Explaining Markovian Time*

Jacob Lettie

Abstract

I offer a response to the explanatory challenge, 'Why is time Markovian?' (i.e., why is it that the future is constrained by the present just as strictly as it is constrained by the entire history of the universe up to and including the present?). My response to this explanatory challenge does not rely on any claims about the ontology of time, undermining a recent empirical argument for Presentism which appeals to the fact that Presentism can be used to address this explanatory challenge. My account shows that we can accept explanatory challenges of this sort, while denying that they lead to any strong metaphysical conclusions.

1. Introduction

Our physical theories agree that at any given moment, the future is constrained by the present just as strictly as it is constrained by the entire history of the universe up to and including the present; if we gave the Laplacian demon a full description of the present situation, informing them about the past would not help them predict what happens next.

This result, *Markovianism*, rules out certain scenarios. Imagine that some recent adverse events were caused by my breaking a mirror in 2020. Suppose that these adverse occurrences could not, even in principle, have been predicted based on the physical state of the world just prior to their occurrence, but they could be accurately predicted once the fact that I broke the mirror in 2020 has been factored in. Given Markovianism, such a situation could not occur. Nor could there be particles which are liable to vanish without a trace, and then reappear one second later.

* Forthcoming in *Analysis*. I am grateful to Elanor Taylor, Jenann Ismael, Ben Holguín, Ian Phillips, and two anonymous reviewers for thorough and detailed feedback, and to David Builes, Gabrielle Kerbel, and Michele Odisseas Impagnatiello for helpful discussion during and after the session of the 2023 Eastern APA where I presented part of this material as comments, and to Owen Crandall, Alexander Doan, Nellie Dougherty, Hüseyin Güngör, Jessica Luo, and Lars Sobieski for valuable comments and criticism, and to Sanggu Lee for useful comments at the 2024 Pacific APA plus audience members there for their probing questions, and to my peers in the philosophy graduate program at Hopkins who offered sharp questions on this material in February 2024. Uploaded to PhilSci-Archive in October 2024.

Processes which adhere to Markovianism, such as Brownian motion, are commonly called 'Markovian'. But Markovianism is a general claim about temporal processes, and if our physical theories are right, this general claim is true. We can put this by saying that the *universe* is Markovian, and/or the *laws of physics* are Markovian, and/or *time* is Markovian. I use these interchangeably to express endorsement of Markovianism, a universe-wide claim about processes, laws, and time.

Markovianism was recently cited in a new argument for Presentism due to David Builes and Michele Impagnatiello (forthcoming).[1] The classic argument against Presentism from relativity has an empirical basis, but so does this new argument for Presentism, which runs as follows:

(P1) A theory of time that explains why time is Markovian is preferable to one that does not.

(P2) Particular versions of Presentism (plus non-Humeanism) explain why time is Markovian.

(P3) No versions of Eternalism (even with non-Humeanism) explain why time is Markovian.

(C) So, we should reject Eternalism and endorse one of those particular versions of Presentism.

I defend an answer to the explanatory challenge, 'Why is time Markovian?', which works regardless of whether Presentism or Eternalism is true. This undermines (P1) by showing that it may not be the job of a theory of time to provide such an explanation.

§2 argues that in order for this explanatory challenge to have force, the question 'Is Markovianism probable?' must make sense. §3 applies this result to address the question 'Why is time Markovian?' without relying on any claims about the ontology of time. §4 draws on this alternative explanation to undermine both non-Bayesian and Bayesian versions of the argument that we should accept Presentism because it helps explain Markovianism.

2. Does Markovian Time Demand an Explanation?

Consider how Builes and Impagnatiello (forthcoming) motivate their explanatory challenge. They report that Markovianism 'strikes us as a very surprising fact' (Ibid.: 6), and worry that 'Eternalism does not give us any reason to expect that our universe should be Markovian' (Ibid.: 1). They argue that unless we can

[1] See (Ibid.: 2-5) for a careful definition of Markovianism, including a relativity-friendly version that eschews absolute simultaneity, an indeterminism-friendly version, and a version where the present plus an arbitrarily small part of the immediate past fully determines what will happen next. I assume throughout that the universe is Markovian, since 'all of our best physical theories, from Newton on' uphold this claim (give or take a technicality or two). (Ibid.: 6) However, see (Barandes 2023) for a recent framework which does not.

explain why Markovianism 'should be true', we must dubiously claim it is an 'unexplained coincidence' (Ibid.: 17). I will identify and assess two strands of this motivational strategy, labeled (i) and (ii), and argue that securely motivating the explanatory challenge involves clarifying the question: 'Is Markovianism probable?'.

