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Title: Time Travel and the Immutability of the Past within B-theoretical Models

Abstract: The goal of this paper is to defend the general tenet that time travelers cannot change the past within B-theoretical models of time, independently of how many temporal dimensions there are. Baron (2017) offered a strong argument intended to reach this general conclusion. However, his argument does not cover a peculiar case, i.e. a B-theoretical one-dimensional model of time that allows for the presence of internal times. Loss (2015) used the latter model to argue that time travelers can change the past within such model. We show a way to debunk Loss's argument, so tha the general tenet about the impossibility of changing the past within B-theoretical models is maintained.

Keywords: Time Travel, Time, Hyper-Time, B-Theory, Changing the Past.

1. Introduction

What would you do if you had a perfectly functioning time machine right in front of you? Well, probably one the most tempting thing is to take advantage of it by traveling to the past to change it. You might plan to go back to 1890 and kill baby Hitler to prevent all the evil he brought forth, or you might want to advise the Titanic crew not to take their trip. Or, more selfishly, you, currently broke, might want to go back few years and tell your younger self to invest all your savings into what you easily know will be the top performing stock. Alas, these tasks are impossible to carry out. Even if episodes of time travel do occur, a past time T cannot change from containing an event E to lacking it, and for familiar reasons. One might follow Lewis (1976) and think that only what has temporal parts can change, and times, like numbers, do not have them. Or, one might argue that the past cannot change without committing herself to the Lewisian requirement for change. For a time traveler cannot prevent an event E that did take place at a past time T because in that case T would both contain and not contain E, and this would be contradictory. Hence, changing the past is impossible. Don't even try to apply for funds for your promising time travel machine project. The fact that the past cannot change together with the fact that our past is full of unpleasant events will make the committee decide not to fund your project. For either you won't eventually be successful in creating a time machine or if you will, you won't use it to prevent those past unpleasant events (See Casati and Varzi 2001).

This is not the whole story, though. What we said before holds true for standard B-theoretical eternalist models where time is one-dimensional (henceforth, 1D). In such models, changing the past is impossible. But this view of time is not the only one possible. For instance, van Inwagen (2010) showed, arguably successfully, that within an A-theoretical growing-block model featuring two dimensions of time (henceforth, 2D) — time and hyper-time — time travel can coherently result in alterations of the past. In his model, the (growing) Block of Reality normally grows as hyper-time goes by. However, when past-changing time travel takes place, the portion of reality that goes from the time traveler's time destination to the time of departure gets erased, making it possible for the Block to re-grow differently from how it hyper-used to be. Say that Tim travels from 2017 to the past year 1920, a time where he has never been around. If so, his departure takes place at the pair time/hyper-time (2017,2017), whilst his arrival takes place at, say, (1920,2018). The past year 1920 *changes* from hyper-earlier not-featuring Tim to hyper-later featuring him. The Block will hyper-then re-grows differently from how it hyper-used to be, due to Tim's presence. As a result, within such model it is possible to change the past.[1]

So, changing the past is impossible within standard B-theoretical eternalist 1D models, whereas it is possible within at least some A-theoretical 2D models. The first moral to draw is that whether or not the past can change by means of time travel depends heavily on what theory of time is correct, or more weakly, what theory of time one is willing to endorse. But the theories of time are many, and one might easily feel lost while trying to pin down whether it is possible or not to change the past within one specific kind or sub-kind of theory of time. Fortunately, Baron (2017) provided us with a convincing argument to a general conclusion. His argument purports to show that the past *cannot* be changed within any B-theoretical model, independently of whether time is 1-dimensional, 2-dimensional or n-dimensional, for any natural number n. In short, Baron's point is that no matter how many dimensions of time there are, time travelers within B-theoretical models can at best affect the past, i.e. they can have a causal influence over past events, but cannot change it.[2] His argument does not say anything about A-theoretical models. Yet, it provides enough generality to have a good understanding of how several theories of time behave with respect to the problem of the (im)possibility of changing the past. It is impossible within B-theoretical models. Period. Case closed. End of story. Or maybe not. In fact, there is still one challenge to face, not covered by Baron's argument. Consider a B-theoretical 1D model such that it allows for the presence of sub-times, i.e. internal time series which somehow overlaps the fundamental linearity of the single dimension of time. Baron's argument does not cover such a case, for when he discusses 1D cases, he does so having in mind standard 1D models that do not feature sub-times. Interestingly, Loss (2015) employs this B-theoretical 1D (plus sub-times) model to provide a sophisticated argument to the conclusion that in such model time travelers *can* change the past.

