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RESEARCH ARTICLE

Lewis and the Price of Time Travel: Lessons from *Großvater*

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Abstract: Responding to Lewis's (1976) defense of the consistency of time travel (TT), Horwich (1987) and Price (1996) claim that TT may nevertheless be shown to be improbable, due to its need for unlikely coincidences. Smith (1997, 2024) and Ismael (2003) reply, correctly, that this begs the question against TT. Where does this leave us, and TT itself? To put the issue in a broader frame, I note (i) a Lewis-inspired "defense" of Aristotelian mechanics against a famous argument by Galileo; and (ii) the relevance of the Duhem-Quine Thesis. With a range of comparison cases thus in view, TT may be assessed by the Quinean pragmatic standards for theory choice that Lewis elsewhere endorses. I conclude that it is not unreasonable to conclude that TT is highly implausible, despite the fallacy of a direct appeal to the unlikelihood of coincidences. By Lewis's own standards, treating Quinean pragmatic virtue as a guide to truth, this amounts to an argument for the epistemic improbability of TT.

Keywords: David Lewis; time travel; causal loops; bilking.

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1. Death of the Author

Let's begin with autoinfanticide – *auto*autoinfanticide, in fact, from my point of view, because I don't mean the usual impersonal example. I want to describe a case in which I myself was perpetrator and victim. Happily for both of us, not to mention the present text, the deed was dialectical. Nodding off at the wheel, my young self collided with his own epistemic guardrails, without noticing that he was doing so.

To set the scene, imagine the closing years of the twentieth century, deep in the pages of *Time's Arrow and Archimedes' Point* (Price 1996, hereafter TAAP). In Chapter 7, discussing the so-called bilking argument against backward causation, our young author mentions the parallel with time travel, and Lewis's famous defense.

> [I]t is clear that even given the hypothesis of time travel, we are never actually justified in expecting the experiment to yield contradictory results, for logic alone rules that out. A number of authors have made this the basis of a defense of the possibility of time travel against the bilking argument. See Horwich (1975), Lewis (1976) and Thom (1974), for example. This issue is not directly relevant to our present concerns, which exploit a much larger loophole in the bilking argument. In passing, however, let me record my view – similar to that of Horwich (1987), ch. 7 – that the bilking argument survives the former challenge. Roughly speaking, it shows us that the hypothesis of time travel can be made to imply propositions of arbitrarily low probability. This is not a classical reductio, but it is as close as science ever gets. (TAAP, 278; endnote to p. 171)

This endorsement of Horwich is noted both by Nicholas Smith (1997) and Jenann Ismael (2003), in papers defending Lewis's argument. Both Smith and Ismael also pointed out the mistake to the author in person – probably more than once.[1]

[1] On the most recent occasion, Ismael also pointed out the analogy on which I'm relying below: the similarity between her objections to Horwich and myself, on one hand, and points I make in TAAP, on the other.

To put the point in my terms, I had hit one of the very fallacies that TAAP was trying to expose. For example, TAAP discusses the suggestion that entropy will *decrease* in the future, if the universe eventually recollapses under its own gravity. There are several ways in which this proposal emerges in discussions of links between cosmology and thermodynamics. Most directly, some writers argued that the familiar increase in entropy is *explained by* the fact that the universe is expanding (e.g., Gold 1962; see TAAP, Ch. 4, for discussion).

From this claim – call it the *Gold Hypothesis* – the proposal about a future reduction in entropy is an easy consequence. For suppose that the universe does recollapse in what we think of as the distant future. In that era, the universe may equally be said to be *expanding,* if we simply reverse the sign on the temporal axis. The physics of gravitation doesn't have a preference between the two labellings. Unless we slip in some time-asymmetric principle to break the symmetry, this means that the Gold Hypothesis will imply that entropy *increases* in that region, in the reversed labelling sense. In other words – reverting to our familiar labelling – it implies that entropy *decreases* in that future recollapsing era.

