

Why do we find randomness in nature?

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A statistical ontological argument is given which uses an anthropic approach to suggest that an observer should expect to find randomness, such as we find in quantum mechanics, in nature. An observer needs thermodynamics to be operating to be able to experience conscious thought. Thermodynamics means that the number of versions of a kind of situation which we can imagine must be greater than the number of past situations we can imagine that could lead to it. For example, we can imagine more ways for a broken glass vase to exist than for an intact glass vase to exist. In a deterministic world, past situations must be unique, and this means that there are not enough of them for every conceivable present situation to have a past situation. Thermodynamics therefore causes a loss of possible situations. This issue does not arise in non-deterministic worlds, as situations can share past situations. The probability space of possible situations in which observers could exist therefore mostly consists of situations in non-deterministic worlds. This applies whether a Level IV multiverse is assumed to exist or not, or if the matter is considered in terms of observer-centred possible worlds. A link between thermodynamics and randomness in nature therefore seems to be suggested.

1 INTRODUCTION

Prior to the discovery of quantum mechanics, the world was considered, at least in principle, to be deterministic. Quantum mechanics seems to describe a non-deterministic world. A “deterministic” world, in this article, will be taken to be one in which the future state of the world can in principle be determined from full knowledge of the present state of the world and the relevant “laws”: the laws of nature are such that each possible state of the world logically implies a single future state of the world. A “non-deterministic” world will be taken to be one in which the future state of the world cannot be determined from full knowledge of the present state of the world and its laws, even in principle: the laws of nature are such that each possible state of the world can logically imply any one of a number of different future states of the world.

It seems that there is non-determinism in quantum mechanics, but why do we find ourselves in a world with non-determinism like this? This article will present a statistical ontological argument which uses an anthropic approach to explain this. To some people, it may not seem to make sense to try to explain the randomness when, with quantum mechanics, it is already known to be here, so we should first try to phrase the question in a clearer way. The question which will be considered is as follows.

“Should an observer who has not performed any significant scientific investigation of reality expect, on starting a detailed investigation of the world, to find randomness in the laws of nature, and if so, why?”

It will be shown that our experience of reality as being non-deterministic is due to the need for thermodynamics, or something like it, to apply in a world in which conscious observers exist. This should have consequences for our expectations of the degree of randomness in nature. There are two ways in which the argument can be made: the argument can be made based on the assumption that modal realism [1] is true – that we live in a Level IV multiverse of the kind described by Max Tegmark in which all possible worlds will *actually* exist [2,3,4]. This version of the argument should be the one from which an understanding of the general idea is more easily gained and it will be presented first. This will be followed by a consideration of the situation in which modal realism is not true – that we are not in a Level IV multiverse – and this does not substantially change anything: any conscious observer should still expect to find randomness in nature.

The argument that will be given here will, for the most part, discuss matters in terms of “numbers” of situations or possible situations, as if there were a finite set of situations or possible situations from which all possible situations of an observer were drawn. This is a simplification.

A statistical ontological argument of the kind that will be given here should really discuss things in terms of measure across worlds or possible worlds. The simplification is made for clarity. A discussion in terms of “numbers” of worlds or possible worlds should make the general idea behind the argument easier to understand, and a reader wanting to understand it in terms of measure should have little difficulty considering it in such terms.

The first version of the argument, which supposes modal realism, will now be given.

2 THE ARGUMENT, SUPPOSING A LEVEL IV MULTIVERSE

2.1 Assuming a Level IV Multiverse

We will start by assuming that reality is a Level IV multiverse or “mathematical universe” [2,3,4] as described by Max Tegmark. Such a multiverse can also be considered a version of modal realism, as described by David Lewis [1]. The author has also argued for a version of modal realism which he considers very likely to be the same thing as Max Tegmark’s multiverse [5]. In such a multiverse, every possible world that can be formally described actually exists, and what we think of as “the real world” would merely be one of these worlds. The argument in this article will not ultimately depend on such a claim, nor is such a claim being made. That we are in a multiverse will, however, be assumed for now to facilitate development of the argument.