If Loss's argument is correct, then the generality of Baron's conclusion is lost because we would have a peculiar B-theoretical 1D model that opens up the possibility for time travelers to change the past. The goal of this paper is to defend the generality of the tenet that the past can never change within any B-theoretical model, and to do so we will debunk Loss's argument. If we will be successful, friends of the

[1] Bernstein (2017) offers an A-theoretical model that features a Movable Objective Present to make van Inwagen's point more general. There, time travel does not necessarily feature the annihilation of some portions of reality, but it necessarily features a shift of the Objective Present. The result is that past-changing time travel within an A-theoretical framework is compatible not only with the growing-block theory like in van Inwagen's, but also with presentism and the moving spotlight view.

[2] Baron's argument to this conclusion is quite long and complex, and thus we don't try to summarize it here in few words. The interested reader is redirected to his paper to know more.

immutability of the past within B-theoretical models can be relieved and stick to the thought that changing the past in any B-theoretical model remains impossible.

Roadmap: in the next section (Section 2) we need to spend some time analyzing Loss's model of time in order to see how he can argue that his B-theoretical 1D (plus sub-times) model allows time travelers to change the past. In Section 3, we present what we think is a serious flaw of that model. We will also argue that this flaw should incline us to abandon the model and hence the possibility to change the past by appealing to that model. In section 4, we offer a patch to Loss's model such that the resulting view a) does not suffer from the flaw presented in section 3 and b) retains an important theoretical virtue of Loss's model. Under the resulting view, there is no room for claiming that the example Loss discusses is a case of past-changing time travel.

2. How to change the past in a B-theoretical 1D model

This section is devoted to provide an overview of Loss's argument to the conclusion that time travelers can change the past in a B-theoretical 1D (plus sub-times) model.

Before getting into Loss's argument, we need to make a point about the dialectic of this paper. Our aim is to defend the general conclusion that it is impossible to change the past within B-theoretical models, and we are saying that this conclusion is threatened by Loss's case (not covered by Baron's argument). Whilst Baron explicitly claims that he is interested only in B-theoretical models, Loss never makes such an explicit claim. However, nothing Loss says makes the reader think that he is working within an A-theoretical framework. In fact, Loss's account of time does not feature any objectively privileged present, nor it features an objective passage of time. Moreover, Loss models his central notion of internal time, to be explained later, on the Lewisian notion of personal time, implicitly adhering to the Lewisian B-theoretical view. Thus, it is clear that Loss's account of time falls into the category of the B-theoretical models.[3]

Into the model of time Loss employs to make his point. Loss's model is made up of five components. The first component is eternalism, the idea that all times are equally real. The second component is an

[3] With regard to the dialectic of this debate, Baron (2017: 131) is worried about whether or not there are philosophers who can qualify as his opponents in virtue of holding a B-theoretical 2D view of time to make a case for changing the past, for that position is the intended target of his argument. He then individuates Goddu (2003, 2011) and Hudson and Wasserman (2010). However, this does not seem correct with regard to Hudson and Wasserman. In fact, Hudson and Wasserman are responding to van Inwagen (2010) A-theoretical growing-block 2D model, and one of their points is that the spirit of van Inwagian model can be cashed out also by assuming eternalism in place of the growing block. Even though most eternalists endorse the B-theory of time, eternalism is compatible with the A-theory. And this latter combination is precisely what Hudson and Wasserman have in mind while proposing their model. In fact, in their model, past-changing time travel occurs when the *objective present* hits the T-slice within the eternalist block where the time traveler pushes the button of her time machine. See also Wasserman (2017, Ch. 3) for more details on such A-theoretical eternalist 2D model. At any rate, the position Baron discusses is general enough that, we think, there is no need to look for someone holding that position in order to make a case for the changing past.

