one learns is that some region contains life, since probabilities conditional on that proposition do have a value according to one's ur-probability function. Since $P^*(I|L)$ does have a value, one can legitimately set $P^+(I)$ equal to $P^*(I|L)$. It will then be the case that $P^+(I) > P^-(I)$, as desired.

I will briefly consider one response to the above reasoning. What if one simply assigned a name to each region, so that one can formulate a conditional probability about each region, including the region we find ourselves in? For example, one can evaluate ur-probabilities involving region 17, say, and then it can turn out that region 17 is our region. Whether region 17 contains life is independent of whether any other region does, so the proponent of the "this region" objection could argue that learning that region 17 contains life does not provide evidence for there being an infinite number of regions.

My reply is that one is learning the same information one learned before, that some region contains life. Assigning an arbitrary name to the life-containing region should not produce any change in what one can infer when one learns that some region is life-containing.[3]

I conclude that the "this region" objection to my main argument is unsuccessful. I stand by my thesis that life is evidence for an infinite universe.

[3]For a related response in the context of the "this universe" objection, see Manson and Thrush 2003, 74.

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