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RESEARCH ARTICLE

Is it Time Travel?

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Abstract: According to David Lewis, time travel occurs when a traveller's 'personal time' has a discrepancy with what we might call 'external time' (Lewis 1976, 145). For example, one of two clocks located within a time machine could signal a short trip, while the other may diverge even without limit. In the science fiction classic, *Back to the Future*, Dr. Brown tries to convince Marty McFly that he sent Einstein, Dr. Brown's dog, on a time travel mission. To do this, he uses previously synchronised clocks (one internal to the time machine and the other external), noting the discrepancy in how they recorded the duration of the trip. The Lewisian characterisation of time travel has many virtues, but it is not without issues and queries. This paper will propose original cases to reflect on the Lewisian definition. As will be shown, the aim is not just to question this definition by introducing problematic cases but rather to clarify and reformulate it: 1) the time traveller's personal time (internal time) must be greater than zero, despite Lewis's explicit acceptance of zero-duration journeys, which he characterizes as 'broken streaks' (Lewis 1976, 145, 147); and 2) there are unique cases in which no criteria, especially based on Lewis's definition, seem sufficient to conclude with certainty

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whether a time travel event has taken place. The fictitious cases to be discussed are all intended to support the above conclusions, providing us with an opportunity to appreciate the little-mentioned aspects of the Lewisian definition and its implications.

Keywords: Time travel; temporal experience; temporal dimension; internal time; external time.

Introduction

In his 1976 classic, 'The Paradoxes of Time Travel', does Lewis provide a definition of what time travel is? Or does he merely present us with a simple characterisation of the concept? In this article, I will assume that Lewis intended the former.[1] The difference between 'definition' and 'characterization' concerns the fact that we do not need to propose necessary and sufficient conditions to properly characterise a thesis or concept. However, to define something, we are supposed to do this. It also seems true that a definition could count as a characterisation of a concept or thesis, but not vice versa (i.e. a characterisation may not be a definition). It is important to note that what follows will not be particularly relevant if the reader, contrary to what we assume here, considers that Lewis is actually characterising time travel, because the cases to be addressed will remain problematic anyway. My goal is to suggest possible revisions to Lewis's definition without changing the core of his explanation – the discrepancy between times as the most important factor. However, while David Lewis's definition of time travel is internally coherent as a purely metaphysical account grounded in logical possibility, this paper argues that the definition becomes problematic once we attempt to reconcile it with physically informed intuitions about temporal passage, causation, and persistence. Rather than merely clarifying Lewis's proposal, I offer a revision that departs from its original metaphysical neutrality by introducing constraints motivated by physical considerations, achieving cases that are limits to Lewis's

[1] For further definitions of time travel, see, for example, Arntzenius (2006, 602); Smeenk and Wüthrich (2011, 5, 26).

definition, and showing that Lewis's account is compatible with 'false negatives'.

One of the main theses is that Lewis's definition finds its 'false negatives' by introducing a difference between times that is equal to zero from internal or personal time. Because of this, the personal time should never be zero after a time travel episode. If we do not accept a restriction based on this aspect, changing Lewis's perspective in this way, some strange scenarios would become possible (i.e. cases in which there is little clarity about the application of the concept 'time travel', such that we would not unequivocally know that something is a time journey).

1. Classical Issues and the Lewisian Definition

One objection to be removed involves a contradiction or inconsistency in the concept of time travel itself. Time travel would imply accommodating inconsistent or contradictory times, which would be impossible (cf. Smith 2024). Therefore, the scenario thus conceived should be considered a logical or conceptual impossibility, according to what some people call the 'Time Discrepancy Paradox' (cf. Holt 1981; Effingham 2020, 42). Examples of inconsistent scenarios are as follows: 'travelers who travel fifty years in just one'; 'a traveler who attains the age of 21 after 50 years of his birth', etc. If this objection were correct, the concept of time travel, as we know it, would have to be rethought.

However, Smith argues that something must be wrong with this objection, since scenarios such as these are physically possible[2] and known. Although on a much smaller scale than advanced fictional examples, such results, predicted by relativity, have already been realised (cf. Hafele and Keating 1972).[3] Time travel along the lines above seems physically possible– someone travelling 50 years (externally) in just one year in their own time (internally). As is known, something can only be physically possible if it is

[2] That is in accordance with what the laws of nature establish.

[3] For a different opinion, which refuses to give time dilation a relevant role in this debate, see Holt (1981). The author states that this kind of inconsistency, which he assumes occurs, is a reason to not believe that time travel is even possible.

also logically possible.[4] For this reason, we must either review the nomological possibility of such a trip or find the problem in the reasoning that accuses it of inconsistency. Smith (2024) shows that events such as these have already been registered on a smaller scale. Therefore, they must be not only physically possible but also logically possible (i.e. without any contradiction or inconsistency). However, since our point is conceptual, we must go one step further and elucidate the problem with the objection. After all, why does the alleged inconsistency not exist?

