Back to the (Branching) Future

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2019

This is a pre-print of an article published in *Acta Analytica*. The final authenticated version is available online at: https://doi.org/10.1007/s12136-019-00404-1

Abstract

The future is different from the past. What is past is fixed and set in stone. The future, on the other hand, is open insofar as it holds numerous possibilities. Branching-tree models of time account for this asymmetry by positing an ontological difference between the past and the future. Given a time t, a unique unified past lies behind t, whereas multiple alternative existing futures lie ahead of t. My goal in this paper is to show that there is an incompatibility between the way branching-tree models account for the open future and the possibility of time travel. That is, I argue that once time travel enters the picture, branching time fails to model the openness of the future by means of alternative future branches. I show how this holds independently of whether branching-time models are cashed out in A-theoretic or B-theoretic terms.

Keywords: Open Future, Branching Time, Time Travel, A-theory, B-theory.

1 Introduction

We tend to think that there is a profound asymmetry between the past and the future. The past is singular, settled, and out of our reach. There is one past behind us. What lies there is now set in stone and beyond our influence. The future, on the other hand, holds numerous possibilities and it is (at least partly) up to us how it will ultimately end up being. This, in brief, is the asymmetry between a closed past and an open future. Time travel gets in the way of such picture. Suppose time travel were possible. Then traveling in time inevitably creates a discrepancy between what is past and what is future. For instance, if you are about to enter your time machine to travel back in time, then *your* future will be *our* past. We might in principle have accurate records of all *your* future actions, so how can your future be open? Or, if you decide to travel forward in time, upon arrival *your* past will be the future *of* the people you leave behind. From your perspective, our future doings will be in the past and hence set in stone. Once time travel enters the picture, it is at first glance unclear how the future can be open in a way the past isn't.

There are several ways to precisely model the asymmetry between the past and the future (see Torre 2011 and Grandjean 2019 for an overview). One way to do so consists in endorsing a branching-tree model of time. The branching-tree model of time has two key features. First, it admits the possibility that time 'branches' towards the future: a time within the tree can correspond to a multiplicity of strictly alternative futures. This feature is understood to model the openness of the future. Given a time, there literally exist several ways the future could be. Second, there is no 'branching' towards the past: for any time in the

tree, the times preceding it constitute a unique and unified past. This feature is understood to model the closedness of the past. To exemplify, suppose that yesterday there was a sea battle, and that it is now open whether tomorrow there will be another one. If so, the ontological status of the future is different from that of the past. There is a unique past, which features yesterday's sea battle, but there are at least two alternative futures, one that features a sea battle tomorrow and one that does not.[1] Branching-tree models can be cashed out in two ways: either in A-theoretic or in B-theoretic terms. According to the A-theory of time, the world features a moving objective present. In such view, presentness is an absolute non-perspectival feature of reality. The typing of this sentence has now the property of being objectively present. By the time you are reading it, the typing has moved to the past and is no longer objectively present. B-theorists deny the existence of such feature of reality. Accordingly, in the A-theoretic version of the branching-tree model we have an objective present moving along the tree, whereas we don't in the B-theoretic version.

My goal in this paper is to show that there is an incompatibility between the way branching-tree models account for the open future and the possibility of time

[1] Positing a branching structure of time is just one of the possible ways to account for the asymmetry between a fixed past and an open future. The discussion and development of branching-tree models goes back at least to the seminal work of Prior 1967. MacFarlane (2003(@, 2008(@) can be seen as one of the recent proponents of the idea that branching-tree models correctly account for the asymmetry between the past and the future. Belnap 2017 offers and defends a rigorous theory of branching-tree models in relativistic settings. There are ways other than branching-tree models to account for the asymmetry. For instance, Markosian 1995 holds that the openness of the future amounts to the failure of the principle of Bivalence for future contingents. Growing block theorists (e.g. Broad 1923) can argue that the past is fixed because past entities and events exists, whereas the future is open because there is no entity such that it is future. Or, the asymmetry could be explained via an asymmetry in counterfactual dependence between the past and the future (see Lewis 1979). Further proposals have been put forward. As mentioned above, Torre 2011 and Grandjean 2019 offer an overview and discussion of the different ways to account for the asymmetry.

travel. Indeed, once time travel enters the picture, branching time fails to model the openness of the future.[2] I will argue that this incompatibility holds independently of whether we take the branching-tree model in its A-version or in its B-version. Some work in this direction has already been done. Miller 2005 offers an argument that shows the incompatibility in the case of A-theoretic branching-tree models. However, Martinez 2011 disagrees and offers a counter-argument to try to reconcile the two. Therefore, in order to reach my goal and cover both the A-theoretic and the B-theoretic versions of branching-tree models, I need first to rebut Martinez's argument. The reason that I identify to explain why Martinez's argument fails is interesting. That is, Martinez's argument overlooks the implications of the fact that branching-tree models account for the openness of the future by positing the existence of alternative future branches. I will exploit this fact to offer an argument for the incompatibility with respect to the B-theoretic branching-tree model, thereby ending up covering both the A-theoretic version of branching time and the B-theoretic one.