A common response to this argument is that such an entropy decrease would be extraordinarily unlikely, by the usual statistical arguments. But this begs the question against the proposal. The probabilities are time-symmetric, as Boltzmann famously learned from Loschmidt. Towards what we call the past, it is commonly accepted that something overrides the statistics – the so-called Past Hypothesis (Albert 2000). My point in TAAP was that we're guilty of a double standard if we don't allow that the same might be true towards the future. The statistics only show that entropy increases *so long as it is not constrained to decrease* (as it seems to be towards the past).

This is precisely the kind of point that Smith and Ismael make against my remark in support of Horwich. In his more recent SEP piece, Smith puts it like this.

> We can set out Horwich's argument this way:
>
> 1. If time travel were ever to occur, we should see extensive uncaused correlations.

2. It is extremely unlikely that we should ever see extensive uncaused correlations.
3. Therefore time travel is extremely unlikely to occur.

> The conclusion is not that time travel is impossible, but that we should treat it the way we treat the possibility of, say, tossing a fair coin and getting heads one thousand times in a row. As Price (1996, 278 n.7) puts it—in the context of endorsing Horwich's conclusion: "the hypothesis of time travel can be made to imply propositions of arbitrarily low probability. This is not a classical reductio, but it is as close as science ever gets." (Smith 2024, §2.2)

Smith then describes his own argument from (Smith 1997).

> Against the second premise, [Smith 1997] argues that, from the fact that we have never seen extensive uncaused correlations, it does not follow that we never shall. This is not inductive scepticism: let us assume (contra the inductive sceptic) that in the absence of any specific reason for thinking things should be different in the future, we are entitled to assume they will continue being the same; still we cannot dismiss a *specific reason* for thinking the future will be a certain way *simply* on the basis that things have never been that way in the past. You might reassure an anxious friend that the sun will certainly rise tomorrow because it always has in the past—but you cannot similarly refute an astronomer who claims to have discovered a specific reason for thinking that the earth will stop rotating overnight. (Smith 2024, §2.2)

2. Reversing in His Grave?

To tie this to my discussion in TAAP, consider these remarks by the famous Cambridge astronomer, Sir Arthur Eddington (1882 – 1944).

> If someone points out to you that your pet theory of the universe is in disagreement with Maxwell's equations—then so much the worse for Maxwell's equations....But if your theory is found to be

> against the second law of thermodynamics I can give you no hope; there is nothing for it but to collapse in deepest humiliation. This exaltation of the second law is not unreasonable. There are other laws which we have strong reason to believe in, and we feel that a hypothesis which violates them is highly improbable; but the improbability is vague and does not confront us as a paralysing array of figures, whereas the chance against a breach of the second law … can be stated in figures which are overwhelming. (Eddington 1928, 74 – 75)

Eddington is well aware of the puzzle of the time-asymmetry of the second law, and of the origin of low entropy in our universe. Concerning the latter, he says that it requires us 'to admit anti-chance; and apparently the best thing we can do with it is to sweep it up into a heap at the beginning of time' (1931, 452). Eddington does not regard this as a novel suggestion. On the contrary, he regards it as implicit in physics since the mid-nineteenth century.

> There is no doubt that the scheme of physics as it has stood for the last three-quarters of a century postulates a date at which either the entities of the universe were created in a state of high organisation, or pre-existing entities were endowed with that organisation which they have been squandering ever since. Moreover, this organisation is admittedly the antithesis of chance. It is something which could not occur fortuitously (1928, 84).

In other words, Eddington sees the need for a Past Hypothesis, overriding the usual statistical probabilities in inferences towards the past – hence his term 'anti-chance'. So far as I know, he never considers the possibility that there might be anti-chance at some point in the future, too. However, his mocking dismissal of any 'theory … found to be against the second law of thermodynamics' shows what he would think of the suggestion. But here Eddington falls into the fallacy that I described in TAAP, and that Smith and Ismael rightly identified in my expression of support for Horwich. To adapt Smith's argument above, 'you cannot [appeal to the usual statistical arguments to] refute an astronomer who claims to have discovered a specific reason for thinking that' because the (future) end of the universe is *also* subject to 'anti-chance', entropy will eventually decrease.