(i) It is *surprising* and/or *unexpected* that the world is Markovian.

This provides some intuitive support for the explanatory challenge, since we usually try to explain things that are surprising or unexpected. However, not everything that surprises us deserves an explanation. We would not expect the sun and the moon to appear the same size in the sky, but this fact has no deep explanation. It makes for some great solar eclipses, but these are just a nice quirk of our cosmic home.

Also, there are explanations of Markovianism that can blunt the motivational force of our feelings of surprise towards Markovianism, such as the following: The world is Markovian because Markovianism is entailed by most of our best physical theories, which yield an accurate description of the world because of how they are constrained by empirical evidence.[2]

This explanation may quell the feeling of surprise in some people, and it provides 'reason to expect that our world should be Markovian' (Ibid.: 6). But B&I must deny that such an explanation is satisfactory, and insist that some different sort of explanation for Markovianism is still needed; otherwise, Presentism would not be needed to explain Markovianism after all. The explanation that B&I offer is a *determinative* explanation, namely, an explanation that identifies whatever *causes*, *grounds*, or otherwise *determines* the explanandum.[3] Additionally, their explanation renders the explanandum probable (and in fact necessary, since their explanans entails Markovianism (Ibid.: 16)). More than a feeling of surprise is needed to motivate the demand for an explanation that is determinative and/or makes the explanandum probable. (Baras 2022: Ch. 3.1.1) argues generally that surprisingness does not provide reason to think that a fact has an explanation with certain good-making features. My narrower claim is that reasons beyond surprisingness are needed to justify the claim that we should seek an explanation for Markovianism that is determinative and/or shows that Markovianism is probable.

---

[2] This is a modified version of Gabrielle Kerbel's explanation from comments on (Builes and Impagnatiello forthcoming) at the 2023 Eastern APA, which used the fact that the Humean mosaic is best summarized by a Markovian description to explain the Markovian laws; this explanation is available on Eternalist Humean views.

[3] See (Taylor 2018a: 198), (Taylor 2020: 1297-99), and (Emery 2023: 109).

(ii) The world's being Markovian is a matter of *mere luck* or *unexplained coincidence*.

If we read this claim metaphorically, then it just reiterates the concern about surprisingness. Taking it literally involves treating it as a modal claim about what the world *might have been like*. Then we can motivate the explanatory challenge as follows. Let *p* be the claim 'The world just happens to be Markovian', or to put it more formally, 'Markovianism is not true in many or most possible worlds'.[4] In other words, *p* is the claim that Markovianism is *rare* among the distribution of possibilities. Then we can use *p* to present a motivated explanatory challenge:

(a) If *p* holds, then Markovianism is a bizarre coincidence.

(b) It is preferable to avoid accounting for things by appeal to bizarre coincidence.

(c) However, the conceivability of many possibilities where Markovianism is false is prima facie evidence for *p*.

(d) Given (a) and (b), a view that counters the prima facie evidence for *p* is preferable to a view which does not.

(e) Only a determinative explanation for ~*p* can counter the prima facie evidence for *p*.

This provides solid motivation for B&I's stronger explanatory challenge. However, it requires us to take seriously the question of whether ~*p* holds, i.e., 'Is Markovianism probable?'.

Note, however, that this approach requires detailed engagement with questions about the distribution of possible worlds. This is a thorny issue; when claims about the probability of the world having been a certain way are assessed in the context of the fine-tuning argument (which, like B&I's explanatory challenge, presses a question of the general form 'why does the world have this striking contingent-looking feature?'), there are a number of objections based on how to specify what sort of modality is involved, and how to deal with the problem of old evidence (Monton 2006). There are also objections to the notion that there is a canonical and well-motivated weighting of possibilities that could serve as a pre-empirical starting point for assessing the conditional probability of a hypothesis given our body of relevant empirical evidence (Ismael 2009: 94-99; Salmon 1967: 75-79, 121, 128). To avoid leaving the explanatory challenge at hand unmotivated, I grant that despite all this we can ask, 'Is Markovianism probable?'.