Roadmap. In the next section, I will spend some time to recapping Miller's argument. In section 3, I will show how Martinez's argument against Miller's can be rebutted. In section 4, I will offer an argument to show the incompatibility between the way the B-theoretic version of the branching-tree model account for the open future and the possibility of time travel.

[2]For another kind of tension between branching-time models and the possibility of time travel, see Norton 2018 who argues that if backwards time travel to our location is possible, then our universe is not a branching universe.

2 Time travel, the open future, and the shrinking tree

In this section I will recap Miller 2005's argument for the incompatibility between the A-version of branching-tree models and time travel. She considers the A-theoretic version of the branching-tree model proposed by McCall 1994. I will refer to McCall's view as the 'shrinking tree view'. The shrinking tree view combines a branching-tree conception of time and the A-theory. Under such view, a complete description of reality must specify what time is the objective present, in accordance with its A-theoretic character. Say that t is now the objective present. Then the past relative to t is the objective singular past and it is represented by the model as an unique trunk containing all past events. The future, on the other hand, consists of a multiplicity of non-actual but ontologically real alternative branches, representing the different ways the world might unfold from t onward. Say that two future branches stem from t. One of them features a sea battle at t_1, whereas the other one does not feature it. If you had a description of reality specifying (i) that t is the objectively present time, (ii) the state of the world at t, together with (iii) all the objectively past and actual events in the trunk and all the non-actual but ontologically real events in the objective future, then this complete description would be temporary. As time moves forward, only one of the branches stemming from t becomes actual. Say that it is the one containing the sea battle. When t_1 is the objective present then, reality changed. Not only the objective present has moved from t to t_1. Also, by failing to become actual, the branch that does not contain the sea battle ceased to exist and it is now no longer part of reality. Future branches that are not 'selected' and do not become actual go out of existence. The

tree shrinks, it gets smaller as time goes by.

Miller's thesis is that

(1) time travel (as it is standardly conceived) is logically possible

(2) necessarily, our world is a shrinking tree

are incompatible.[3] Her argument shows that at most one of them is true. This means that if someone believes that models of time are either necessarily true or necessarily false, then this incompatibility implies that if time travel is logically possible, then the shrinking tree view is necessarily false. Models of time might be contingently true, though. In such case the example she uses in her argument, which we shall see shortly, shows that the shrinking tree way of modeling the open future gets into trouble when time travel takes place. This latter point is what I need here. Besides endorsing Miller's argument, in the next section I will rebut Martinez's criticism of it.

The claim (1) above refers to a standard conception of time travel, which Miller takes it to feature the following two tenets.

The standard conception of time travel

(i) necessarily, P is a genuine time traveler only if all of P's temporal stages are united by some causal relation.

[3]Miller argues for a broader incompatiblity in her article. That is, she takes (1) to be incompatible with any model of time that features both an objective present and an open future. To that goal, besides the shrinking tree, she offers arguments for the incompatibility between time travel and presentism — roughly, the view according to which only the present exists — and between time travel and the growing block view — roughly, the view that only the past and the present exist. In this article I focus on branching-tree models, therefore I set aside the case from presentism and the one from the growing block view.

(ii) it is not logically possible to change the past.[4]

(i) demands the proper kind of causal connectedness among the stages of a time traveler in order to rule out cases of counterfeit time travel (see Lewis (1976: 148). As Lewis observes, if an individual is *randomly* created by a demon out of thin air at a time t and it happens to be a duplicate of a stage of a person P annihilated at a later time t_1, whatever this is it should not count as a case of time travel, for there is no causal continuity among the stage disappearing at t_1 and the stage appearing out of nowhere at the earlier time t. It's just a coincidence that the stage at t happens to be continuous — but not *causally* continuous — with respect to the annihilated stage at t_1. The tenet (i) correctly rules out such cases.

The second tenet refers to the idea that the past is fixed. It is logically impossible that the past changes. As a consequence, nothing and nobody (time traveler or past-directed signals) can change it. Although many Hollywood movies try to make us believe that time travelers can and do change the past, this is thought by many to be a confusion about the nature of time. For the past is whatever has happened. If tomorrow Jane travels back to 1920, the past 'already' features Jane appearing out of nowhere in 1920, all the actions she performed there, their consequences, and so on so forth. Jane will be causally effective in the past, but she will not bring about any change. Before she travels, what *will* happen to her *happened* in the past. Again, the standard arguments for the impossibility of changing the

[4]The two tenets are taken literally from Miller (2005: 225). There is actually a further one Miller considers, which has to do with the impossibility of traveling from a non-existent location to an existing one. However, this tenet is used by Miller in her arguments regarding presentism and the growing block view, whereas it plays no role in her argument with respect to the shrinking tree view. I therefore shall ignore it here.