3. Get out of Jail Free?

This is a strong point, but it may seem too strong. What stops it becoming an all-purpose Get Out of Improbability Free card? After all, the application to the case of a potential Future Hypothesis requires us to stare down a truly phenomenal level of improbability. To give a ball-park figure, Roger Penrose (1989, 444) calculates the improbability of the low entropy initial condition as about 1 in 10 to the power 10^{123}. Symmetry suggests that a low entropy final condition would be similarly 'special'. Bananas enough for time travel (Smith 1997) seems an easy trick, in comparison. If the defense works in this cosmological case, what's to stop it working anywhere at all?

Pursuing this thought, we might note a structural similarity to an argument that Lewis himself mentions, tongue somewhat in cheek, in discussing Putnam's challenge to metaphysical realism. This 'malicious argument', as Lewis calls it (1984, 221), has since made a name for itself as Goodman's Proof that P.[2]

> Zabludowski has insinuated that my thesis that *p* is false, on the basis of alleged counterexamples. But these so-called "counterexamples" depend on construing my thesis that *p* in a way that it was obviously not intended – for I intended my thesis to have no counterexamples. Therefore *p*. (Chalmers 2025)

In a similar (impious and fictional) spirit, here's Lewis's Proof that Probably P.

> Horowitz and Priczki have insinuated that P is improbable, on the basis of alleged unlikely consequences. But the claimed improbability of these consequences depends on assuming that not-P – for, given P, they are not unlikely in the first place. (Therefore probably P.)

[2] I am grateful to Daniel Nolan and Jason Grossman here. In the version given by Lewis, the imagined opponent is a Mr Z, not Zabludowski, but the same unusual initial perhaps speaks to a common ancestor.

The optional final step makes a very big difference, obviously – a huge trade of plausibility for strength. More on that below, but for the moment, these are our questions. Does Lewis's defense of time travel overgeneralise, in a way that requires that it be qualified in some way? If so, what's the upshot of such a qualification, for the time travel case?

Let's take this in two stages. First, to get another example on the table, I want to introduce a famous thought experiment. Like the grandfather paradox, it can be presented as a *reductio.* It is widely regarded as a strong argument, and yet there's an apparent response to it, analogous to Lewis's defense of time travel.[3] Where does this leave us? I'll address that question at the second stage, by setting all three examples – time travel, future low entropy, and the one I'm about to describe – in a familiar general framework.

4. Dumping the Bodies

In the early seventeenth century, reflective people knew that heavier bodies fall faster than lighter bodies. If they wanted an authority for such a self-evident truth, Aristotle gave them one. Famously, Galileo challenged this received wisdom in *Dialogues Concerning Two New Sciences* (Galileo 1954). Let's borrow a formulation of Galileo's argument from John Norton.

> The argument is a reductio ad absurdum:
>
> 1. Assumption for reductio proof: The speed of fall of bodies in a given medium is proportionate to their weights.
> 2. From 1: If a large stone falls with 8 degrees of speed, a smaller stone half its weight will fall with 4 degrees of speed.
> 3. Assumption: If a slower falling stone is connected to a faster falling stone, the slower will retard the faster and the faster speed the slower.

[3] Or, more precisely, to Lewis's explanation of how his imagined time traveler, Tim, will fail to kill his grandfather: 'For some commonplace reason. Perhaps some noise distracts him at the last moment, perhaps he misses despite all his target practice, perhaps his nerve fails, perhaps he even feels a pang of unaccustomed mercy.' (Lewis 1976, 150)

4. From 3: If the two stones of 2 are connected, their composite will fall slower than 8 degrees of speed.
5. Assumption: the composite of the two weights has greater weight than the larger.
6. From 1 and 5: The composite will fall faster than 8 degrees.
7. Conclusions 4 and 6 contradict.
8. Therefore, we must reject Assumption 1.
9. Therefore, all stones fall alike. (Norton 1996, 341 – 42)

Like the bilking argument, then, this is a thought experiment by *reductio.* And it is easy to imagine a response, modelled on Lewis's defense of the possibility of time travel. We know on logical grounds that the result of such an experiment would not actually be a contradiction: the body in question would not fall both slower and faster than 8 degrees of speed. What should Aristotle expect?