One option to delegitimise the inconsistency is to reject it as a 'question beginning'. That is, the accusation of inconsistency presupposes something fundamental, without which the inconsistency does not occur, and what it presupposes is exactly what this objection is supposed to show. In this case, what is assumed is that time is absolute, and only then do we assign a mismatch in the indication of 'inconsistent' time intervals. However, we already know that time is not absolute, or, at least, we have good reasons to believe that it is not. Indeed, in addition to presupposing the inconsistency this objection was supposed to prove, the objector's reasoning seems to evoke the empirically rejected figure of the absolute time interval.[5]

This difficulty is not new; indeed, much debate of this problem has been sparked in the time travel literature (cf. Christensen 1993; Pitkin 1914, 523; Smart 1963, 239; Williams 1951, 463, 2018, 190–3). The proposed solutions are, however, effective, and, in many cases, include a Lewisian component. If we do not assume beforehand that the time intervals must be absolute, it becomes easy to use the Lewisian apparatus to overcome this problem. In this case, when we say that someone has travelled fifty years in just one year, we should consider that fifty years refers to time measured externally, while one year refers to internal time perceived by the time traveller, which,

[4] I know that I am being conservative regarding this aspect. However, traditionally, this is the proper way the relationship between modalities stands.

[5] According to Tegtmeier, Lewis's account of persistence requires some absolutism on time (cf Erwin Tegtmeier 2007). Nonetheless, absolutism does not imply the thesis that time intervals are absolute. For different meanings of 'absolute' in the literature on space and time, see Friedman (1983, 65).

in any relativistic scenario, would match the 'proper time' of the traveller.[6] All this considered, the contradiction wanes, and only a *petitio principii* that totally disregards relativistic effects could ever argue otherwise (cf. Lewis 1976, 145–8; Grey 1999, 62–3; Harrison 1971, 9–10; Horwich 1987, 114; Le Poidevin 2005, 339–41; MacBeath 1982, 403–6; Nahin 1999, 256–9; Williams 2018, 208–9). Therefore, I conclude in favour of the possibility of having contrasting times, as in Lewis's definition, which is shown to be logically consistent and empirically adequate.[7]

If correct in their response to this paradox, what the above authors show us is that the Lewisian definition is equipped with the conceptual apparatus necessary to deal with such difficulties. According to Effingham (2020, 42), similar attempts to reject the possibility of time travel have few proponents today. However, the paradox above helps us introduce and discuss the Lewisian distinction properly, since the solution to this problem consists of avoiding a contradiction by indicating different time intervals in different contexts – one external and one internal (Gilmore 2016; Sorensen 2005). Before moving on, it will therefore be useful to take a closer look at the Lewisian definition, especially the author's characterisation of 'personal time'.

How can we understand and characterise the fundamentality of the Lewisian distinction between times, especially in the context of the debate about its consistency? To understand the difference between times requires more than instants of time on synchronised clocks, but also facts in the world to be compared. 'Time itself' is objective time (Lewis 1976, 160), and personal time is defined as 'that which occupies a certain role in the pattern of events that comprise the time traveller's life' (Lewis 1976, 146). For this reason, properly characterising the Lewisian difference requires more than pointing

[6] In physics, 'proper time' refers to the time duration measured by a clock moving with the traveller.

[7] Far be it for me to sound like there are no questions about the logical possibility of time travel. There are many such questions, as the kinds of paradoxes (including the grandfather paradox, the self-visitation paradox, and the bootstrap paradox, etc.) involving the notion of time travel, especially into the past (cf. Asimov 2010; Hawking 1992, 604). For the opinion that time travel to the past is metaphysically impossible, see Markosian (2020). For answers to some famous paradoxes, see Effingham (2020).

out discrepancies in clocks that have been previously synchronised. In an interesting article from Sara Bernstein (2022), a broader characterisation of the concept of 'personal time' contributes to finding a difference between times, even when there is no discrepancy that could be pointed out in synchronised clocks. Bernstein considers the case of Tamika, a time traveller who travels for just one hour on a time machine. Tamika returns to the past, but precisely to the time one hour before the start of her journey. In this case, according to the author, although there is no quantitative difference between 'times', there will be a difference in the direction of the processes that appear in the comparison between two timelines (i.e. one internal and one external), and this difference makes up a scenario consistent with the Lewisian definition. This seems to suggest that the difference in the interval between times, especially in journeys to the past, usually involves causally directed processes in a sequence of phenomena (i.e. the direction of biological events in which the time traveller takes part is different from the direction of the same events *tout court*, when considered in external time). In a journey into the future, the difference is usually signalled between speeds of processes when comparing two timelines. However, it is not difficult to find even more challenging scenarios in the literature, such as the following:

> Reverse Aging: 21-year-old DeShawn presses the button on his time machine, and takes twenty years in personal time to travel back twenty years in external time. However, the time machine ages him backwards at a rate of one year per year, such that his body and bodily processes match those of a one-year-old baby upon his arrival in the past (Bernstein 2022, 249).