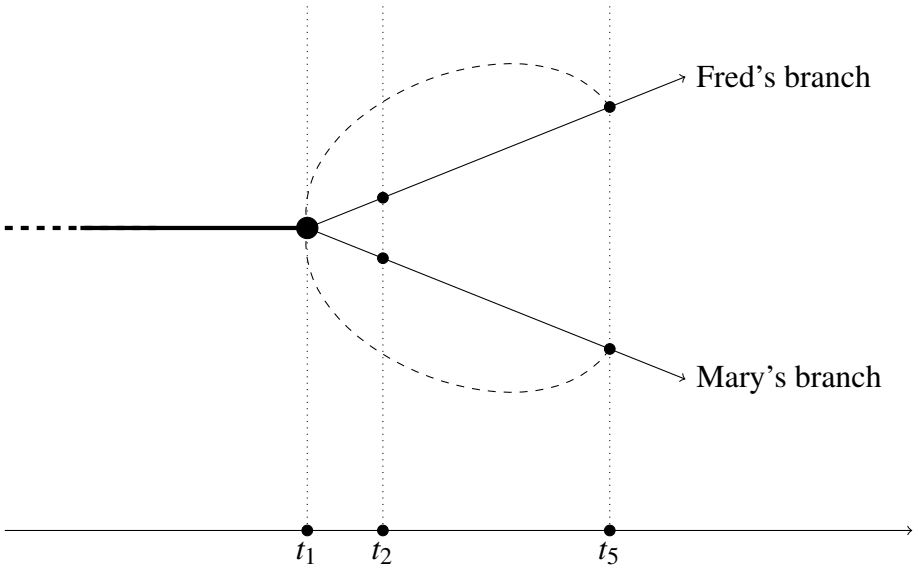

Figure 1 – t_1 is the objective present. The thick line represents the actual past. The dashed lines represent Fred and Mary traveling from two distinct non-actual but ontologically real future branches.

past can be found in Lewis 1976.[5]

That being said, we move to the time travel scenario Miller considers to build her argument. We assume the possibility of time travel and the shrinking tree view of time. Say that t_1 is the objectively present time and only two future branches branch off t_1. Fred is born at t_2 on one of the two branches, whereas Mary is born at t_2 on the other branch. Given that we are assuming that time travel is possible, we can imagine that both Fred and Mary have a perfectly functioning time machine. Fred can time travel to the past. But so can Mary. Say that they do both time travel. Fred time travels from t_5 on *his* branch to t_1, and Mary travels from t_5 on *her* branch to t_1 (see figure 1). As a result, when t_1 is present they

[5]See also Baron 2017 for a more recent discussion on this. Actually, there is a great deal more to say about the possibility of time travel resulting in alterations of the past. Some philosophers, for instance van Inwagen 2010, think that models of time that make use of a second dimension of time, i.e. hyper-time, can allow changes in the past due to time travel. See Wasserman (2017: Ch. 3) for an overview of the debate. I will have more to say about this tenet in the next section.

are both around at t_1, after having time traveled from their respective locations. Under the shrinking tree view though, time moves forward and only one of the two branches branching off t_1 becomes actual. Say it is the one where Fred is born and t_5 is now objectively present. When t_5 is objectively present, the branch where Mary is born and activates her time machine does no longer exist. What goes on at t_1 then? Maybe when t_5 is objectively present Mary is not around at t_1, for erasing the cause of her existence at t_1 erases her presence at t_1 too. In such case, the past time t_1 would change from containing her (when t_1 is objectively present) to *not* containing her (when t_5 is objectively present), contravening the second tenet of the standard conception of time travel. Maybe instead she keeps existing at t_1, despite the branch where she is born having been wiped out of existence. In such case though, Mary would *change* from being a genuine time traveler (when t_1 is objectively present) properly causally connected to her earlier temporal stages — see the first tenet of the standard conception — to not being a genuine time traveler (when t_5 is objectively present), having her lost her earlier temporal stages. Thus tenet (ii) is again violated for the past would have changed. Either way, the standard conception of time travel is violated.

Miller, as many others do, takes the standard conception of time travel to be plausible and correct. What the case of Mary and Fred shows then is that the way the shrinking tree models the openness of the future is incompatible with the possibility of time travel.

3 Martinez's objection and my rejoinder

Martinez 2011 criticized Miller's argument for the incompatibility between the

possibility of time travel (standardly conceived) and the shrinking tree view. His overarching goal is to show that the two are indeed compatible. I am going to argue in this section that Martinez's attempt is ineffectual and that thus Miller's argument for the incompatibility remains in place.

Martinez's counterargument deals with the same Fred/Mary time travel scenario Miller considers and proceeds in two steps. He first argues that Miller's argument trades on a confusion. He argues that from (3) and (4)

(3) it is open at t_1 that Fred travels from t_5 to t_1.

(4) it is open at t_1 that Mary travels from t_5 to t_1.

it does not follow that

(5) it is open at t_1 that both Fred and Mary travel from t_5 to t_1.