Norton himself discusses the possibility of systematic loopholes, arguing, for example, that the argument depends on 'tacit assumptions' such as this:

> 8a. Assumption: The speed of fall of bodies depends only on their weights. (Norton 1996, 342)

One way for Aristotle to escape Galileo's *reductio* is to do so systematically, identifying and rejecting some such tacit assumption. But there's another option. Experiments often fail, for boring, accidental reasons. Here 'fail' covers a usefully wide range, from experimenters slipping on banana skins, to many sorts of error within the apparatus itself. By Aristotle's lights, Galileo has described a case in which, as a matter of logic, the natural tendencies of falling bodies will not be wholly manifest. If there isn't a principle to explain why not, random contingencies will do the job instead. We might object that it is very unlikely that experimental errors will conspire to hide the truth in this way, but this begs the question against Aristotle, in the way we have described.

For all that Galileo's argument shows, then, we may be living in an Aristotelian world. Such a response may seem absurd, but Aristotle has some powerful modern allies. Some of the most influential are intellectual forebears of Lewis himself. Let's invite them to the table.

5. Lessons from *Großvater*

Lewis's *Doktorvater* was W. V. Quine (a feather in both caps, obviously). One of the doctrines that now bears Quine's name is the Duhem-Quine thesis. Here Duhem, as the senior partner, may be regarded as the *Doktrinvater*. By a somewhat gerrymandered *Dokt'vater* relation, then, we may regard Duhem himself as one of Lewis's distinguished intellectual *Großväter*. Let's see what he and Quine have to tell us about Lewis's defense of time travel.

One of the central tenets of the Duhem-Quine thesis is that there is no such thing as a decisive refutation of a single scientific hypothesis. This claim has two aspects to it. One is a kind of holism, pushed to a famous limit in Quine's presentation of the view, as we'll see in a moment. The other, more relevant here, is the fact that any claimed refutation of a scientific hypothesis is bound to depend on auxiliary hypotheses. In the face of recalcitrant experience there will always be an option of abandoning some of those auxiliaries, instead of the target hypothesis.[4]

Duhem himself puts the central point like this.

> In sum, the physicist can never subject an isolated hypothesis to experimental test, but only a whole group of hypotheses; when the experiment is in disagreement with his predictions, what he learns is that at least one of the hypotheses constituting this group is unacceptable and ought to be modified; but the experiment does not designate which one should be changed. (Duhem 1914 – 1954, 187; quoted in Stanford 2023)

For Duhem this was merely a thesis about physics. In Quine's famous development of the idea, it becomes a view about the 'totality of our so-called knowledge or beliefs'. Here is a well-known passage from 'Two Dogmas'.

> The totality of our so-called knowledge or beliefs, from the most casual matters of geography and history to the profoundest laws of atomic physics or even of pure mathematics and logic, is a man-made fabric which impinges on experience only along the edges. Or, to change the figure, total science is like a field of force

[4] Even worse, there will be the possibility of inventing new hypotheses, with new forms of relevance, and attributing the recalcitrant experience to those.