[4] Builes and Impagnatiello also use the 'happens to' idiom (forthcoming: 6, 17).

3. Explaining Why Time Is Markovian Without Ontology of Time

I agree with claim (b), that it is preferable to avoid chalking things up to bizarre coincidence. However, against (a), I will offer an explanation of why time is Markovian according to which Markovianism is not a bizarre coincidence, although it is improbable. This response requires no assumptions about the ontology of time, undermining the idea that Presentism is needed to account for Markovianism.

Consider this analogy. I will now have my computer generate a random number between 1 and 1,000,000. No matter what, the result will be rare; I got 680,336. If I ask, 'why was the result 680,336?', it seems legitimate to answer, 'it was just a fluke!'.

But there is more to it than that. The full answer: Getting 680,336 was the outcome of an *event*, in the probabilistic sense. This event, the drawing of a random number from one to a million (from a uniform distribution), is an event with no probable outcomes. Although drawing 680,336 was 'just a fluke', getting *some* rare outcome was guaranteed by the nature of the event.

With this in mind, consider the following property of properties of possible worlds:

> A property of possible worlds is **Markovian-like** if (like the Markovian property) it is a universe-wide pattern, picked out by the best physical theories of that world, which seems surprising and notable.

How many properties of possible worlds are *Markovian-like* (and thus surprising and notable like the Markovian property)?[5] Suppose there are many such properties, and that overall, the presence of *some* property like this is probable, even though each *specific* Markovian-like property is absent in many or most possible worlds. Then we can respond to the question 'Why is the world Markovian?' like so:

The world's being Markovian can be modeled as the outcome of a probabilistic event: Select an arbitrary possible world, and then inspect it for whether it has any Markovian-like properties. This is an event with *no probable outcomes*, aside from the (suppose) not-too-common case where the world has no Markovian-like properties. So, although Markovianism is highly contingent, it is not a bizarre coincidence, because the world's having a feature *like* the Markovian property was made probable by the nature of the event.

This explanation draws on two ideas: that an event's being low probability does not preclude it from being explained, and that it is somewhat common for chancy processes to yield outcomes that might seem

[5] It may be difficult to break down the 'surprising and notable' requirement more precisely, but we need some way to distinguish questions like 'Why is the universe Markovian?' from silly questions like 'Why aren't there, in addition to electrons, *zelectrons*: particles just like electrons except with .07% more mass?'.

bizarre. As for the former, objections to the demanding view that an explanation must show that the explanandum is probable are longstanding, and they motivated the development of the statistical-relevance model of scientific explanation (Salmon 1989: 58-67). That demanding requirement has the unpleasant consequence that 'low probability events are in principle incapable of being explained' (Salmon, Jeffrey, & Greeno 1971: 9), even though we plausibly can explain such events (Jeffrey 1969: 108).

On the latter point, that it is somewhat common for chancy processes to yield outcomes that seem bizarre: Imagine a friend taking a coin from a change jar, flipping it five times, and being struck by the fact that it only landed tails once. The friend suggests that this is a trick coin that is more likely to land heads, but this is implausible. You might explain that there are thirty-two different possible outcomes of flipping a coin five times, and that twelve of these outcomes involve all, or all but one, of the flips coming up the same. So, there is a 37.5% chance of getting such a bizarre-looking outcome. Since such outcomes of fair-coin flipping are not the bizarre coincidences that they seem to be, we should not conclude that the coin is rigged.

The hypothesis that Markovian-like properties are individually improbable but collectively probable is analogous to the fact that bizarre-looking outcomes of flipping a fair coin five times are individually improbable but collectively probable. According to the hypothesis, the world's having some bizarre-looking feature like Markovian time is not really a bizarre coincidence, and so we can make sense of this outcome without supposing that there is a metaphysical cause or ground for Markovianism.

So far, I have only stated a rival hypothesis; I have not argued for it. The following section will defend my explanation over B&I's, drawing on real-life cases where the hypothesis that a fluke has occurred is plausible, or even favorable.