In the above scenario, there does not seem to be a difference in the speed at which processes occur, nor does there seem to be a difference in the direction of biological events in which the traveller takes part. So how can we characterise a discrepancy between times from a Lewisian perspective? Of course, if it is not possible to find such a difference, then it will also not be possible to say, on the basis of the Lewisian definition, that a time travel has taken place; otherwise, we would have a counterexample to the definition in question.

In the following pages, I will introduce new dilemmas regarding the Lewisian definition. The aim is to accommodate some difficult cases through the inclusion of novel restriction clauses. We will see that in order to maintain the divergence between times, considering the above sense in which 'personal or internal time' is characterised, it will be important that personal time has an interval of greater than zero.

2. New Cases to the Lewisian Definition

In this section, I propose new challenges to examine the pertinence of the Lewisian definition. These challenges are inspired by cases in which there is little clarity about the application of the concept of time travel, such that we would unequivocally know if something counts as it.

2.1 The Present-to-Present Journey

The first case is as follows: (a) inside a time travel machine, there is an onboard computer indicating the occurrence of a time journey. After initiating the 'boarding procedure', the traveller, out of curiosity, attempted to set the exact moment of departure as the destination (perhaps equipped with a trip-scheduling system) to then receive an indication, on the onboard monitor, that a trip was successfully undertaken. In other words, the temporal traveller chooses the instant of departure as his temporal destination, or at least that is what he intended to do, as far as he can see it.[8] The computer recorded the occurrence of the trip; thus, the traveler has no reason to think that he did not take it. Nonetheless, when the traveller compares their clock with other synchronised devices, there is no indication of a discrepancy between the times, inside and outside the time machine.

[8] It could be said that if both events – the arrival and the departure – occurred at the same point in space-time, then we would have the same event, not two separate events. This conclusion could somehow discredit the fictitious case presented. However, it is not obvious that two events are always the same, as long as they occupy the same point in space-time. In any case, I do not think that in such a journey, as in (a), the destination has to be the same spatio-temporal point of origin, but just the same point in time, establishing a possible difference.

Moreover, as we know, there are no differences in the order, direction, and speed of processes that can be relevant to indicating the existence of a difference between times, as in any possible Lewisian case. However, in the above scenario, there does not seem to be any such difference, recognisable by any means. It is then that the traveller considers that 'naturally, if the trip had been made for the exact moment of departure, everything else going on as usual, there would be no difference between the synchronised clocks, after the end of the trip'. Should this indicates that a time travel had elapsed, without, however, the Lewisian condition that always characterise it?

The key issue in the Lewisian definition is related to the 'proper time' in the frame of the traveller, when we compare it with 'time' as it normally passes.[9] In the literature, examples of this are part of the known and imagined cases of the so-called 'twin paradox'[10], and, in each of them, there is effectively a discrepancy between times, signalled by a discrepancy in the clocks (bodies, process, and changes in systems, etc.) that perform their measurement. Therefore, even in the imagined scenario, such a difference would have to occur in order to meet the Lewisian condition (i.e. the divergence between times would have to be accompanied by noticeable differences between previously synchronised clocks or something that relates process to use as a parameter, when they are accurate enough to record the occurrence of that trip).

[9] Thus, the non-discrepancy between times, when verified on clocks (or some other process that shows us a divergence between time), must mirror a equivalence in 'times', just as a difference between times also includes the possibility of its verification.

[10] The 'twin paradox' refers to a thought experiment in special relativity involving twins, one of whom makes a journey into space in a high-speed rocket and returns home to find that the twin who remained on Earth has aged more. That is a result implied by the theory, not paradoxical at all. However, it appears to be paradoxical just because each twin sees the other as moving, and so, as a consequence of an application of time dilation and the principle of relativity, each should paradoxically find the other to have aged less. However, the paradox is just a consequence of a naive application of the principle of relativity, among other physical principles.