Moreover, if Fred roams around at t_1 after having time traveled, this implies that his branch *will* become actual. But the same goes for Mary if she is around at t_1 after having time traveled. This implies that two future alternative incompatible branches will both become actual, and such thing is impossible in the shrinking tree view. Hence, Martinez observes, the simultaneous presence of Mary and Fred at t_1 is impossible. The state of a shrinking tree universe where t_1 is the objective present and we have the two Fred and Mary non-actual but ontologically real future branches branching off t_1 (the state depicted in figure 1) is an impossible one. At this point, one might think that what Martinez observed so far actually goes in the same direction as Miller's in showing that there is an incompatibility between the shrinking tree and the possibility of time travel. After all, if the fact

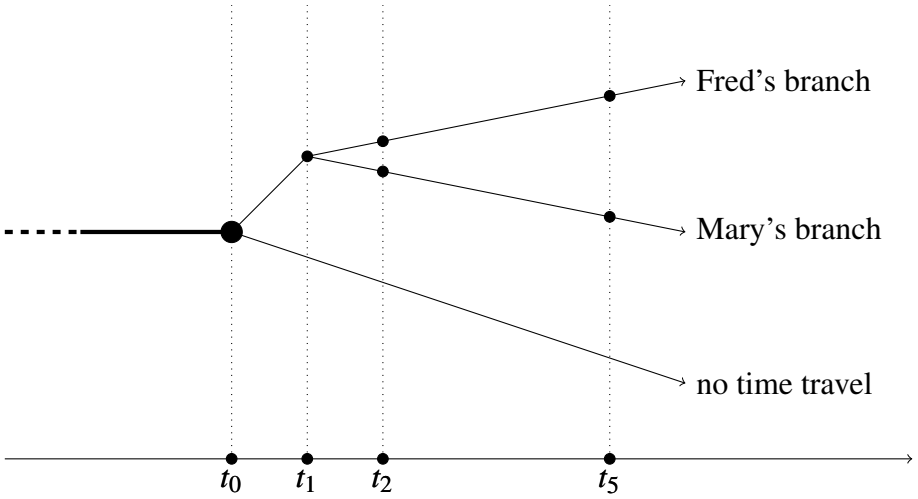

Figure 2 – t_0 is the objective present. The thick line represents the actual past.

that Fred (or Mary) roams around at t_1 after having time traveled from t_5 rules out the possibility of having existing alternative branches that might become actual, then the future of $t1$ is *not* open, at least for the time interval from t_1 up to t_5 because in that interval we can have only one branch. However, Martinez goes on and observes that in the Fred/Mary scenario there are times when it is correct to say that it is open whether Fred will time travel and open whether Mary instead will. To this goal, he makes us consider a possible state of the shrinking tree universe at a time prior to t_1. Imagine that t_0 is the objective present. In the 'upper part' we have a branching featuring Fred and Mary's case, whereas 'below' we have a branch where Fred and Mary are not born and no time travel takes place (see figure 2).

As things stand when t_0 is the objective present, Martinez argues that it is open whether Fred will time travel back in time, Mary will, or the world will not feature either of them. When t_0 is objectively present, it is not settled which of them will be the case. There are three genuine future possibilities, represented in

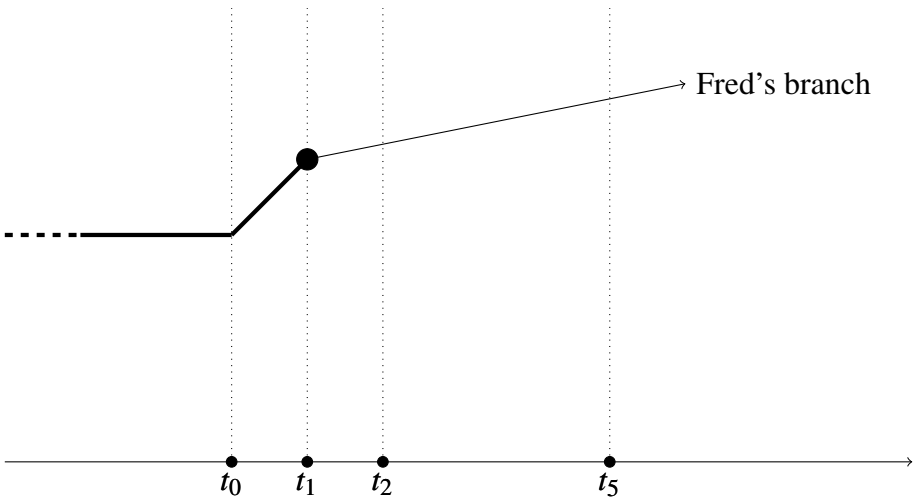

Figure 3 – t_1 is the objective present. The thick line represents the actual past.