4. Is Markovianism Evidence for Metaphysical Conclusions?

This section will argue that Markovianism does not provide decisive evidence in favor of metaphysical conclusions like Presentism and non-Humeanism. I address both non-Bayesian and Bayesian lines of reasoning to the contrary, and show how my explanation could be preferable to B&I's.

Nina Emery defends a general principle which is exemplified by B&I's particular challenge:

> [Pattern-Explanation Principle:] When choosing between competing empirically adequate theories, choose the theory that does not leave well-established patterns without a metaphysically robust

> explanation, even if that theory involves the introduction of some type of entity that is metaphysically weird or novel. (Emery 2023: 109)

The probabilistic explanation of §3 is not a metaphysically robust (i.e. determinative) explanation, but it is not just an attempt to 'explain Markovianism' by improving our understanding in any old way. It provides a way to make sense of the surprising explanandum even if there turns out not to be a determinative explanation. But the combination Presentist/non-Humean views suggested by B&I provide a determinative explanation of Markovianism. According to the Pattern-Explanation Principle, we should prefer B&I's explanation even though it involves stronger metaphysical assumptions.[6]

I contend that this is a case where we should make an exception to the Pattern-Explanation Principle. Emery motivates the principle by arguing that philosophical methodology should draw on scientific methodology (2023: Ch. 1), and reviewing a variety of cases in science where metaphysically novel entities were introduced in order to avoid leaving a well-established pattern without a determinative explanation (Ibid.: 103-107). She suggests that contrary examples might be useful for trying to undermine the principle (Ibid.: 107).

Here is one contrary example. Imagine drawing a coin from your change jar, flipping it, and getting ten heads. You haven't inspected the coin carefully yet, and you wonder: was that just a fluke, or is this a double-headed coin? On the one hand, ten heads is quite rare, about one in a thousand. On the other hand, what are the odds of an arbitrary coin from your change jar being double-headed? If you reckon that the odds of this are far slimmer than one in a thousand, the fluke hypothesis is preferable.

It is reasonable, in this case, to leave the target phenomenon without a determinative explanation because of the very low prior probability of the most salient candidate determinative explanans. More generally, leaving some phenomenon without a determinative explanation seems appropriate in cases where we have reason to think that there is no such explanation. This follows the view that in order to make a good argument for the bruteness of some fact, one viable strategy is to provide 'good reason to be pessimistic about future explanations' (Taylor 2018b: 41).

---

[6] At least if we generalize, using the Principle to license metaphysical claims that don't just posit new entity types.

This leaves the question of whether we have reason to think there is no determinative explanation of Markovian time. If we do, then we may opt for my explanation from §3; otherwise not. I will consider this key question in the context of B&I's Bayesian formalization of their argument.

4.1. Limits to the Bayesian Support for Presentism Offered by Markovianism

Because NHP (the disjunction of the two combined Presentist/non-Humean views suggested by B&I) entails Markovianism, B&I are correct in their claim that there is no rational prior distribution where the following does not hold (forthcoming: 16):

(∗) $Cr(\text{Markovianism} \mid \sim\text{NHP}) << Cr(\text{Markovianism} \mid \text{NHP}) = 1$

From this claim, B&I conclude the following: upon updating on the evidence that the world is Markovian, 'we should substantially increase our confidence in NHP' (Ibid.: 16). This is correct, at least if we are thinking in terms of *relative* increase as opposed to *absolute* increase. However, this increase may still result in a posterior credence in NHP that is quite low, if the following holds:

(∗∗) $Cr(\text{NHP}) << Cr(\text{Markovianism} \mid \sim\text{NHP})$

For example, suppose one has a coherent prior distribution such that:

$Cr(\text{NHP}) = .001$; $Cr(\text{Markovianism} \mid \sim\text{NHP}) = .01$; $Cr(\text{Markovianism} \mid \text{NHP}) = 1$;
$Cr(\text{Markovianism}) = .01099$

If one then learned about the empirical evidence that the world is Markovian, adopted a posterior credence $Cr'(\text{Markovianism}) = 1$, and updated accordingly, their credence in NHP would change as follows:

$Cr'(\text{NHP}) = Cr(\text{NHP} \mid \text{Markovianism}) = Cr(\text{NHP}\&\text{Markovianism})/Cr(\text{Markovianism}) =$
$Cr(\text{NHP})/Cr(\text{Markovianism}) = .001/.01099 \approx .091$

So, in this situation the subject is still left thinking that NHP most likely does not obtain. Intuitively, this is because their priors are such that Markovianism obtaining in the absence of NHP is more probable than Markovianism obtaining because of NHP, even though NHP does entail Markovianism.