exdurantist account (or stage-theory) of persistence, according to which continuants are instantaneous stages which persist and possibly change in time in virtue of having qualitatively different *counterparts* located at different times. For instance, say that Jane sits at T_0 and stands at T_1. In such view, *she* persist and change in time from T_0 to T_1 because her instantaneous stage is sitting at T_0 and there is a standing-counterpart of *her* located at T_1. What makes her stage at T_0 and her stage at T_1 counterparts of each other is a relation of continuity and similarity which sticks together qualitatively different stages.

The third component Loss adopts is the fact that the *whole* world itself can be treated as a continuant. Standardly, the stage-view, or any theory of persistence for that matter, deals with *things* — objects, persons or events — that persist and possibly change in time. Loss extends the stage-view to T-slices, where a T-slice 'is the mereological sum of all the entities x, such that x exists at T, and only at T' (p.4). Under this view, *the world* persists and change in time the same way things in the world persist and change in time. That is, a world persists and change in time in virtue of the existence of qualitatively different T-slice counterparts located at different times.

The fourth component is the distinction between *external* and *internal* time(s) of a world. External time is understood as being just the standard earlier-later relation, which does the job of ordering all the T-slices belonging to a possible world by telling you for any pair x, y of T-slices, whether x is earlier than y, or y is earlier than x.[4] On the other hand, the notion of internal time is modeled on the Lewisian (1967) notion of *personal* time of a time traveler. Personal time applies to time-travelers and it does the job of ordering the time-travelers stages which are scattered throughout external time. This ordering is made on the basis of the regularities which normally hold in the world the time-traveler inhabits. It is a regularity in our world that, say, we first eat pizza and then digest it. Consider a time-traveler in our world who has a slice of pizza for lunch, time travels 40 years back and then digest that slice 1 hour later. Given the regularity just mentioned, the time-traveler eating-stage is earlier than the digesting-stage according to her personal time, even though the latter is earlier than the former according to external time. Loss's internal time extends the notion of personal time by applying it to compositions of T-slices rather than sums of the stages which constitute a time traveler's life. We shall see what this amounts to by means of an example Loss himself provides. Loss makes us ponder the possible world W_1. W_1 is a qualitatively duplicate of our world, except for the fact that in W_1 there is a 10 years break after the last[5] instant of 1989. All continuants existing at the last instant of 1989 in W_1, which is qualitatively identical to our last 1989-instant, are completely annihilated and replaced for ten years by a bunch of spheres bouncing around in an otherwise empty space. After this 10 years break, all the spheres are annihilated and replaced by a T-slice that is qualitatively identical to our first 1990-slice, and then things develop the way they do in our world. W_1 is a block universe as any other possible world, given that we are assuming eternalism, where *all* its T-slices are tied together by an earlier-later relation that tells us how the slices are ordered.

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[4] The earlier-later relation does this job for *any* pair of T-slices, as long as time is linear. In branching-time models we might have pairs of times which are not related by such relation. We set aside this case, given that Loss's example is a case where time is linear. We are setting aside also considerations from special theory of relativity, where what is primitive are spatio-temporal intervals.

[5] For the sake of simplicity and exposition, we shall assume throughout the paper that time is discrete. This way we can safely talk of the first, second and last instant of a given interval. The points we are making do not depend on this assumption.