> whose boundary conditions are experience. A conflict with experience at the periphery occasions readjustments in the interior of the field. But the total field is so underdetermined by its boundary conditions, experience, that there is much latitude of choice as to what statements to reevaluate in the light of any single contrary experience. No particular experiences are linked with any particular statements in the interior of the field, except indirectly through considerations of equilibrium affecting the field as a whole. (Quine 1951, 42 – 43; quoted in Stanford 2023)

Setting aside Quine's willingness to revise even logic, it is easy to see the relevance of this to our current concerns. If you accept this thesis, then of course there's no knock-down argument against time travel, or the hypothesis that one is oneself a time traveller. At least in empirical matters, there are no knock-down arguments against anything.[5]

Is this good news or bad news for time travel? On the one hand, it puts Lewis's defense of the possibility of time travel on solid foundations, or at least widely-shared foundations. (After all, one of the lessons of the general case is that there is less bedrock than we might have hoped for.) But if the effect of this is to confirm that time travel is in the same boat, or raft, as Aristotelian mechanics, that's rather cold comfort. The Duhem-Quine thesis may prevent us from regarding Aristotelian mechanics as *contradictory,* but it doesn't commit us to giving it significant credence.

This is the point left ambiguous by our probabilistic version of Goodman's Proof that P. A sound dismissal of an argument for *improbability* need not be an argument for *probability,* or *plausibility.* With this sorted out, what can we say about time travel? How should loyal descendants of Duhem and Quine address the issue? And do the analogies we have drawn with future low entropy and Aristotelian mechanics have anything useful to say?

[5] This need not diminish Lewis's achievement in defending the possibility of time travel. As Sherlock Holmes reminds us, it is one thing to know that there is a culprit, quite another to find a plausible candidate.

6. Meeting the Market

At this point, we need a convenient path through a large forest. The methods and rationality of theory choice, downstream from Duhem and Quine (not to mention, e.g., Kuhn), are huge topics. How can we find something condensed enough for current purposes, without too much risk of misrepresentation? Answer: by letting Lewis himself be our guide. In well-known passages in *On the Plurality of Worlds* (Lewis 1986), Lewis offers an explicitly Quinean case for realism about possible worlds. As he says, it is modelled on a similar case for the existence of sets. Neither example is empirical, but they give us enough of a sense of Lewis's view of the Quinean method to apply it to our present cases, without serious risk of getting him wrong.

Here are some key passages from (Lewis 1986). First, the case of set theory:

> Set theory offers the mathematician great economy of primitives and premises, in return for accepting rather a lot of entities unknown to *Homo javanensis*. It offers an improvement in what Quine calls ideology, paid for in the coin of ontology. It's an offer you can't refuse. The price is right; the benefits in theoretical unity and economy are well worth the entities. (1986, 4)

Next, the extension to possible worlds.

> As the realm of sets is for mathematicians, so logical space is a paradise for philosophers. We have only to believe in the vast realm of possibilia, and there we find what we need to advance our endeavours. We find the wherewithal to reduce the diversity of notions we must accept as primitive, and thereby to improve the unity and economy of the theory that is our professional concern – total theory, the whole of what we take to be true. What price paradise? If we want the theoretical benefits that talk of possibilia brings, the most straightforward way to gain honest title to them is to accept such talk as the literal truth. It is my view that the price is right, if less spectacularly so than in the mathematical parallel. The benefits are worth their ontological

> cost. Modal realism is fruitful; that gives us good reason to believe that it is true. (1986, 4)

These are not empirical cases, but they give us a sense of what is in play, by Quinean and Lewisean lights. Is a proposal fruitful? Are the benefits worth the costs? Let's think about our two comparison cases, and then about time travel.

Galileo's thought experiment creates an anomaly for Aristotelian mechanics, a place where additional measures are needed to avoid contradiction. We saw that those measures might be systematic, in identifying additional dispensable assumptions on which Galileo's argument relies. Or they might be *ad hoc,* in the sense of banana skins. Either way, Aristotle has his loophole, and it won't do simply to declare it improbable – that risks begging the question against Aristotle, as we've seen.

But the components of Quinean ideology and ontology are a different matter. We may find the additional Aristotelian measures inelegant and expensive. Then the fact that they turn out to be entailed by the theory, in the light of Galileo's argument, gives us no reason not to debit them to its account – quite the contrary. The Galilean alternative needs no such measures, is elegant and economical in comparison, and turns out to lead to Newton's paradise. It's a steal, in comparison.