I will argue that there can be rational prior distributions where (∗∗) holds, to establish a counterexample to the claim that on *any* rational prior, updating on the evidence of Markovianism will result in a posterior credence in NHP (and thus Presentism) that is high in absolute terms. I will first provide reasons for why it

could be rational to have a low prior credence in NHP, and then argue that it could be rational to have a comparatively higher prior conditional credence in Markovianism given ~NHP.

One might have a low prior credence in NHP because of the apparent soundness of some existing argument against Presentism, non-Humeanism, or both. This might be the case for theorists who accept direct rival views like Eternalism and Humeanism, or views that would deflate debates in ontology of time or deny that there are laws of nature of any sort. Alternatively, one might suppose that Presentism and non-Humeanism are views that could obtain contingently, and use intuitions about the ways they might conceivably turn out true or false as a basis for one's prior credence in each view. Such conceivability intuitions could pull in conflicting directions, but if this approach is adopted, one could for example reasonably have a very low credence in non-Humeanism based on the conceivability of possibilities where no clear lawlike patterns obtain, and the apparent relative abundance of such possibilities.

One might have a comparatively higher prior conditional credence in Markovianism given ~NHP due to the view that conceivability considerations are a weak guide to metaphysical possibility. In that case, one might have a middling prior conditional credence in Markovianism given ~NHP, in contrast with someone who is moved by the many conceivable non-Markovian possibilities where ~NHP holds. Alternatively, if one does take conceivability considerations to be a guide, this too could result in a higher conditional credence in Markovianism given ~NHP relative to one's prior credence in NHP. One could reason as follows: Given an arbitrary possibility where Markovianism holds, what are the odds that there is some deeper metaphysical reason that Markovianism holds? We can imagine scenarios where there is a deeper reason, and ones where there isn't. What if the prevalence of NHP, among metaphysical possibilities, is far lower than the prevalence of *brute Markovianism*? One might reasonably think so, on the following basis: for every Presentist or non-Humean possibility where Markovianism holds, we can conceive of another possibility which is entirely similar except that it is Eternalist and Humean. So, there are at least as many brute Markovian possibilities as there are possibilities where NHP (and therefore Markovianism) holds. Moreover, for each of these possibilities, we can imagine various slight modifications which preserve Markovianism while introducing enough minor exceptions to the laws of nature to ensure that it would be impossible for non-Humeanism to hold (since non-Humean laws, at least at the fundamental level, are standardly taken to be exceptionless).

Summary: there are at least two distinct ways to rationally have a low prior credence in NHP, and at least two distinct ways to rationally have a comparatively high prior conditional credence in Markovianism

given ~NHP. So, there can be rational prior distributions where (**) holds, undermining the claim that on any rational prior, updating on the evidence of Markovianism will result in a posterior credence in NHP (and thus Presentism) that is high in absolute terms.

This result also bears on the non-Bayesian line discussed above, because the views associated with these prior distributions provide reasons to think there is no determinative explanation of Markovian time. Together with B&I's objections to determinative explanations other than NHP (Ibid.: 7-10), my suggested views which yield a low prior credence in NHP provide reason to think that Markovianism lacks any determinative explanation. And on the conceivability-based view that brutely Markovian possibilities are prevalent among Markovian possibilities, it is probable that Markovianism is brute, in which case there is no determinative explanation for Markovianism.

Another reason for assigning low credences to candidate determinative explanantia like NHP concerns general obstacles to the goal of establishing positive metaphysical conclusions. There are few decisive arguments for positive metaphysical views, and many rival views to assign credence to on any given topic. Substantive views like Presentism and Eternalism can be weighed against deflationist alternatives, and there are multiple varieties of Humeanism and non-Humeanism to consider alongside views which would do away with laws altogether. Plus, given the meta worry that we have not yet spelled out all of the available views on a given issue, one could reasonably assign quite low credences to each of the current views on a topic; these need not sum to 1, since the right view might be one that we haven't yet developed. So, one might reasonably have a very low credence in any package view involving multiple conjuncts each making positive metaphysical claims, such as the two disjuncts of NHP.