2.2 An Anthropic Justification of the Existence of Time

The concept of “time” may not be relevant for describing every world in a Level IV multiverse. The idea of “thinking”, however, only seems conceivable in a world with time. We should therefore assume that observers will only be found in those worlds of which time is a feature. Any observer, therefore, on commencing his investigation of reality, should expect to find himself in such a world – as we do.¹

¹ This idea is quite trivial, and will be obvious to many readers: it has merely been introduced for completeness.

2.3 An Anthropic Justification of the Existence of Thermodynamics

Even given time, thermodynamics need not be assumed to apply in every world in a Level IV multiverse. Thermodynamics implies a direction to time, with entropy increasing in one direction and decreasing in the other, and there does not necessarily have to be such a direction.²

For the thinking of conscious observers like ourselves to occur, however, computation would seem to be necessary, and this would seem to need functional computational machinery that can only work in a world with thermodynamics or something like it. In a world in which thermodynamics does not apply, conscious observers will not exist. Some readers may subscribe to a non-computational theory of the mind, such as Penrose’s idea of “non-computability” [6]. Even in such a case, however, machinery to do thinking in *some way* would still seem to need to work, and this would still seem to need thermodynamics. Any observer, therefore, on commencing his investigation of reality, should expect to find himself in a world where thermodynamics applies – as we do.

2.4 Deterministic vs. Non-Deterministic Worlds

A Level IV multiverse is itself atemporal. What we would imagine as the history of a world will actually correspond to all the different instants of time existing in a structure in that multiverse.

Some of the worlds in a Level IV multiverse will be *deterministic*. That is to say, each past state of a world can only correspond to a single future state: for any past state of the world, P_1 , there is only one future state, S_1 . If there were a number of future states, S_1, S_2, S_3 , etc., for any single past state, P_1 , it would be impossible to predict the future, even in principle, because any of the states S_1, S_2, S_3 , etc. could follow, so this cannot be the case for a deterministic world.

Some of the worlds in a Level IV multiverse will be *non-deterministic*. That is to say, each past state of a world can correspond to a number of future states: for any past state of the world, P_1 ,

² If there were no direction, it does raise the issue of why we would call it “time”, though, as such a world would seem to lack anything that we would recognize as temporal patterns.

there are a number of possible future states, S_1 , S_2 , S_3 , etc. It is impossible for an observer to predict the future, even in principle, because any of the states S_1 , S_2 , S_3 , etc. could follow P_1 . All possible worlds are realized, so that if S_1 can follow P_1 then there must be a world in which this occurs, and likewise if S_2 can follow P_2 then there must be a world in which this occurs, so non-determinism in a Level IV multiverse effectively implies the existence of something like the Level III multiverse – the Everett multiverse described by the many-worlds interpretation of quantum mechanics (MWI) – in which there are consistent laws of physics and all the possible paths through history are realized within that multiverse [7,8]. Whether we regard each of the “worlds” in such a Level III multiverse as a “world” in the Level IV multiverse, or whether we regard the entire Level III multiverse as a “world” in the Level IV multiverse is largely semantics, though there are issues of separation of worlds, raised by Tegmark, that are beyond the scope of this article [9].

2.4.1 A Flawed Argument

It may *seem* tempting to think that what has been said so far implies the following argument:

“A single past state, P_1 , in a deterministic world implies only a single future state, S_1 , but a single past state, P_1 , in a non-deterministic world implies many future states, S_1 , S_2 , S_3 , etc. Therefore, a non-deterministic world “produces” more future states, with more observers in them. An observer in some state, S_n , should assume that it is one of the states S_1 , S_2 , S_3 , etc. in a non-deterministic world rather than the state S_1 for a deterministic world: there are more non-deterministic world-states than deterministic ones, so one of these is more likely to be the current state of the observer’s world.”