We may be idealising here, but the point we need is simple. Defensibility *in principle* does not guarantee plausibility. If it did, the Duhem-Quine thesis would be a disaster for theory choice – every option would turn out to be plausible.

Now to the case of future low entropy. Recall that the Gold Hypothesis (GH) postulates that the increase in entropy in our region is due to the expansion of the universe. If it were plausible, GH would perform an immense theoretical service, in linking thermodynamics to cosmology in this way. But from GH it follows directly, as we noted above, that entropy will decrease again if – a big if – the universe eventually recollapses. The conclusion can only be blocked by some move to break the evident symmetry between the two cases – a move that is bound to look *ad hoc,* unless it has some other motivation.

Perhaps even more strikingly, the probabilistic argument *against* entropy decrease is an argument form with two possible applications, in the

two directions of time. In endorsing the Past Hypothesis (Eddington's 'anti-chance') we already concede that it fails in one of these two possible applications, towards the past. From this point, it looks blockheaded to try to insist that it must nevertheless be a good argument in its other possible application, towards the future.[6]

As it turns out, GH seems unsuccessful for other reasons: GH does not guarantee PH (Price 1996), and even if it did, expansion by itself does not do the necessary work (Wallace 2010; Rovelli 2025). Moreover, it now seems unlikely that the universe will recollapse. However, there are other ways in which the combination of (i) an attempt to give a cosmological explanation of the low entropy past, and (ii) a respect for time-symmetry can lead us to similar conclusions.[7]

Summing up: at least in some cosmological models, the proposal that entropy will eventually decrease offers a large gain in symmetry and simplicity. And the probabilistic argument against it is already highly questionable, on symmetry grounds, before this proposal hits the table. In this case, then, it is easy to see how the proposal might emerge as the economical choice, in Quine-Lewis terms.

7. What Price Time Travel?

What about time travel and backward causation? They are certainly more interesting than Aristotelian mechanics, by contemporary standards. It is easy to find reasons in modern physics for bringing them to the marketplace, as Ismael points out.

> Lest it be thought that the bilking argument only has interest as an objection to a class of esoteric physical hypotheses, closed

[6] Compare this sales pitch, from a team of rocket scientists we'll identify only as X. "Here's your spaceship to the stars. It's extremely reliable. We have the best statistical mechanics on the planet, and they've checked every angle. We even fired an identical copy in the opposite direction, just to be sure." "Did it work?" "No, it blew up on launch. But this one, as we say, is extremely reliable."

[7] In TAAP, Chap 4, I criticise both Hawking and Penrose, among others, for paying insufficient attention to the consequences of symmetry in these issues.

> causal loops are less star-trekky than one would think. Godel's solution to the equations of General Relativity forced physicists take them seriously as nomological possibilities, tachyons have been explored as potential explanations for quantum non-locality, and it is not as clear as had once been thought that superluminal signaling or influence of certain kinds is impossible in Minkowski space-time. (Ismael 2003, 306 – 307)

Indeed, readers familiar with TAAP will know that I argue at length for taking retrocausality seriously. I claim that it has the potential to solve one of the deepest puzzles of quantum mechanics (QM). One of the great challenges of modern physics is to reconcile the work of John Bell in QM with Einstein's theory of relativity. On the face of it, Bell's discovery of 'non-locality', now confirmed in many experiments, seems to require some sort of spacelike action-at-a-distance, in tension with relativity.

As Ismael says, some writers have suggested that tachyons might help to explain nonlocality. Tachyons are (hypothetical) particles travelling faster than light. They thus have spacelike worldlines, and so travel backwards in time in some inertial frames; that's why they seem to imply retrocausality. But this is not what I had in mind in TAAP. In my view, if we're paying for retrocausality anyway then it is much more economical to confine it to past light cones. There, we have all the ordinary particles. If the particles involved in EPR-Bell experiments can be influenced by measurements they are to encounter in the future, then there's no need for direct spacelike influence (or tachyons). Instead, there's a zigzag causal path, via the worldlines of the particles themselves and the point at which they interact.