There are reasonable views which warrant rejecting B&I's explanation and others like it. Is there also a positive reason to accept the rival explanation of §3? Yes, given the modest claim that we should favor views which are at least able to *in some way* address the explanatory challenge 'Why is time Markovian?' over ones that leave this challenge unaddressed. My explanation in §3 is not determinative, and does not show that Markovianism is probable, but it does show that comparably surprising outcomes are collectively probable. I offer no independent reason to think that Markovian-like properties are collectively probable. But if the independent case for NHP is unfavorable, yet *some* answer to 'Why is time Markovian?' must be endorsed even if all candidate answers lack solid independent support, it seems best to opt for the least speculative answer, assuming no more than needed. Since NHP entails my claim that the presence of some Markovian-like property is probable (NHP makes Markovianism not just probable, but necessary, by entailing it), my

strictly weaker claim is the cheaper option. Absent independent support, we ought not accept any substantive view of time or laws unless we have to, and the availability of my explanation shows that there are answers to 'Why is time Markovian?' which do not depend on such views.

5. Conclusion

I have proposed an explanation of why time is Markovian, and argued that it helps to rebut arguments from Markovianism to Presentism, of the Bayesian variety and also those rooted in Emery's Pattern-Explanation Principle. This shows that it is feasible to accept explanatory challenges like B&I's, while denying that they lead to any strong metaphysical conclusions. There is a third option, beyond rejecting such challenges or fully embracing the strong metaphysical conclusions that they seem to yield.

References

Barandes, J. A. 2023. *The Stochastic-Quantum Correspondence*. arXiv preprint, arXiv:2302.10778. https://doi.org/10.48550/arXiv.2309.03085.

Baras, D. 2022. *Calling for Explanation*. Oxford: Oxford University Press.

Builes, D. and M. Odisseas Impagnatiello. Forthcoming. An Empirical Argument for Presentism. In *Oxford Studies in Metaphysics Volume 14*, eds. K. Bennett and D. Zimmerman. Oxford: Oxford University Press. Quotes and pagination are from *PhilArchive* Version 1, uploaded September 26th, 2022: https://philpapers.org/versions/BUIAEA.

Emery, N. 2023. *Naturalism Beyond the Limits of Science: How Scientific Methodology Can and Should Shape Philosophical Theorizing*. Oxford: Oxford University Press.

Ismael, J. 2009. Probability in Deterministic Physics. *Journal of Philosophy* 106: 89–108.

Jeffrey, R. C. 1969. Statistical Explanation vs. Statistical Inference. In *Essays in Honor of Carl G. Hempel*, ed. N. Rescher, 104-13. Dordrecht, Holland: D. Reidel Publishing Company.

Monton, B. 2006. God, Fine-Tuning, and the Problem of Old Evidence. *British Journal for the Philosophy of Science* 57: 405–24.

Salmon, W. C. 1967. *The Foundations of Scientific Inference*. Pittsburgh: University of Pittsburgh Press.

Salmon, W. C., Jeffrey, R. C. and J. G. Greeno. 1971. *Statistical Explanation and Statistical Relevance*. Pittsburgh: University of Pittsburgh Press.

Salmon, W. C. 1989. *Four Decades of Scientific Explanation*. In *Minnesota Studies in the Philosophy of Science Volume XIII*, eds. P. Kitcher and W. C. Salmon, xiii–234. Minneapolis: University of Minnesota Press.

Taylor, E. 2018a. Against explanatory realism. *Philosophical Studies* 175: 197–219. https://doi.org/10.1007/s11098-017-0862-0.

Taylor, E. 2018b. How to Make the Case for Brute Facts. In *Brute Facts*, eds. E. Vintiadis and C. Mekios, 28–44. Oxford: Oxford University Press.

Taylor, E. 2020/2022. Backing Without Realism. *Erkenntnis* 87: 1295–1315. https://doi.org/10.1007/s10670-020-00249-w.