This would be naïve. Trying to build our case on such an argument would be a fallacy. When asking how likely it is that he is in some kind of situation, an observer should assume that it is equally likely that he is in any particular situation consistent with his knowledge, and that the probability that he is in some kind of situation therefore depends on the proportion of all possible situations in which he could be that is made up by that kind of situation. This is about *specificity*. The lower the specificity of a situation – the greater the number of ways in

which it could be described with an observer in it – the greater the proportion of possible situations that it makes up, and therefore the more likely it is that one of these is actually the observer’s situation.

Yes, for any given kind of state, there will be only one future corresponding to that kind of state in a deterministic world and multiple futures corresponding to that state in a non-deterministic world, but the chance that an observer is in a kind of situation does not depend on how many ways that kind of situation could follow from some single past state, but merely on how many ways the observer could be in that kind of situation as a proportion of the number of situations in which he could be, and we should not, without good reason, think that situations of some kind in a deterministic world are any more specific – that they exist in any lesser number – than situations of that kind in a deterministic world: it merely means that each of these situations must have a unique past.

Putting this another way, an observer might be in one of the situations S_1 and S_2 in a non-deterministic world, with S_1 and S_2 being future states of some past state, P_1 , but he could also be in a deterministic world in state S_1 , with P_1 as its past state, or in a state S_2 with P_2 as its past state. For each way in which an observer could be in a deterministic world, we should be able to imagine a corresponding state in a deterministic world: the only difference is that each state, S_1 , S_2 , etc., in a deterministic world must have its own, unique past state, P_1 , P_2 , etc.

This in itself does not give any reason to think that an observer is more likely to find himself in a non-deterministic world or a deterministic one. There is, however, an element that has been omitted: thermodynamics.

2.4.2 Consideration of Thermodynamics

Thermodynamics imposes a direction on time and one way of viewing this is in terms of the requirement for the past of some kind of situation to be more specific than the kind of situation to which it leads. For a situation of any kind, there are more ways for that situation to exist – more ways to describe such a situation – than there are for the past of that situation to exist.

Let us consider the breaking of a glass vase as an example. We can imagine many ways in which a broken glass vase can exist, with many combinations of different shapes of pieces of glass and different positions for them, but the requirements for the *unbroken* glass vase from which all this comes are more demanding: there will be fewer ways of describing an unbroken vase than a broken one.

Suppose we consider some kind of situation in a deterministic world and in a non-deterministic world, and the past situations that give rise to it. It might be, for example, a situation in which there is a broken glass vase and the situation with the unbroken vase that led to it.

2.4.3 Paired Situations for Deterministic Worlds

First, we will consider the different ways in which this kind of situation could exist in deterministic worlds. We list all the different situations, S_1, S_2, S_3 , etc. Each of these situations needs to be paired with a corresponding past situation, P_1, P_2, P_3 , etc., and, as these are deterministic worlds, *each past situation must be unique*. We must therefore have:

$P_1 \Rightarrow S_1, P_2 \Rightarrow S_2, P_3 \Rightarrow S_3$, etc.

(where \Rightarrow indicates the relationship between a situation and a situation that temporally follows it.)

not $P_1 \Rightarrow S_1, P_1 \Rightarrow S_2, P_1 \Rightarrow S_3$, etc.

(This would imply that one state, P_1 , can give rise to multiple future states. Determinism, however, prohibits this.)

There are more ways for the kind of situation being considered to exist than there are for the *lower entropy* situation that gives rise to it to exist. We might imagine a number of situations, S_1, S_2, S_3 etc., but the number of past situations P_1, P_2, P_3 , etc., will be less. As each situation, S_1, S_2, S_3 , etc. needs its own unique past situation, P_1, P_2, P_3 , etc., not every situation S_1, S_2, S_3 , etc. can be paired with a corresponding past situation: $P_1 \Rightarrow S_1, P_2 \Rightarrow S_2, P_3 \Rightarrow S_3$, etc. is not possible for all situations, S_1, S_2, S_3 , etc.: we do not have enough past situations, P_1, P_2, P_3 , etc.,. Situations in the list S_1, S_2, S_3 , etc. without corresponding past situations are not possible and must therefore be removed from the list S_1, S_2, S_3 , etc.