2.2 Equal Time Slots for Time Travel

A second counterexample could be as follows: (b) imagine that the traveller has a time travel machine at his disposal, which to be successful in such a trip, needs to reach a certain 'warp speed' (i.e. a speed such that, when reached, hurls the traveller to a temporal destination).[11] Suppose the minimum time to reach such a speed is, say, 3600 seconds, always accelerating. Now, imagine a traveller who wants to travel just one hour into the future, starting and accelerating to complete the journey (ignore the complication that no one would want to make such an unnecessary trip). In this case, the relevant factor could be that the time elapsed during acceleration and upon arrival coincide in previously synchronised clocks, since 1 hour corresponds to 3600 seconds. If the times coincide, there will be no discrepancy between times that Lewis's definition requires. We can then ask: Was there a time travel? Or again: Was there any time travel, according to what Lewis tells us? If the answer to the former is 'yes' and to the latter is 'no', we may have a problem to deal with.

The conscientious reader will notice some problems with the proposed scenarios. Therefore, let us look carefully at two possible objections to the considerations mentioned above.

Relativity: The scenario in (b) contradicts basic relativity principles, as personal time in this case is necessarily shorter than external time.

No travel at all: The Lewisian definition correctly predicts that no time travel has occurred and, because of that, there is no challenge.

What can we say about the above objections? First, this traveller's case is supposed to be a purely conceptual problem and therefore independent – as is usually the case in such matters – of the accessory details that make up the fictional scenario in a thought experiment. However, our objector makes an important point: any possible scenario should not contradict relativity. Fortunately, this problem is solvable. Imagine that the time machine at the traveller's disposal has to warm up for, say, 3600 seconds before being launched to its temporal destination. In this case, *mutatis mutandis*

[11] In science fiction, it is common for a 'warp speed' to allow, in a short time, the connection between two remote points in space. In our fictional example, a 'warp drive' can quickly connect remote points in time.

for the details of the previous example, the same dilemma arises: Is there a time journey or not, given that the triggered destination corresponds to 3600 seconds? My final answer will be in the affirmative; but first, let me comment on the second objection.

This objection suggests that Lewis would correctly predict that, in such cases, no time travel will occur. The issue lies in the fact that even if internal and external time coincided, which is a theoretical possibility, this would not constitute time travel, according to the definition. However, this conclusion seems a little hasty to me. To show this, we can appropriately expand our story. Imagine that the time traveller makes a sequence of journeys, only one of which causes the clocks to coincide. Now, let's say that the traveller starts a journey to the future one hour and ten minutes (i.e. 4200 seconds) after the start of the activated device, and another for fifty minutes (i.e 3000 seconds), also counted from the activation of the temporal device (from this point on, I will refer to cases such as this as b*). Only on a third journey is the time device launched one hour into the future, having to warm up for precisely 3600 seconds in order to be immediately thrown into its temporal destination (b). In all three scenarios, the Lewisian thesis envisages at least two journeys through time. In the first, the previously synchronised clocks show that there is a difference of ten minutes or so, counted from the activation of the time device. In the second, the traveller's personal time seems to be ahead of the outside clock, indicating that there is a difference between 'times'. Only in the third does there seem to be an unwanted coincidence between what the clocks indicate, suggesting that there is no temporal journey at all, since there is no difference between times. However, as far as we can imagine, the operation of the time device and the state of our time machine are the same, within a lack of relevant differences that could separate the cases. Why does the same mechanism of constructing fictitious scenarios sometimes result in scenarios of time travel and, in others, in scenarios that do not constitute it?

Normally, we challenge a definition in one of two ways. We may present a case that is not captured by the definition, although we believe it should be. Alternatively, we may present a case that the definition easily accommodates, although we believe it should not. In either case, what must be clarified is the underlying intuition, and simply reiterating that the

definition does not accommodate some cases, as in (a) and (b), does not count as a promising defence of Lewisianism here.[12] Naturally, because Lewis's definition does not cover cases such as (b), the question we want to ask is: Are (a) and (b) cases of time travel?, and not: Are (a) and (b) cases of time travel according to Lewis's definition? The idea would be just to consult our pre-theoretical intuitions about time travel.

With this in mind, I then present a few reasons for considering cases (a) and (b) as possible challenges. One reason to think of them as challenging can be illustrated by a simple analogy. Just as I can travel between any points in space, the same should apply to time. The present is a point from which and to which we can travel, if we can travel through time in the first place. So, I can leave Manhattan, New York City, and, after a whole trip around the world, without stopping, return to the same place. Within time, everything would be similar. In any case, the journey can be or appears to be 'instantaneous', such as in (a) and (b). Just imagine, for example, that this journey is made at an extremely high speed. If we were to complete the journey at an infinite speed, it would be durationless from the traveller's internal perspective.[13]

Finally, we can explore a special scenario from a Gödelian world. This scenario is an example of what is stated above. In 1949, Gödel famously proposed a solution to the field equations of general relativity, with closed curves connecting the future and the past. In his proposal, someone travelling indefinitely into the future would, from a certain point, return to the past and could even reach the point of origin if the travel continued (cf. Gödel 1949). The question of whether or not, in such worlds, we can move

[12] In any case, when challenging Lewis's definition, we cannot simply assume this author's thesis. That is, anyone who presents a difficult case to consider, taking the Lewisian definition as a backdrop, is certainly not asking whether the alleged counterexamples represent Lewis's definition (doing so would be nonsensical). The question should be 'whether the cases presented are examples of time travel despite what the Lewisian definition tells us'.