the model by the three existing non-actual future branches. As it is usual with the shrinking tree model, only one of them will become actual as time goes by. The peculiarity of this time travel case, Martinez argues, is that if the upper branching becomes actual, settling things at t_1 'inevitably' settles things all the way up to t_5 as well. That is, from the situation in figure 2 above, there are only three possible continuations of the evolution of the shrinking tree, *given how things are when* t_0 *is the objective present*. The first one is that the no-time travel branch becomes actual and thus the upper branching part goes out of existence. Or, the second one, is that Fred time travels. In such case the tree now looks like the one depicted in figure 3 — t_1 is now the objective present and Fred's future branch where he will be born is 'already' selected, whereas Mary's branch goes out of existence, before it normally would if there were no backward time travel. Or, the third one, is that Mary time travels, where likewise the tree would now look like the one depicted in figure 4. In other words, if the moving present 'selects' at t_0 the upper branching in figure 2, things get settled up to t_5. Either it becomes 'immediately'

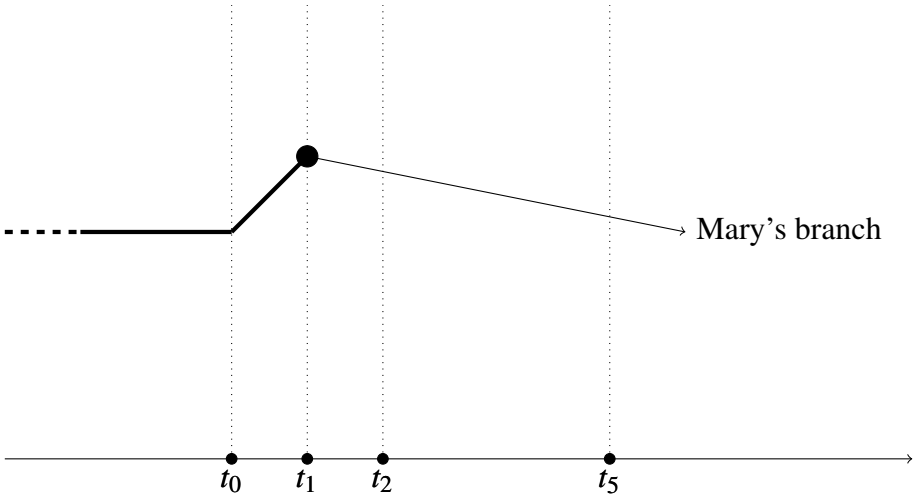

Figure 4 – t_1 is the objective present. The thick line represents the actual past.

settled that Fred will time travel, or it becomes settled that Mary will. We do not need to wait the next bifurcation at t_1 for the objective present to make a further 'selection' among the two, for as argued by Martinez the state of the shrinking tree in figure 1 is not an admissible one.[6]

He thus observes that:

> there are times (e.g., t_0) at which it is open that Fred travels back in time, that Mary does or that no one does [...] The conclusion is that there is no incompatibility between the branching time picture of time

[6]More precisely, Martinez's point here is that what he calls 'standard tree-pruning' should not apply when backwards time travel takes place in the shrinking tree. According to standard tree pruning, if a time t is the objective present and we have branches stemming off t, then the universe evolves respecting the following two conditions: (i) only one of the branches stemming from t becomes actual up to the later branching node t_x and all the other branches stemming from t cease to exist, (ii) the branches stemming off t_x remain existing non-actual possibilities. In case of backward causation from a later time t_y to t_x, Martinez argues that the tree pruning does not have to respect standard tree-pruning. It might be the case that when time moves from t to t_x, condition (ii) is not respected. That is, some branches stemming off t_x might cease to exist before they normally would. The state of the universe depicted in figure 1 respects standard tree-pruning, but it is not acceptable, Martinez says, given the occurrence of backward causation from t_5 to t_1. My upcoming argument against Martinez does not assume standard tree-pruning, hence I can grant him that in case of backward causation standard tree pruning does not hold.

and backwards time travel. (p. 281)

In sum, Martinez argues that the following two are the case in the example at hand:

(6) it is open at t_0 that Fred travels from t_5 to t_1.

(7) it is open at t_0 that Mary travels from t_5 to t_1.

This way, Martinez concludes, the compatibility between the way the shrinking tree view models the open future and the possibility of time travel is back on the table.

Before getting into my criticism of Martinez's argument, I need to say something more about the second tenet of the standard conception of time travel, i.e. that it is not logically possible to change the past. To change a past time t means to make something that have happened at t, say an event e, not have happened at t (or to make something that have not happened happen). But this implies a contradiction, i.e. that e both happens and does not happen at t. In case of time travel, we might be tempted to talk of 't's first occurrence', when the time traveler is *not* around and e takes place, and 't' second occurrence', when the time traveler *is* around and prevents e. As Lewis (1976: 150) observes though, 'if we do speak so, we merely confer two names on one thing', i.e. the time t. And t either contains e, or it does not. So, it is logically impossible to change the past. Not even time travelers can change it. Almost everyone agrees that this tenet holds if time is linear and one-dimensional.[7] One might argue tough that when it comes to the

[7]For an exception, see Loss 2015 who argues that time travelers can change the past even if time is linear and one-dimensional. He proposes a sort of branching model where all the branches are ordered in a linear way. At any rate, I set aside this case here.