However, Loss argues that in this and other similar cases we are entitled to consider just *some* T-slices which make up a world. That is, whereas a world is an unrestricted composition of all its T-slices, sometimes it makes sense to talk of maximal *restricted* compositions of T-slices, tied together by a relation of similarity and regularity. Loss names such compositions 'internal worlds'. For instance, take the initial segment of W_1 from its beginning up to the last 1989-instant and its final segment which starts from the first instant after the spheres break. This is a proper part of W_1, let's name it W_{1a}, which is made up of T-slices tied together by a relation of relevant similarity and regularity. That is, within this internal world we have the same kind of regularity and continuity which is supposed to hold in our world. Internal worlds come with their own *internal time*. As Loss observes, people in W_1 located in the year that is qualitatively identical to our 1990 will say things such as "The Berlin's wall fall occurred one year ago", even though that event happened eleven years before according to external time, given the 10 years spheres break.[6] This is due to the distinction between internal and external time. The former claim refers to W_{1a}'s internal time, i.e. it refers to the way things are time-ordered in the internal world W_{1a}, whereas the latter refers to W_1's external time. The T-slice where that claim about the Berlin's wall fall is uttered is in the year 1990 according to W_{1a}'s internal time *and* in the year 2000 according to W_1's external time.

The last component Loss adopts to make up his B-theoretical 1D (plus sub-times, i.e. internal times) model of time has to do with the notion of change as applied to times. According to this last component, a (past) time genuinely changes when we have two times x and y similar enough to be counterpart of each other, and there is a time z distinct from x, y such that both x and y are, for some n, n *internal*-time-units later than z (2015: 10).[7]

Having clarified what Loss's account comprises, we can see how Loss can say that it is possible for time traveler to change the past within such B-theoretical 1D (plus internal times) model. To argue for this possibility, Loss makes us consider the possible world V_1. V_1 is qualitatively identical to our world from its beginning up to the last instant of 2010 (external time). But then, at the very last instant of 2010 (external time), Tim presses the button of his brand new time machine. The next instant, he finds himself in a T-slice which looks qualitatively identical to the first 1920-slice (external time), except for his

[6] Loss implicitly assumes that external time always has its own metric. But external time is here just the earlier-later relation, and it's at least open what stance one should have with respect to metric determinations. Roughly, an *objectivist* with respect to temporal metric takes as primitive a metric version of the earlier-later relation. Thus, according to the objectivist there are fact of the matter not only about what comes before or after what, but also about the *length* of temporal intervals. Whereas, according to a *conventionalist* with respect to temporal metric, there are only facts of the matter about what comes earlier or later what, but no facts of the matter concerning temporal distances. Facts concerning distances are given only relative to a chosen measurement device, that is a clock. Depending on the variety of conventionalism, the choice of the clock can be more or less constrained by reliability considerations (See Newton-Smith 1980). Since Loss appeals liberally to temporal distances of the earlier-later relation even when measuring systems get abruptly annihilated and replaced, like in the case of the spheres break, his account assumes an objectivist metric version of the earlier-later relation. For the sake of discussion, we will stick to this assumption.

[7] The reference to the time z as a "common ancestor" at the same internal temporal distance from both x and y is crucial for Loss to make his point. Without it, any possible world with two T-slices similar enough to count as counterpart of each other would be a case where a (past) time changes. And this would be wrong. A possible world might just *end up* in a state very similar to an earlier one.

presence. From a *sub specie aeternitatis* perspective, V_1 is a world where the last instant of 2010 (external time) is followed by a final segment which starts with a 'second' 1920, and then develops regularly. Here the notion of internal time can be summoned. In fact, V_1 from its beginning up to the last 2010-instant (external time) displays the same kind of regularity which holds in our world, and moreover it is a maximal composition. Hence it is an internal world, let's name it V_{1a}, with its own internal time. And, there is a further maximal regular composition, let's name it V_{1b}, namely the world's beginning up to the last 1919-instant (external time) together with the segment from 2011's first instant (external time) to the world's end.[8] The 'first' 1920 and the 'second' are both one year later than 1919 (external time) — the first one is one year later than 1919 according to V_{1a} 's internal time, whereas the second one is one year later than 1919 according to V_{1b} 's internal time. Moreover, those two times similar enough to be one counterpart of the other. Hence, the principle that appears as the fifth component of Loss's account is respected. This means that we have a case where a past time, the year 1920, changes thanks to Tim's episode of time travel. The year 1920 *changes* from not containing Tim to containing him. In Loss's words:

> (Internal) times themselves can thus be seen as persisting and changing in (external) time. Within an exdurantist account of persistence, to say that the year 1920 has changed is to say that the year 1920 is a continuant which has a qualitatively different past counterpart. This kind of change is precisely what is the case in Tim's universe according to the theory I am presenting. The internal 1920 changes from being Tim-free, to being Tim-ful. It persists and changes in (external) time by having qualitatively different temporal counterparts: on occurring in 1920 external time, the other occurring in 2011 external time. (p.10)

To sum up this section, Loss's B-theoretical 1D (pus internal times) model of time (and change) does entail that in V_1 time travel results in alterations of the past. This result clashes with the general conclusion that we wish to defend, namely that the past cannot be changed in any B-theoretical model. However, we are not forced to accept the plausibility of Loss's model. In the next section we will show that such model comes with a serious flaw that should incline us not to accept it.

3. Undesired Change

In this section we present what we think is a problem for Loss's account of time (and change). That is, we show how his account predicts that cases where the past does not change count as cases where the past does change.

Let us see why. Consider the world K_1. K_1 is qualitatively identical to our world from its beginning up to the last instant of 1920 (external time). After that instant, everything is annihilated and replaced by a one-day break that features only elementary micro-particles bouncing around in an otherwise empty space. Let us say that D is the complete description of the particles position over that day at each instant and that one specific particle P is motionless at the location in space <1,0,0>. Right after this D-day, the

[8] Actually, as Loss observes, V_{1b} is *quasi -regular.* In fact, in V_{1b} Tim appears out of thin air. This kind of *local* irregularity should not bother us, though. Tim's case is supposed to be a time-travel case. Hence, some local irregularity has to be expected.

elementary micro-particles are annihilated and K_1 restarts where it earlier stopped, i.e. there is a perfect continuity between the 1920's last instant and the first one after the D-day. The calendars now read 1^{st} January 1921, people refer to events happened two days ago in external time as happening yesterday, and so on. Then, the world goes on, until one day very far in the future, the universe as we know it looks very differently. The physical processes taking place over billions of years make it the case that the universe no longer features planets, stars, galaxies and so on. All the universe features are elementary particles, qualitatively and intrinsically identical to the ones appeared in the D-day, bouncing around in an otherwise empty space. Eventually, in the year $2010 \cdot 10^9$ (external time), these elementary particles but one, P's counterpart, are arranged D-wise. That is, the particles arrangement for that day can again be described by D, with the only exception of P's counterpart that is here stationary at <2,0,0> — let's name this description D*. Then K_1 keeps evolving in accordance with the physical laws governing these elementary micro-particles until the end of its days.

Let us see why K_1 is problematic for Loss's model. To do so we just apply his model to this world. We start by looking for internal worlds. A first one is easy to find. Take K_1's initial segment up to the last instant of 1920 together with the segment that follows the D-day. This restricted composition of T-slices is regular because it leaves out the only discontinuous time interval happening in external time, namely the D-day. It is also maximal with respect to regularity because no other T-slice can be added to it while maintaining the property of regularity of the restricted composition. Hence it makes up an internal world, let's name it K_{1a}, with its own internal time. But there is a further internal world. Just take again K_1's initial segment up to the last instant of 1920, add the segment that goes from the first instant after the D-day until the last instant before the D*-day, add then the D-day, and ultimately the final segment after the D*-day. This restricted composition is again regular and maximal with respect to regularity, simply because it is made of the same parts of the previous one and in the same order, with the only exception that the D*-day has been replaced by the D-day. Hence it makes up a second internal world, let's name it K_{1b}, with its own internal time. Let us check now the principle that stands as the fifth component of Loss's model. The principle states that a (past) time genuinely changes when we have two times x and y similar enough to be counterpart of each other, and there is a time z distinct from x, y such that both x and y are, for some n, n internal-time-units later than z. In K_1 we do have two times that are similar enough to be counterpart of each other. The D-day and the D*-day are almost qualitatively identical, the particle P's position being the only difference. Moreover, take the day just before the D*-day, and say it's January 1^{st} in the year $2017 \cdot 10^9$.[9] The D-day and the D*-day are both one day later than January 1^{st} $2017 \cdot 10^9$ (external time) — the D*day is one day later than January 1^{st} $2017 \cdot 10^9$ according to K_{1a}'s internal time, whereas the D-day is one day later than January 1^{st} $2017 \cdot 10^9$ according to K_{1b}'s internal time. Hence, the principle applies. As a result, Loss's model predicts that here a time changes. It changes from having the particle P at <1,0,0> to having it at <2,0,0>. The problem is that this result is wrong. Take the D*-day. It is just the result of the normal physical processes going on later in time in the world K_1. The micro-particles just bounce around in accordance with the laws governing them, and it just so happens that at some point their arrangement for one day is highly similar and almost identical to one taking place at an earlier time. No time traveler is doing her magic, no one nor anything is trying to change the past.