[13] Fortunately, such a condition is unrealistic and violates what we think we know about the laws of nature (i.e. that there is a physically possible speed limit, namely the speed of light). But the problem here is the character of zero duration of the trip and not the fact that it is a trip from point t to the same point, as it is in the examples I am proposing.

forward until reaching the point of origin, thus making this journey 'instantaneous', is simply a matter of speed, except in the case of instantaneous teleportation, which is another possibility. If the speed attained by the traveller was infinite, no matter how great the distance would be, the possibility of there being an interval equal to zero would be settled. Naturally, this is not a scenario we should endorse; however, the reasons for this have nothing to do with the impossibility, *prima facie*, of establishing travel from present to present. What is important here is to show that although some journeys apparently do not establish a divergence between times, we perhaps want to avoid suggesting they are not – consulting only pre-theoretical intuitions – cases of time travel. After all, if on a journey to the far future you return to the past and reach the point of origin, this event could be described as a journey from the present to the present.[14] Clearly, this scenario is perfectly Lewisian, thus offering a clue of how journeys such as this should appear. Consequently, someone unfamiliar with the Lewisian definition could well identify cases such as (a) and (b) as examples of time travel, using only pre-theoretical intuition.

I think we should look for a Lewisian scenario in the proposed challenge. Not considering it as a challenge will seem *ad hoc*, everything else remaining the same. This seems to be just an expedient way to avoid the main issue, namely, how to find a Lewisian discrepancy within the apparent coincidence between times in the example discussed.[15]

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[14] It could be objected that there are alternative ways of describing the scenario in question. For example, we could hypothesise that the case involves not one journey, but two: one outward and one return, from the present to some point and so again to the present. Although this is true, it does not pose a problem at all. The way of describing events such as this takes on a certain conventional aspect, and maybe there is no more correct way of doing this, strictly speaking. Note that the same applies to spatial journeys (i.e. my journey between Barcelona and Madrid can also be described as many ten-kilometre journeys between different parts of Spain, and so on).

[15] It is important to stress that these cases do not show that Lewis's definition is internally inconsistent. On the contrary, they arise precisely because Lewis consistently allows for zero-duration journeys and discontinuous personal histories. The problem is rather that, once such cases are admitted, the criterion of temporal discrepancy may fail to classify certain scenarios as time travel, even when the operation

2.3 A Confused Traveller between Worlds

One last challenge will be considered: (c) suppose a mountaineer enters a cave in the Himalayas. He could never have imagined that in this place, unknown and abandoned, resides a 'dimensional portal'. By going through this portal, the mountaineer enters a different and peculiar world. In this world, the past appears identical to the mountaineer's homeworld past. It would seem that our character had been transported to a possible world with the same past, or, better said, a past *prima facie* indistinguishable from the past in his world of origin. Seeing himself in this unusual situation, he peremptorily concluded that 'that cave holds a time tunnel from where I was transported to the past'.[16] Suppose now that our mountaineer is an amateur philosopher, familiar with Lewis's definition, which he uses to arrive at the conclusion: 'Effectively, my passage through the fog of the cave took only five minutes, as shown by my watch. Despite this, what appears outside the cave is very different. It is as if outer time has gone back many years, and everything is now exactly as it was, except maybe for my presence.[17] I am perhaps, so to speak, the first time traveller into the past!'

We know from the description of the story that the traveller is mistaken. He effectively did not travel to the past, having only travelled between different dimensions, in the manner of modal dimensionalism (cf. Yagisawa 2010). Of course, Lewis would certainly not consider a case such as this. According to the author, possible worlds are isolated in space and time, making it impossible for there to be transworld entities (cf. Lewis 1986, 69). Question (c) therefore presupposes a break with aspects of Lewis's theory,

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of a time-travel mechanism is stipulated. This suggests not a flaw in Lewis's metaphysics, but a limitation in the definition's ability to accommodate physically motivated intuitions about temporal passage.

[16] Effingham (2020) calls such events 'warped time travel' (i.e. the idea is that a special place, rather than a machine, is responsible for one's travelling in time).