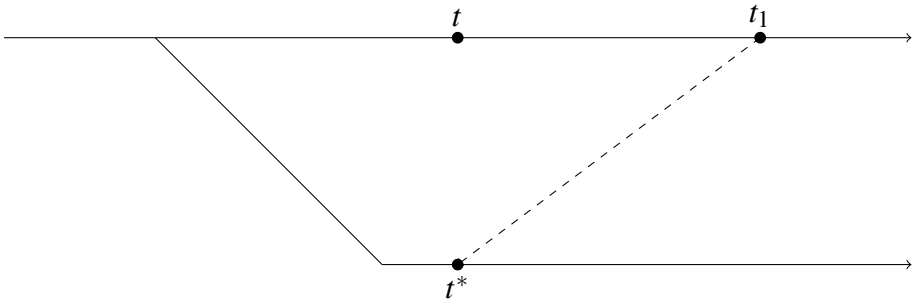

Figure 5 – A basic time travel case in branching time.

branching-tree conception of time the matter is different. Consider the following simple time travel case in a branching universe. Tim travels from t_1 to t^* to prevent an event e that happened in his past at t (see figure 5). Tim is successful and e does not occur at t^*, which is located on a *different* branch from the one where he departed. It can be argued that in such case the past does indeed change. The past time t changes from featuring e to not featuring it. In such case we don't get into any contradiction because e happens at t *relative to one branch*, whereas it does not happen *relative to another alternative branch*. If so, one might argue that the second tenet of the standard conception of time travel does not apply in the branching-tree scenarios that we are here considering. Perhaps, *pace* the second tenet, it is logically possible to change the past if time branches. This is actually a matter of disagreement. Whether Tim's case and other similar cases should or should not count as genuine cases of past alteration is debatable.[8] What is *not* debatable is that also in the branching view it is the case that a single past time, independently of on what branch it is located, *cannot* change. For substantially the same reasons as above. For instance, the time t^* eternally and unchangeably does not feature e. To think that t^* could change its content — for instance from

[8]See Wasserman (2017: Sec. 3.3) for a summary of the debate on this specific issue. For the purposes of my argument, I don't need to take a stance on this.

not featuring e to featuring it — would again imply a contradiction, i.e. that e both happens and does not happen at t^*.[9] Hence it is logically impossible to change a specific past point of a branching-tree time structure. Moreover, this apply to actually *any* point in the branching-tree structure. The considerations made for the past hold in the exact same manner for times in the future. This applies too to the particular version of the branching-tree model that is the shrinking tree view. The only addition is that in the shrinking tree view times in the objective future of the tree-structure can go out of existence if they fail to become actual. This is the only possible change. On the other hand, the content of a specific time cannot change. With this in mind, I propose to change the formulation of the standard conception of time travel as follows.

The (updated) standard conception of time travel

(i) necessarily, P is a genuine time traveler only if all of P's temporal stages are united by some causal relation.

(ii) it is not logically possible to change any time.

This second formulation of the second tenet is broader than the formulation used by Martinez and Miller. However, it is in perfect accordance with the spirit of how they treat time travel in their respective arguments. I will adopt this one from now on.

Here is my reply to Martinez. I am going to argue, *contra* Martinez, that (6) and (7) cannot both be true, as he maintains, if the standard conception of

[9] One might think that there is a time which is the mereological sum of what I called t and t^*; t and t^* would then be temporal parts of that time, which could change in virtue of having qualitative different temporal parts. Granting such possibility, the spirit of what I have been saying would then apply to this option too. In such case one should say that the temporal parts of times composing a branching universe cannot change, for the same reasons.

time travel has to be respected. Consider the state of the shrinking tree when t_0 is the objective present. On the upper branching, we have Fred and Mary's branches. What goes on at t_1 in the upper branching, when t_0 is the objective present? Inevitably, one of the following things happens there: (i) only Fred is there appearing out of thin air, (ii) only Mary is there appearing out of thin air, (iii) none of them is there, or (iv) both are there. Whatever situation obtains there, it unchangeably obtains — see the second tenet of the updated standard conception of time travel — at most it can go out of existence later on.

Suppose (i) is the case. Then it is not the case that (7), i.e. that it is open at t_0 that Mary travels from t_5 to t_1. For a peculiar feature of any branching-tree model upon which I will rely on here and in the next section. That is, within branching-tree models, something is an open future possibility if and only if it happens on at least one future branch and it is not the case that it happens on all future branches. It follows that something is an open future possibility only if it happens on at least one future branch. For instance, it is open for me to have coffee tomorrow morning only if I do have have coffee tomorrow on at least one of the future branches ahead of me. If in no future branch I have coffee tomorrow, then having coffee tomorrow morning is not an open possibility for me. In Mary's case, if she does not appear out of thin air at t_1, it is not the case in any branch that she time travels from t_5 to t_1. Therefore, it is not open at t_0 that Mary travels from t_5 to t_1. Likewise for (ii). If Fred does not appear out of thin air at t_1, then it is not the case that (6) holds, for the same reasons. For if (ii) obtains, than there is no future branch where Fred time travels from t_5 to t_1. Hence it is not an open possibility at t_0. If neither of them is roaming around at t_1 — option (iii) — then for the same reasons as above neither (6) nor (7) are the case.