This will be true for the situation of a broken vase: we can list every possible broken vase situation, but most of these will need to be removed: they cannot all connect to a unique past situation when past situations are in short supply due to thermodynamics. This will apply for any kind of situation.

Determinism, together with thermodynamics, therefore means that, if we list all the possible situations, S_1, S_2, S_3 , etc., of some kind in which an observer could exist, some of these will need to be removed because they cannot all have unique past situations: with determinism and thermodynamics, *there is not enough past to go round*.

Consideration will now be given to how this works out when non-determinism is in effect.

2.4.4 Paired Situations for Non-Deterministic Worlds

As with the deterministic worlds, we list all the different ways in which the kind of situation being considered could occur: S_1, S_2, S_3 , etc. As with the deterministic worlds, each situation needs to be paired with a corresponding situation. However, as these are non-deterministic worlds, *each past situation does not need to be unique*. For example, for the situations S_1, S_2, S_3 , etc. we could have:

$P_1 \Rightarrow S_1, P_2 \Rightarrow S_2, P_3 \Rightarrow S_3$, etc.

or we could have:

$P_1 \Rightarrow S_1, P_1 \Rightarrow S_2, P_2 \Rightarrow S_3$, etc.
(with S_1 and S_2 "sharing" P_1)

or we could have:

$P_1 \Rightarrow S_1, P_1 \Rightarrow S_2, P_1 \Rightarrow S_3$, etc.
(with S_1, S_2 and S_3 all sharing P_1)

and so on.

Thermodynamics needs to be considered now, as it was with the deterministic worlds, but it merely requires us to have fewer past situations than present situations. With the deterministic worlds, the effect of this was that we could not have enough past situations for every S_1, S_2, S_3 , etc. situation to have a past situation, so not all of them could be valid. With non-determinism, however, this problem does not arise, because situations can share past situations: the number

of situations, S_1, S_2, S_3 , etc., can be greater than the number of past situations, P_1, P_2, P_3 , etc., and each situation, S_1, S_2, S_3 , etc., can still be matched with a past situation.

When non-determinism applies, if we list all the possible situations, S_1, S_2, S_3 , etc., of some kind in which an observer could exist, we will not need to remove situations, because they do not all need to have unique past situations: with *non-determinism* and thermodynamics, *there is enough past to go round*.

2.5 Implications

For any kind of situation that we imagine, if we list all the versions of that kind of situation in deterministic worlds, thermodynamics and the need to have unique past situations prevent some of these corresponding to past situations, so some of these situations need to be removed from the list. On the other hand, if we list all the versions of that kind of situation in non-deterministic worlds, thermodynamics has no such effect, because past situations need not be unique. The list of possible situations in deterministic worlds is therefore “edited” by thermodynamics, while the list of possible situations in non-deterministic worlds remains unaffected. Of the possible situations of this kind that remain, therefore, most will be situations in non-deterministic worlds. This will apply for any general kind of situation in which an observer might imagine finding himself. Most observers should therefore exist in worlds with non-determinism. An observer who has not previously investigated nature to any significant degree, therefore, on starting to investigate nature, should expect to find that he is in a non-deterministic world: he should expect to find randomness in nature. This, of course, is what humans have found with quantum mechanics, and we should expect this situation to be the more common one for observers in general.

3 More Detailed Consideration

3.1 Consideration of Measure

Objections might be made to the argument so far based on measure. It can be argued that measure is reduced in MWI as worlds split, the measure of some situation being shared out among the situations into which it splits. As splitting does not occur with determinism, it may seem that this measure reduction does not occur, and

therefore that a situation in a deterministic world will have a higher measure than the corresponding situation in a non-deterministic world. If true, this would mean that the argument that has been given here would not work: the “extra” members of S_1, S_2, S_3 , etc. would not make the corresponding situation more likely, because all these situations would have lower measure than the corresponding deterministic ones. A simple consideration, however, will now be given to show that measure will not behave so inconveniently (for the author).