[17] The idea that in a return to the past events would repeat themselves, identically to their first occurrence, is not innocent. It brings with it immense theoretical baggage and seems to be committed to some form of determinism or 'necessity of the past'. However, this approach seems to be the most common way of thinking about a return to the past scenarios.

modal realism. Fortunately, for our purposes, nothing indicates the impossibility of approaches compatible with the imagined scenario (e.g. Everettian multiverses (Everett 1957)[18], modal dimensionalism (cf. Yagisawa 2010), etc. Even if we do not abandon Lewis's modal realism, a conceptual problem remains: in certain scenarios, it is impossible to determine with certainty whether time travel has occurred. For example, a supposed time traveller could still be present at a hyper-realistic simulation of the past, or take part in a world with duplicates of future temporal parts of objects, people, and events, etc. It would not be difficult to make these scenarios compatible with the mountaineer's deception by imagining possible misdiagnoses, motivated by a Lewisian technique or method of ascertaining time travel (i.e. based on detecting a supposed discrepancy between times, which perhaps does not exist).

Now we can see why this hypothetical scenario poses difficulties. The point to clarify concerns not the Lewisian definition itself but the possible method by which we can tell if time travel has taken place. This method consists of comparing previously synchronised clocks (or some process that can work as clocks) before and after the journey. In some cases, a comparison will be necessary using other strategies, such as the many sequences of ordered events. The traveler may come to the realization that he has traveled to the future when he observes that the individuals he knows have aged significantly over the course of five minutes. Alternatively, he may observe that the sequence of events he is currently witnessing is identical to 'another one' that he has already experienced, in a meticulously maintained order that is consistent with the one he witnessed in the past (or records, perhaps from the distant past). As the method in question consists of comparing 'times' in some way, whether by means of clocks or calendars of sequential events, we can call it 'Lewisian'. However, is this method reliable? Are there any methods that are so?[19]

[18] In the proposal known as quantum modal realism (cf. Wilson 2020), Everettian multiverses are like Lewisian worlds, spatio-temporally separable from each other. But is this necessarily the case?

[19] Some people might think that this counts as both (i.e. travel between worlds and travel between times). I do not believe so. I want to say that travel between worlds

3. Answers to the Above

I am convinced that the cases presented can assist us to see that the Lewisian definition is insufficient for certain physically motivated cases. More specifically, I think that the solution to the above entails accommodating some criteria collectively. The following are not presented as an interpretation of Lewis's original account but as conditions for a revised definition capable of accommodating the negative cases, even considering that we are keeping the Lewisian core – the discrepancy between times – as the most important thing:

1. A trajectory through the time dimension (fourth dimension) of the same world, or temporal line, the spatial dimension being irrelevant.
2. A discrepancy between 'times', in Lewis's terms.
3. The proper (personal or internal) time interval, from the perspective of the traveller, should not be equal to zero but greater.
4. There must be a causal relationship between the journey and the discrepancy between 'times'.

Let us see how elements 1 through 4 help us meet challenges (a) through (c). We can first take into consideration the challenge of the 'journey from the present to the present'. Here, such a case would only represent difficulty if condition 3 were not respected.[20] It would be more correct to separate cases of time travel from cases of 'temporal teleportation'. Temporal teleportation is a case in which the traveller's internal time can coincide with zero between the beginning and end of a temporal journey.[21] This is because teleportation

seems to be a different kind of journey, since it is not clear that there is a correspondence between times in different worlds. For this reason, there is also no clear discrepancy between times.

[20] According to current physical understanding, the proper time interval for any traveller is indeed non-zero, which makes the Lewisian definition generally appropriate when approached in the technical context of the theory of relativity.

[21] However, the idea of teleportation faces more difficulties than just the one imposed by Lewisian definition. Effingham presents some problems with typical scenarios involving temporal discontinuity. In cases such as these, where will the temporal traveller be? Is he divided between the initial and final moments, when the trip is between different instants? Or is he entirely in both points in time? How can

is a discontinuous journey in space-time (i.e. a journey between two points without any passage through intermediate stages).[22] I believe that some cases of temporal teleportation may generate false negatives within the Lewisian definition, since by passing through time without any intermediate steps, criteria 3 could be disrespected, generating the possibility of (a) and (b).[23] To clarify, I do not think that cases of temporal teleportation are impossible or inconsistent. I do believe, however, that we should include, in cases such as these, an interval between times greater than zero to prevent false negatives. So criteria 3 must be true to work as a restrictive factor here.[24]

We can propose that by not violating criteria 3, what appears to be a trip from the 'present to the present' can be interpreted as a trip to another time. When the time device is triggered to a destination equal to the moment of departure, a journey begins, and the time machine moves through the fourth dimension of the universe. Only then does it return to the initial instant. If, when moving through this dimension, you first advance and then retreat, the journey will be toward the future; however, if, when travelling through the fourth dimension, the path is reversed, the trip will then be a trip to the past, and later, a return to the present. Of course, since it is a

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we substantiate the random order of instantaneous events (e.g. the arrival and departure of the time traveller)? What would happen if the traveller instantly arrived at a point in space-time occupied by some material, such as a concrete wall? Given that his arrival is immediate, how could he avoid such a circumstance? (cf. Effingham 2020, 11–12; Pitkin 1914, 524–25).