[9] We are aware that days are not the most appropriate units of time to refer to the length of time intervals in a scenario where there are just micro-particles. One can replace days with other units. Obviously, the gist of our argument is not affected by that.

No one nor nothing changes it. Yet, this is what Loss's model (wrongly) predicts it's happening in K_1, and hence we have a strong reason to doubt the model's plausibility.

One might complain that our example is too far-fetched and hence it must be ignored. But Loss's example is far-fetched as well. There, Tim activates his time machine and externally next there is an abrupt change such that everything but Tim is annihilated and replaced by discontinuous entities. Our example features abrupt changes as well, namely at the beginning and at the end of the D-day (whilst everything goes smoothly when it comes to the D*-day). So, we are even when it comes to appealing to odd possible scenarios. But, it's Loss who brought us on a terrain populated by odd scenarios, and he is the one arguing for the possibility of changing the past in a B-theoretical 1D (plus internal times) model. The burden of proof lies with him. If we are ready to accept that his bizarre scenario provides evidence to the claim that the past can change provided we adopt his model, then our example is a genuine and strong counterexample to the model Loss uses to argue that in his case the past changes. Therefore, we think that our counterexample is strong enough to dismiss Loss's model of time. And, if his account has to be dismissed, his world V_1 is no longer a case where the past changes because this result was achieved only by adopting the model. Hence, the possibility of changing the past within B-theoretical 1D (plus internal times) models is rejected and thus the general unchangeability of the past within B-theoretical models is restored as we wished.

At any rate, we don't want to stop here. Two final tasks awaits us. First, Loss's account proved to be useful in accounting for the truth of claims about temporal intervals in those worlds where breaks take place, like in the case of the spheres break in W_1. However, we offered reasons to think that his model must be dismissed. Can this virtue be retained without running into the problem seen in this section? Second, provided we discard Loss's model as we suggest, what we should say about the example Loss provides, namely the world V_1? What happens there? Is that a case of time travel? These two issues will be the focus of the next session.

4. Restoring the Immutability of the Past

In this last section we offer a patch to Loss's model such that the resulting view a) retains the capability of grounding claims about temporal intervals within worlds that feature breaks, b) does not run into the problem we have seen in the previous section, and c) shed some light on what Tim does in V_1 .

Internal worlds, the fourth component of Loss's model, are what ground true claims like "The Berlin's wall fall occurred one year ago" uttered by people in W_1 eleven years (externally) after the Berlin's wall fall. This truth is grounded on the internal world W_{1a}, which comes with its own internal time. Internal worlds are maximal restricted compositions of T-slices, tied together by a relation of regularity. However, the model
as a whole runs into the the troubles we have seen with respect to the possibility of changing the past. We propose to amend the notion of internal words by making appeal to causal continuity. That is, we propose that internal worlds should be thought of as maximal restricted compositions of T-slices, tied together by a relation of regularity and by a relation of causal continuity of the right sort. After all, the notion of

internal time associated to the internal worlds is modeled on the Lewisian notion of personal time of a time traveler. And, Lewis (1976: 148) claims that what unites the stages of a time traveler scattered throughout external time is the regularity, plus the causal continuity of the right sort, of the stages through the time traveler's personal time. As he says:

> Finally, the connectedness and the continuity are not accidental. They are explicable; and further, they are explained by the fact that the properties of each stage depend causally on those of the stages just before in personal time . . . (p.148)

Let us see what happens with this amendment with respect to the cases we have been considering thus far. Let us start with the world W_1, the one featuring a ten years spheres break. Here the T-slices composing the internal world W_{1a}, i.e. all the T-slices but the ones composing the spheres break, manifest the proper kind of causal connectedness, whereas what happens in the spheres break does not have causal influence elsewhere. For instance, what happens before the spheres break, causally influence what happens after it. Hence, the true claims like "The Berlin's wall fall occurred one year ago" are still (correctly) grounded on W_{1a}'s internal time.

What about the world V_1, the one with the D and the D*-day? There we encountered a problem due to the fact that we have two internal worlds with their own internal time, one featuring the D-Day and the other one featuring the D*-day. This problem vanishes when we add the requirement of causal continuity, though. In fact, what happens in the D-day, the one which abruptly follows the external year 1920 and abruptly precedes the external year 1921, does not affect causally what happens in the rest of the world. What happens in the D-day stays in the D-day. On the contrary, the D*-day is causally embroiled with the rest of the world. This means that we now have two internal worlds with their own internal times, different from how they would be if we adopted internal times without the requirement of causal continuity. That is, we now have a (short) internal world, just the D-day, and another one, namely all the T-slices but the ones composing the D-day. This way it is no longer the case that both the D-day and the D*-day are one day later than January 1st 2017 $\cdot$ 10^9 (external time). Hence, the principle which stands as Loss's model fifth component does no longer apply. Thus, as it should be, we are not committed to claiming that in K_1 a time changes.

Ultimately, what about Tim in V_1? In V_1 there is only one case of abrupt change, namely the two T-slices externally next to each other where Tim departs and where he arrives. Tim presses his time machine button and externally next the world looks qualitatively (almost) identical to how it used to be in the external 1920. But notice that it's Tim that causes this bizarre result. That is, Tim does something and *as a result*, something else happens. This means that those two T-slices are somewhat causally connected, meaning that the amended notion of internal worlds put them in the *same* internal world — the requirement of continuity is guaranteed by Tim's regular persistence in both T-slices. This way, given that that one was the only abrupt change, V_1 features just one internal world. Hence, there is no way to treat this case as a case where a (past) time changes. What we should say is that Tim *causes* an odd massive annihilation and a subsequent replacement. Accordingly, under the amended notion of internal time here proposed, Tim does not arrive in the past because the T-slice where he arrives is both externally and internally after the one where he departs. Hence, Tim does not time travel to the past and therefore we don't have any change in the past.

To conclude, our aim was to defend the immutability of the past in B-theoretical models. We started from Baron's argument to the general conclusion that time travelers cannot change the past within B-theoretical models, independently of whether time is 1-dimensional, 2-dimensional, or n-dimensional. We noted then that that result does not cover a special B-theoretical case, namely a case where time is one-dimensional but such that it allows for internal times, which is the past-changing time travel model Loss provides. The model as applied to the world V_1 gave us a past-changing case in a B-theoretical framework. However, we presented a problem for this model, and we argued that it is serious enough to dismiss the model. Insofar as the model as a whole is dismissed, V_1 is no longer a case where the past changes within a B-theoretical framework. Moreover, we proposed a patch to the model that makes use of causal connectedness. By adopting it, we can retain the virtues of the original model, i.e. the capability of accounting for true claims in worlds where breaks take place, without running into the problem the original model faces. Either way, the possibility of changing the past within B-theoretical 1D (plus internal time) model is blocked, and the general conclusion that the past cannot be changed within any B-theoretical model is restored.

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