The measure of a situation in a Level IV multiverse will depend on its specificity – and this can be considered to depend on how much information is needed to describe it. Suppose that situation P_1 has measure M . If this situation corresponds to n situations that split off from it, S_1, S_2, \dots, S_n , these “new” situations are like P_1 , but their descriptions need extra information to resolve them apart. The total measure of these situations will be M , and each situation will have a measure of M/n . For example, in the case of P_1 corresponding to two split-off situations, S_1 and S_2 , one binary digit of extra information is needed to resolve S_1 and S_2 apart and the measure of each situation is halved by the addition of this bit, so S_1 and S_2 each have a measure of $M/2$.

At this stage, it may seem tempting to say that the version of P_1 in a deterministic world will also have measure M and that, as splitting does not occur, P_1 will give rise to only S_1 (not S_1 and S_2), with S_1 having measure M . It should make sense that P_1 and S_1 have the same measure in a deterministic world. They are essentially the same situation at different times: knowing P_1 you can determine S_1 . If measure behaved like this, it would cause problems for the argument.

All else being equal, however, measure should depend on the specificity of a situation, and there is no reason to think that the non-deterministic version of a situation is any more or less specific than its deterministic counterpart: the increase in specificity in splitting in MWI is due to the need to specify the details of the situation that actually resulted. For example, if an intact glass vase becomes a broken glass vase, information will be needed to specify how the individual fragments of glass are shaped and arranged, to distinguish it from all the other ways they could have been shaped and arranged on the alternative paths. This specificity is still there with determinism,

however: a broken glass vase in a deterministic world still consists of many pieces of glass with different shapes and in different positions, and it should not be possible for this to be described without having to provide enough information to specify it all. The measure of S_1 in the deterministic world should therefore be the same as the measure of the corresponding situation in the non-deterministic world: it should be $M/2$. How can this be the case if measure does not decrease in going from P_1 to S_1 (there being no splitting) and P_1 has measure M ? The answer is that P_1 does *not* have the same measure as P_1 in the non-deterministic world: it does not have measure M . Instead, it has measure $M/2$ – the same measure as S_1 which is derived from it.

It may seem strange that P_1 has measure $M/2$ in a deterministic world, while P_1 has measure M in a non-deterministic world. Are they not the same kind of situation, with presumably the same degree of specificity? The deterministic version of P_1 , however, *does* need to be more specific than the non-deterministic version: it has to be the past which corresponds to the specific future S_1 , while the non-deterministic situation P_1 corresponds to more than one situation S_1, S_2 , etc. Without thermodynamics, this would not suggest that “the past has lower measure” with determinism: it would just mean that each situation, S_1, S_2, S_3 , etc., needs its own past. The problems for determinism arise when thermodynamics is introduced and the measure of the past is reduced, taking the measure of the future with it.

3.2 Consideration of the Degree of Non-Determinism

It has been said earlier that non-determinism will mean that there can be a past for every situation, S_1, S_2, S_3 , etc. This might be disputed, and it should be admitted that what has been presented is a simplification of what might be an involved situation: discussion of the matter in terms of numbers and lists of situations is itself a simplification of the discussion about measure that might be used. Nevertheless, it should give an idea of why the conclusion of the argument should be accepted.