If this proposal worked, it would be a very strong reason for taking retrocausality seriously. However, it is unclear that it would rely on Lewis's defense. Most advocates of the proposal in QM, including me, propose (i) that it would operate at the level of so-called hidden variables, and (ii) that the kind of restrictions that QM puts on what can be measured would prevent access to this information, in the way that would lead to Lewisean causal loops. This is what I meant by 'a much larger loophole in the bilking argument' (TAAP, 278) in the passage quoted above. It is the loophole identified by Michael Dummett (1964): if information about the past effect can't reach the future cause, there's no loop to worry about.

Still, as Ismael says, there are reasons in modern physics for giving causal loops a table in the marketplace. They are not to be driven out by fallacious or question-begging arguments about inconsistency or improbability. But this is not yet a reason for buying what they are selling – not yet an argument for their *plausibility,* or *palatability.* I'm not aware of any strong arguments for admitting time travel, or the causal loop-generating kind of retrocausality, as part of the accepted account of our actual world.

On the other side, several factors may be regarded as excessive costs. Causal loops would open the door to spacelike signalling, violating a principle often felt to be crucial in QM. One reason it is regarded as important is that it seems to offer a path for peaceful co-existence between QM and relativity. Nonlocality *without* signalling seems much less of a threat to relativity than nonlocality *with* signalling.

For this reason, many contemporary physicists are very reluctant to entertain theories that permit spacelike signalling. We may think of this as an aesthetic or pragmatic preference, but that's a good enough reason to avoid the causal loop table (absent any strong countervailing reason for heading in that direction). If we want an authority for relying on a pragmatic principle here, then again, Lewis's *Doktorvater* is the one we need. Here is the closing sentence of 'Two Dogmas'.

> Each man is given a scientific heritage plus a continuing barrage of sensory stimulation; and the considerations which guide him in warping his scientific heritage to fit his continuing sensory promptings are, where rational, pragmatic. (Quine 1951, 46)

It is no argument against a pragmatic preference of this kind to point out that the theories for sale at your table do not respect it. Perhaps if you can point to previous customers, obviously thriving after buying your product, then you have the beginnings of an argument. One way or another, you need some countervailing advantage, to set against the present pragmatic preferences of reluctant browsers.

For comparison, imagine you are selling Thai food. Many customers prefer to avoid it, because they don't like chilli. Unless you can persuade them to change these preferences, you need to offer them some countervailing reason for buying your wares. ("Sure, it's a little spicy, but it is also tasty, economical, and very nutritious, compared to the rubbish on sale

elsewhere in the market!") The mere fact that Thai food is *possible,* and perfectly normal by its own standards, isn't going to do the trick.[8]

This brings us back (appropriately) to where we began: to the claimed improbabilities of time travel and causal loops. Ismael has a characteristically vivid discussion of the kind of phenomena in question, using an example she calls Earman's rocket. This is a device built to exploit closed timelike curves, in order to prevent its own launch. Earman introduces it like this.

> Consider a rocket ship which at some space-time point x can fire a probe which will travel into the past lobe of the null cone at x. Suppose that the rocket is programmed to fire the probe unless a safety switch is on and that the safety switch is turned on if and only if the 'return' of the probe is detected by a sensing device with which the rocket is equipped. (Earman 1972, 23–32)

Ismael argues persuasively that 'there is no contradiction in supposing there are Earman rockets' (2003, 307)