What if (iv) is the case? Martinez thinks that having both Fred and Mary around at t_1 is impossible because they are traveling from alternative branches and only one of them can become actual. Hence I should probably not consider this option to rebut his argument. However, for the sake of completeness, it is worth observing that if (iv) were the case, then the considerations made by Miller (see section 2) just re-apply in a similar fashion. Given (iv), (6) and (7) are indeed the case. The two open possibilities are accounted by the existence of branches where Fred and Mary time travel. However, we get into trouble with the (updated) standard conception of time travel. Even if we grant Martinez that settling things at t_1 settles things up to t_5, from t_0 we will inevitably reach a point when t_5 is the objective present. Say that at this point Fred's branch is the one that became actual. Given that t_1 still exists, Mary is still there appearing out of thin air, but she changed from being a time traveler (when t_0 is objectively present) to not being a time traveler (when t_5 is objectively present), contravening the (updated) standard conception of time travel. Thus, even if (iv) is the case, there is no way to make (6) and (7) be the case holding fixed the shrinking tree view and the standard conception of time travel.

To sum up, Martinez's arguments are not successful in rebutting Miller's argument. Whatever is the case among the four above options, it is never the case that Fred's traveling and Mary's traveling are *both* open possibilities in a shrinking tree universe, holding fixed the standard conception of time travel. Therefore, the shrinking tree model fails to model the openness of the future if time travel is possible. In the next section I will provide an argument to the conclusion that the B-theoretic versions of the branching-tree model fails too.

4 Time travel, the open future, and the static tree

I now turn to the B-theoretic incarnation of the branching-tree model. My goal is to show that there is an incompatibility here too between the way the B-theoretic version of branching-tree models accounts for the openness of the future and the logical possibility of time travel, as it is standardly conceived.

In the B-theoretic version of the branching-tree model there is no objective present moving along the tree. The universe is represented as a static branching block. No pruning of the branches takes place and what exists on the tree exists eternally. To paraphrase Yogi Berra, when time comes to a fork, it takes it. That is, if two alternative future branches are ahead of me in time, neither of them ever goes out of existence. I will refer to this view as the 'static tree'.[10]

To start, let's note that Miller's example does not apply, nor is intended to, to the static tree. We can have a static tree where Fred and Mary both travel to t_1 from different branches. In the static tree the branches from where they depart never go out of existence, and hence we do not run into the trouble of having one of the two that changes from being to not being a genuine time traveler, thereby contravening the standard conception of time travel.

Now consider this variation of Miller's case. Suppose we want to have a time travel case where from t_0's perspective it is again open whether Fred will time

[10]One might worry that when we move from the shrinking tree to the static tree, we no longer have a genuine account of the open future, independently of whether time travel takes place. For in the B-theoretic case the whole tree-structure is static and unchangeable, and nothing ever goes out of existence. If a future branch ahead of us contains a sea battle event and another one features peace instead, those two events are eternally and statically part of reality. One might then follow (1986: 207-8) and think that (static) branching is problematic insofar as 'If two futures are equally mine, one with a sea fight tomorrow and one without, it is nonsense to wonder which way it will be — it will be both ways — and yet I do wonder.' Advocates of branching time have responses to this and other objections that have been raised against B- theoretic branching time. See Torre 2011 for an overview of the debate on this.

travel from t_5 to t_1 or whether Mary instead will. The universe is such that as things are up to t_0, it is just indeterminate who of the two will time travel backward in time. Imagine though that this time they both want to time travel to occupy the same spatial region R at t_1. We then want to say that

(8) From t_0's perspective, it is open whether Fred travels from t_5 to t_1, region R.

(9) From t_0's perspective, it is open whether Mary travels from t_5 to t_1, region R.

Those two should both be open possibilities as far as the state of the world at t_o is concerned. How things are up to t_0 does not settle the issue of which one of the two will time travel. Hence (8) and (9). The static tree has to model this by having alternative future branches. One where Fred but not Mary time travels, and another one where Mary does but Fred doesn't. The static tree gets into trouble, though. In fact, it cannot be the case that both (8) and (9) are the case. For look at what happens at t_1, region R. It cannot be that both Mary and Fred are occupying the exact same region at the same time. So, either one of the two is there, or none of them is there. Suppose only Fred is roaming around at t_1 after having time traveled. Then Mary can't be there too, meaning that in no future (relative to t_0) branch it is the case that Mary travels from t_5 to t_1, region R. Hence it is not open at t_0 that Mary travels from t_5 to t_1. If Fred is around at t_1, then it is not the case that (9). Likewise if Mary is there. Fred wouldn't be there and thus (8) would not be the case. If none of them is around at t_1, neither (8) nor (9) would be the case. Hence in all possibilities it is never the case that both claims are the case. It

should be possible that how the world is at t_0 just fails to settle whether Mary or Fred will time travel. This would be an open issue at t_0 and hence (8) and (9). The static tree has to model this by having two alternative branches where these two possibilities do take place (in their respective branches). Yet, as I just showed, the static tree gets into trouble and ultimately fails to model this.