Does non-determinism guarantee a future for *every* situation, S_1, S_2, S_3 , etc.? The issue of how the list is constructed may be an issue here, but it should be apparent that, however many situations remain in the list for non-determinism,

the possibility of sharing past situations with non-determinism means that a deterministic list of situations will always ultimately have fewer worlds when thermodynamics is taken into account. We might imagine different “degrees” of non-determinism. Of course, this may be taking some liberty with language: once you have any unpredictability, with one situation, P_1 having two possible situations, S_1 and S_2 , you have non-determinism, but to discuss “degrees of determinism” would be to consider the number of possible situations, S_1, S_2 , etc., arising from each situation, P_1 . This would reflect “how random things seem” to an observer. The extent to which thermodynamics, or something like it, is operating should also be considered. If thermodynamics is operating very strongly the “arrow of time” will be very obvious, but thermodynamics could also operate weakly.

The argument implies that an observer, looking out into reality, should consider the measure of different kinds of situation in which he could exist with various degrees of randomness and thermodynamics. Without any thermodynamics at all, it should be hard to imagine conscious observers existing, so an observer should expect to find thermodynamics operating to some degree. What if thermodynamics is operating to a very small degree? Computers and similar things might be able to exist in principle, but we should expect them to run very slowly, so we should expect them to generate very little “observer experience over time”. We can consider this in terms of Nick Bostrom’s concept of observer moments [10]: we should expect fewer observer moments to be generated. It would seem that thermodynamics has to be operating at a reasonable level for sufficient observer moments to be generated in a situation that observers should consider it likely, but this starts to limit the number of past situations available to an observer, in turn limiting the number of current situations, and this means that the set of possible situations for an observer starts to be dominated by ones in non-deterministic worlds: the observer should expect to see randomness. How much randomness should an observer expect, though? Randomness causes its own problems by making computers less reliable. With almost complete randomness, most of the states, S_1, S_2, S_3 , etc., that might follow some state, P_1 , would merely be ones in which no reliable computation was occurring and no observer existed. In any event, randomness would seem to contribute

nothing once there is enough of it to compensate for the loss of past situations to thermodynamics.

The possibility of a relationship between thermodynamics and randomness is therefore suggested.

4 NOT SUPPOSING A LEVEL IV MULTIVERSE

The argument presented so far may seem to rely on the assumption that we are in a Level IV multiverse – or, as it may seem to explain our observation of randomness given this assumption, it may seem to support the case that we are in a Level IV multiverse. The assumption that we are in a Level IV multiverse is not required for the argument, however, and consequently the argument does not directly support the idea that we are in a Level IV multiverse. The argument was presented with the assumption that we are in a Level IV multiverse having been made for clarity; however, this assumption can be removed and the argument will remain essentially the same, giving the same conclusion.

If we are not in a Level IV multiverse, then all the worlds that we might inhabit should be considered as *possible worlds*, rather than *actual worlds* that are really “out there” in a Level IV multiverse: the multiverse has been replaced by a “probability space” of possible worlds. The structure of this probability space should be the same as the structure of a Level IV multiverse, so your statistical expectations should be the same regardless of whether we are in a Level IV multiverse, a principle the author has previously called “the principle of modal realism equivalence” [11].³

³ The “principle of modal realism equivalence” does not mean that we can never know whether we live in a Level IV multiverse, nor that there can be no reason for thinking that we live in one: the author happens to think that good arguments can be made for thinking that we do. The point is that empirical evidence that differentiates between a Level IV multiverse or the absence of one is not going to come from an experiment when we are using the correct approach to possible worlds and probability. In the author’s opinion, however, the very adoption of the “correct” approach to statistics which prevents us from empirically testing the Level IV multiverse idea should allow us to build arguments in support of a Level IV multiverse: taking a correct statistical approach may mean that the “extra” empirical evidence is not needed.