[22] Note that (a) and (b) are problematic if they exemplify cases of teleportation, as otherwise, travelling from the present to the present, such that the interval of this journey is equal to zero, would require impossible speeds, as in the example of Gödel's world above.

[23] A journey that includes intermediate points between the beginning and the end cannot equal zero, unless it takes place at infinite speed.

[24] Another reason for not including some teleportation cases is a certain violation of the causal order of events. An 'instantaneous' trip violates the way causality normally takes place in time (i.e. the arrival at a temporal destination is caused by a journey that, it seems, should have a beginning separated by a certain duration). Thus, the 'causal signal' between events has a finite speed of communication in time and cannot be durationless – note that this last question does not apply to temporal teleportation that does respect criteria 3.

very short trip, everything could happen in milliseconds, without the time traveller even being aware of it. Importantly, in possession of sufficiently accurate clocks to account for small differences between 'times', we may know that there was 'time travel'.[25]

The reflection on (a), though initially disconcerting, helps shed light on an important condition under which Lewis's account operates, though one that I do not ultimately endorse. Indeed, Lewis seems to think of his definition as entirely consistent with 'instantaneous leaps in time', as when he says, commenting on time travel and the persistence condition of travellers: "*And if he travels either way instantaneously so that there are no intermediate stages between the stage that departs and the stage that arrives and his journey has zero duration, then he is a broken streak"* (Lewis 1976, 147). Or, even more relevant: '*What is time travel? Inevitably, it involves a discrepancy between time and time. Any traveler departs and then arrives at his destination; the time elapsed from departure to arrival (positive, or perhaps zero) is the duration of the journey"* (Lewis 1976, 145). In the passages above, Lewis explicitly allows for instantaneous travel, resulting in what he calls 'broken streaks' (i.e. discontinuous sequences of temporal stages). It is not just Lewis who appears to be willing to accept the possibility of journeys whose personal time is equal to zero. In the following extract, D. C. Holt seems to have the same understanding, as can be seen from the italics I have highlighted:

> It is generally recognized that time discrepancies are an inherent feature of journeys through time. Whether a time traveler travels into the future or past, *whether or not his journey takes time,* there will emerge inconsistent measurements for the interval of time separating his departure from his arrival. For example, if he travels from the last day of 1981 to the last day of 1982 in fifteen minutes, he will arrive at his destination both fifteen minutes and one year after he departs: *if his journey is instantaneous, his*

[25] If I am correct, journeys in which the traveller's personal time is equal to zero cannot be accepted, especially by the Lewisians. We know this restriction may have the cost of excluding fictitious examples of 'time travel'. However, should we accommodate all the cases we can imagine, taking any definition as a starting point? I do not think so.

> *arrival will take place immediately after but also one year after he departs*: if he journeys into the past, he will depart before, but also after, he arrives. This is an essential, indeed a definitive, feature of time travel as it is popularly conceived (Holt 1981, 1).

My proposal rejects such cases, not because they are logically incoherent, but because they conflict with a physically informed conception of temporal passage and causation, generating those false negatives in special limit cases.[26] Regardless, I contend that cases such as (b) can be solved in the same manner, by using the restriction that changes the Lewisian definition in this important manner.The problem will disappear with the non-lewisian restriction in criteria 3. Thus, after reaching 'warp speed' (or when the time machine heats up long enough, in the second version of this thought experiment), the spacecraft, travelling through the fourth dimension, will take a few moments to reach its destination. The Lewisian criteria would be established even if the result was a difference between 'times' of just milliseconds, which only a very accurate clock could indicate. Cases (a) and (b) are similar but not redundant. They are indeed complementary because while one could be suspicious of (a) for seeming too anecdotal, involving instructions whose operation is difficult to interpret in a temporal device, or at least very strange, the second cannot be discarded so easily.