> What is true is that, holding fixed the laws that govern the process, if *everything works as it should,* the rocket fires *iff* it doesn't fire. And we can deduce therefrom that – again, holding fixed the laws – everything never works as it should. We can deduce from the description of the rocket and the laws which are supposed to govern it that something goes wrong, somewhere along the way, every time. Some contingency arises to spoil things, some bug in the program keeps the rocket from firing or some malfunction interrupts the process after the firing, before it is inhibited by the safety switch. If I get a grant from the NSF, set up 70 Earman rockets, and hire lab technicians to sit and press the buttons that activate their programs once a minute, 16 hours a day, for 17 long years, the result will certainly be that each time any of the buttons is pressed, some kind of system failure or malfunction – a different one, perhaps, every time – occurs. (2003, 307)

[8] Not, at least, unless the culinary landscape changes, so that all the self-consistent options are now spicy – Mexican, Pakistani, and Szechuan, perhaps, as well as Thai. Now there's no longer a pragmatic reason for avoiding the Thai option.

Later in her paper, Ismael makes the set-up even more unusual. She adds a button to the rockets which, when it is down, disables the mechanism whereby a fully-functioning Earman rocket would prevent its own launch. '[D]o the correlations in the new set-up constitute a real anomaly?', she asks (2003, 311).

> Certainly, they can be made to look strange; we can arrange a thousand Earman rockets side by side, each manned by a lab assistant who launches his rocket with the hazard button up or down at his whim, and do run after run of the experiment. What we observe – and it is important here that I am not reporting an experimental result; things couldn't go otherwise – is that, although things almost always proceed without a hitch when the button is down, in every case in which it is up, some foiling event – an event with a perfectly determinate and independent causal history, an event which was bound to happen and (if our rockets were well-designed) bound to occur for reasons that had as little to do with the position of the hazard button as the price of tea in China – occurs. (2003, 311)

Ismael goes on to argue that even here, we have no genuine anomalies or inexplicable coincidences. And she's right, provided that we assess the question under the hypothesis in question, namely, that the world permits the construction of Earman rockets. However, this is perfectly compatible with its looking very strange indeed to inhabitants of realms like ours (where, I'm assuming, we have never encountered anything like this).

So, modified or not, Earman rockets are not anomalous by the standards of the time travel table. But to the casual browser, equipped with her own expectations and pragmatic guidelines for theory choice, they may still look very unpalatable indeed.[9]

[9] "Spacelike signalling? No, I'm afraid I don't have the stomach for that. It's worse than coriander!"

8. Conclusion

Summing up, what can we say about time travel? Two things: Price was wrong, but *its* price isn't currently right. We shouldn't ignore the time travel shop, peddling its unconventional theories. But there's no irrationality in regarding what it offers as a very poor deal, in the light, in part, of the kinds of strangeness that Horowitz and Priczki misrepresent as improbability.

In fairness to Lewis, Horwich, and the author of TAAP, let's close with the following note. Lewis himself is explicit that he regards Quine's theory market as a guide to truth. As he says: 'Modal realism is fruitful; that gives us good reason *to believe that it is true*' (1986, 4, emphasis added). By Lewis's own standards, then, the pragmatic unpalatability of time travel theories seems to be a reason *to believe them false* – in fancier words, to assign them low epistemic credence. So there seems to be Lewisean route to the conclusion that time travel is highly improbable – a route that avoids question-begging objective probabilities, appealing, instead, to the alethic implications of pragmatic unsaleability. Like the question-begging argument, this route depends on appeal to the distinctive consequences of causal loops. But it presents them not as objectively improbable coincidences, but as aesthetic and pragmatic reasons to purchase one's theories elsewhere – that being an argument for the *falsity* or *subjective improbability* of the theories thereby rejected.

By my lights, and perhaps by Horwich's, the last step either adds nothing, or relinquishes hard-won pragmatic territory. Either way, I'm not inclined to defend it as an additional argument against time travel. But it does seem fair to leave it on the table as a challenge for would-be defenders of time travel, if they regard Lewis's (1976) argument as a path to anything much stronger than mere consistency.[10]

[10] Warm thanks to Brian Garrett, Jason Grossman, Jenann Ismael, Daniel Nolan, and Nicholas J. J. Smith, for comments on drafts of this material.

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