If we suppose that we are not in a Level IV multiverse, or do not take a position on the issue, the argument retains the same general form. An observer can list *possible* worlds. Each situation, S_1, S_2, S_3 , etc., becomes a *possible* situation in which the observer could be at the current time and each past situation, P_1, P_2, P_3 , etc., becomes a *possible* past situation. A situation of some kind should be represented in the probability space according to its specificity – more specific situations having lower measure. Each *possible* situation, S_1, S_2, S_3 , etc., for a deterministic world needs to be paired with a corresponding possible past situation, P_1, P_2, P_3 , etc., that is unique, while each *possible* situation, S_1, S_2, S_3 , etc., for a *non*-deterministic world needs to be paired with a corresponding possible past situation that does *not* need to be unique. An observer should still expect to find that thermodynamics applies when he investigates nature, and this should limit the measure of possible past situations, in turn forcing the removal of some of the possible situations S_1, S_2, S_3 , etc. for deterministic worlds. The result is that situations corresponding to non-deterministic worlds occupy most of the probability space of situations in which an observer can exist.

When a Level IV multiverse is assumed, the argument seems to be suggesting that an observer should expect to find himself in a Level III “Everett” or MWI multiverse within the Level IV multiverse. When it is not assumed that we are in a Level IV multiverse, such a conclusion does not follow as obviously however. Rather, the argument clearly suggests that an observer should expect to find himself in a non-deterministic world where prediction is limited by some apparent randomness in the laws of nature. Whether this implies an MWI situation or not is another matter that will not be discussed in depth here. The main point is that an observer, looking out into the world, should expect to find himself in a non-deterministic world, whether he assumes that he is in a Level IV multiverse or not.

Ideally, an observer would consider matters in terms of *observer-centred possible worlds* – and the argument would still apply in a general way.

5 CONCLUSION

Why do we find randomness in nature? It was not always assumed that this would be the case.

Before the discovery of quantum mechanics, the world was traditionally considered deterministic, but quantum mechanics seems to suggest that we live in a non-deterministic world. Statistical ontology has been applied to explaining this, with an anthropic argument being developed. The question has been restated as follows:

“Should an observer who has not performed any significant scientific investigation of reality expect, on starting a detailed investigation of the world, to find randomness in the laws of nature, and if so, why?”

The question can be answered by a statistical ontological argument that uses an anthropic approach. In a deterministic world, each situation can only have one possible future situation. This in turn means that each situation must have a unique past situation that gives rise to it. In a non-deterministic world, on the other hand, each situation can give rise to multiple future situations, in turn meaning that each situation does not need to be derived from a unique past situation: situations can share the past situations from which they are derived. This in itself does not imply that an observer should expect to be in a non-deterministic world. However, thermodynamics also needs to be considered. For conscious thought to occur, computation or some organized physical process corresponding to thought needs to occur: thinking machines need to exist. Such machines can only function in a world with thermodynamics or something like it. Thermodynamics, however, requires that there are more ways of describing the future version of some kind of situation than there are of describing the past version of it. With a deterministic world, this means that the number of situations of some kind that can be described must be less than the number of situations in the past leading to that kind of situation. As determinism means that each situation must have a unique past situation, there will not be enough

past situations to go round: some of the situations in which we might have thought that an observer could exist must be invalid. This issue does not arise in a non-deterministic world, as situations can share their past situations. This means that most situations that can be described in which observers exist should be expected to correspond to observers in non-deterministic worlds. An observer, looking out at reality, should therefore should think it more likely that he is in a non-deterministic world, and should expect to see randomness: this agrees with our experience of observing randomness in quantum mechanics.

The argument stated in this way is somewhat simplified – a more rigorous consideration should be in terms of measure – but the general idea behind the argument should be clear from this. The argument’s conclusion follows whether an observer thinks he is in a Level IV multiverse or not – and will still generally apply if an observer considers the statistics of his situation in terms of observer-centred possible worlds. The statistics of the space of possible situations in which an observer could find himself is the same in each case.

There are different degrees to which thermodynamics might apply and there are, in a sense, different degrees to which an observer’s world may be random. With no thermodynamics at all it should be hard to imagine conscious observers existing, and with very “weak” thermodynamics a world should be expected to contain few observer moments. An observer should expect thermodynamics to apply to some reasonable extent, but a certain amount of randomness should be expected to offset the resulting loss in measure. This suggests a possible interesting link between thermodynamics and the degree of randomness we find in reality.

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