One could question the fact that my answer introduces important changes to the cases that were previously presented. Initially, the cases had no time interval; now, after the introduction of the restriction in 3, they have a Lewisian interval between times (even considering that it is very small). However, the change introduced in the answer should not be a problem, as my purpose is to create, with the introduction of these special cases,

[26] Lewis explicitly allows for the possibility of zero-duration time travel, in which the traveller's personal time has zero duration. In such cases, the traveller's career in personal time does not form a continuous sequence of temporal stages but instead exhibits a discontinuity, which Lewis describes as a "broken streak" (Lewis 1976, 147). Importantly, Lewis's account is grounded in logical possibility, where causal relations – understood as counterfactual dependence – do not require physical continuity or temporal duration. It could be read as a permissible consequence of Lewis's four-dimensionalist ontology, according to which personal identity does not require temporal continuity or intervening experiential stages.

an occasion to discuss an issue that has not yet been explored in the Lewisian definition, which is that the traveller's personal time must never be equal to zero.

Fortunately, accepting 3 is all we need to understand those cases as Lewisians. If we can indeed reinterpret (a) and (b), we might be more successful in defending Lewis's definition, without any *ad hoc* steps based only on the need to enforce the definition. However, in virtue of what the criteria 3 is so important, after all? Of course, 3 is not intended to be true just because it helps to avoid problematic cases, but for independent reasons. To put it more clearly, it is the basis that makes 3 true that can act as the reason to avoid (a) and (b). But what is this basis? A strong ground for this concerns the idea that cause and effect cannot be instantaneous events. In this case, scenarios such as (a) and (b) violate this principle. For cause and effect to be instantaneous in this way, the signal between events would have to have an excessively high speed, far exceeding the speed of light. However, of course, these scenarios can be ruled out, since they violate what we believe to be true according to relativity.

One might think that the above principle does not constitute evidence for the truth of 3, but rather for the impossibility of events such as (a) and (b). But this way of thinking is, in my opinion, incorrect. Note that we have argued, especially with the introduction of scenarios such as Gödelian worlds, that (a) and (b), or even some cases of temporal teleportation, are not problematic *per se*. The problematic cases disregard 3, which I think is true and can be defended independently, using the above reasoning. If we reject (a) and (b) in this way, we are left without unproblematic scenarios of time travel which, in the meantime, seem perfectly legitimate and Lewisian (e.g. travelling from point t to the point t, as in a Gödelian world).

It remains to be seen whether we will have the same luck with (c). The problem lies in the fact that our character uses a possible method, inspired by the Lewisian definition, which results in a misdiagnosis of the situation. The point of it is not that Lewis's definition is defective, but that no epistemically infallible method exists for determining whether time travel has occurred, even if a correct metaphysical definition were available. In the case of transworld travel, confusion arises because the mountaineer does not know whether he has made a temporal journey, although he has a criterion

that, taken in isolation, makes him think so. How can Lewis's definition be prevented from being part of that deception? Once in possession of a definition that contemplates 1, our mountaineer will not think of himself as being in a position to know that he has travelled through time. He may realise that he might not know it, or a least he could suspend his judgement of this issue, when well informed by the criteria 1. This will be because the mountaineer knows that a journey through time involves a very specific path, with a necessary route, distinct from space or the transworld. Upon knowing this, he is in the position to know that without a method to discriminate cases such as these, he will not be able to recognise that he has travelled in time. What (c) helps us expose is that the technique of comparing previously synchronised clocks (or any other time counting device) has its limits and is, thus, sometimes insufficient. We can go even further: no known technique seems entirely free of counterexamples. Indeed, there does not seem to be a foolproof method of knowing whether time travel has occurred.[27] I think that in this negative diagnosis lies one of the most important contributions of this paper: There is no method that is completely free of mistakes to know if time travel has been undertaken.

Finally, it may be useful to mention criteria 1 to 4 as complementary: The discrepancy between 'times' must be causally related to a crossing, which in turn must include at least one dimension of the universe (time, the so-called fourth dimension), which cannot be confused with any transworld crossing, and which will not consist of events with no elapsed personal time (arrival and departure). Indeed, the very idea that trips or crossings can be durationless seems to me completely questionable.

[27] Holt (1981) makes a similar point. According to the author, in many cases typically presented as 'time travel', the conclusion that they really are such journeys is hasty. However, unlike the author, our proposal is purely epistemic – it rejects the existence of a criteria from which we can know that there has been a time travel – which in Holt's view contributes to rejecting the alleged scenarios of 'time travel' as a possibility in the first place.

Conclusion

If a time traveller can travel instantaneously to any temporal destination, there will be cases that the Lewisian definition, as originally formulated, cannot reliably capture.

Travelling like (a) and (b), however, can be Lewisian, as in Gödelian worlds, but criteria 3 must always be respected in any such scenario. We have also seen that the possible Lewisian method for discriminating time travel from other scenarios has gaps, and is, in fact, compatible with deception (i.e. cases in which there appears to be a discrepancy between times, when in fact there is not). Finally, by discussing little-explored issues and proposing useful criteria, such as 3, this article presents and substantiates a negative result: We still have no infallible method for verifying or knowing whether time travel has taken place.

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