One might react by saying that there is actually a way to claim that both Fred's traveling and Mary's traveling are open possibilities at t_0. Suppose Fred is successful in his time travel to t_1, whereas Mary attempts to do the same but she somewhat fails. Maybe an unexpected malfunctioning in her time machine occurs at the last minute, maybe she slips on a banana peel, maybe a momentary lack of confidence makes her press the wrong button and she travels to another time destination. If so, one might argue that it is open that Fred time travels from t_5 to t_1— he does so — but it is also open that Mary does the same. The fact that she tries and fails does not imply that she *cannot*. Hence, according to this line of thought, *both* could be open possibilities even if Fred is the only one actually doing it. Thus, we we would have the claims **??** and **??** back, as desired. However, albeit adopting this strategy seems to be a promising avenue for someone who is a compatibilist between a single future and the open future (or in a related debate, a compatibilist between free will and determinism), this reasoning is not a viable option in the case of branching-tree models. For a compatibilist between a single future and the open future thinks that some of what will happen in the single future is not such that it *must*happen (see (2011: 365)). If so, Mary will fail, but this does not imply that she *must* fail. She might succeed, and hence it could be an open possibility that she travels from t_5 to t_1. On the other hand, in the case of the static tree, as it was with the shrinking tree (see section 3), something is an

open future possibility only if it occurs on at least one future branch. In the words of Torre (2011):

> According to such a view (branching theory), tomorrow is open with respect to sea battles in virtue of the fact that there exist future branches in which a sea battle takes place and future branches in which no sea battle takes place, and there is nothing that ontologically privileges one branch over any other. (p.368)

Branching time models must stick to this characterization of a genuinely open future possibility independently of whether they are cashed out in A- theoretic or B-theoretic terms, given that this is part of the core doctrine of branching time. In the case of the B-version, we just need to talk of a relative future instead of an objective one. So, from a time t's perspective, it is open that something happens in the future of t only if it does happen at a time t^* later than t on one of the branches. In the case at hand, if Fred travels from t_5 to t_1 then in no future branch it is the case that Mary travels from t_5 to t_1, hence it cannot be an open possibility that she does so.

Another reaction one might have is to claim that the failure of the static tree to model the two possibilities is due to some feature of the example itself. In the example I used in this section, Fred and Mary both attempt to occupy the same region at the same time, thereby attempting to bring about an impossible situation. It's then no wonder, the reasoning goes on, that the fact that Fred succeeds and Mary succeeds are not both open possibilities. We should not blame the branching-tree model of time for failing to account such openness. However, other accounts of time can indeed model such openness with respect to the case

at hand. Take eternalistic linear time. Unlike in the cases above with branching time, in such model Fred and Mary depart from the same timeline, and they both again attempt to reach region R at time t_1 with their time machines. Of course, only one will succeed. Say it is Fred who travels from t_5 to t_1. Mary tries and fails for some ordinary reason. In case of eternalistic linear time, if something will not happen it doesn't imply that it is *impossible* that it would. To think the contrary would amount to embrace fatalism (see Lewis (1976: 150-151), i.e. the thesis that all future events that will happen are now unavoidable and those who will not happen it's impossible they will. So, unless someone is a fatalist, in the case of eternalistic linear time, there is room to claim that Mary *can* time travel from t_5 to t_1, even if she does not do so. In other words, it is an open possibility that she does so. If so, both (8) and (9) can be true under eternalistic linear time. It is a peculiarity of branching-tree models that something has to happen, on at least one branch, in order to be an open possibility. This is not the case when it comes to eternalistic linear time. Hence, the latter model can account for the fact that at t_0 it is open whether Fred will time travel or whether Mary will instead. The static tree is the culprit then, and not the example I used.

In sum, I take it that this modified Fred and Mary case shows that the B-theoretic version of a branching-tree model, i.e. the static tree, fails to provide an account of the open future if time travel is possible.

5 Conclusion

Branching-tree models offer a convenient and sharp way to account for the openness of the future. If there are several alternatives ways the future can unfold,

branching-time models this by positing the existence of several branches where different events happen. However, once time travelers are allowed to travel around the tree, the branching-tree model gets into trouble. As I showed, there is an incompatibility between the way branching-tree models account for the openness of the future and the possibility of time travel, independently of whether the model is cashed out in A-theoretic or B-theoretic terms.

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