Giacomo Andreoletti*

Branching Time, Fatalism, and Possibilities

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Abstract: The concept of branching time is widely utilized to counter fatalistic arguments to the conclusion that whatever will happen is already unavoidable. The most common semantics for branching time, such as Ockhamism, Peirceanism, and Supervaluationism, offer a formal explanation for why fatalistic arguments are flawed. This paper explores a different type of argument, one that borders on fatalism and is concerned with what *might* possibly happen in the future. In the paper, I show how this type of argument poses a new fatalistic threat to branching time.

Keywords: time; branching time; fatalism; tense logic

1 Introduction

Alice has a goal. She wants her first paper to be published in a scientific journal. After months of work, she is now almost ready to submit. All that's left to do is add a few more references, make some minor amendments, incorporate feedback, and write the conclusion. However, after some thoughts, Alice decides to give up with all her work and submit the manuscript as is. Incomplete.

The reason for the unfinished submission is that the following argument persuades Alice. Either her paper will be accepted for publication, or it won't be. If it will be, then it is *necessary* that it will be. If it won't be, then it is *impossible* that it will.

What Alice is persuaded by is a classical fatalistic argument to the conclusion that either it is *necessary* that Alice's paper will be accepted, or it is *impossible* that it will. This, thinks Alice, makes any further work on the manuscript futile. If it is necessary that the paper will be accepted, then this event is inevitable and will happen no matter what. If, on the other hand, acceptance is impossible, then it won't be published no matter how much Alice improves her work. Either way, why bother? Convinced by this, Alice submits her paper without further working on it.

Even though almost everybody (if not everybody) finds such fatalistic arguments unconvincing, they are usually taken seriously. For fatalistic arguments of this kind represent a legitimate threat to the way we understand the future, insofar as we

***Corresponding author: Giacomo Andreoletti**, University of Salzburg, Salzburg, Austria,
E-mail: giacomo.andreoletti@plus.ac.at. https://orcid.org/0000-0001-5632-4213

commonly think, contrary to Alice, that there is some contingency in the future. Moreover, there is actual disagreement on what is wrong with such arguments (see, among many others, Hasker 1988, 2021; Hoffman and Rosenkrantz 1984; Purtill 1988; Todd 2013). So, it is no wonder that philosophers developed several different strategies to counter these arguments.

One popular strategy to resist Alice's fatalistic argument consists in endorsing a branching conception of time (see, among others, Belnap, Müller, and Placek 2022; Belnap, Perloff, and Xu 2001; MacFarlane 2003; McCall 1976, 1994; Müller 2012; Ploug and Øhrstrøm 2012; Santelli 2021; Spolaore and Gallina 2020; Wawer 2014). According to branching time, the past consists of a unique and linearly ordered set of moments, whereas the future includes several alternative branches all stemming from the past. The resulting picture paves the way for contingency, and the specter of fatalism allegedly fades away. In the case of Alice, a branching time theorist can reply that there might be several possible futures ahead of Alice – some in which her paper is accepted, and some in which it isn't. So, even if the future unfolds in such a way that she actually publishes her work, this was *not* inevitable. Her paper *could have been* rejected, as this is what happens in other possible futures.

Branching time certainly fares well in countering the fatalistic argument that convinced Alice, insofar as it grants contingency in the future and provides a principled rejection of fatalism. However, fatalism strikes back in another form, even if we adopt a branching conception of time, or so I will argue in this paper. More precisely, as I show later, a variation of the original argument for fatalism, this time concerned with what *might* possibly happen in the future, still raises some fatalistic worries, even on the assumption that, at any moment in time m, there are various incompatible futures stemming from m.

To see this, consider Bob. Bob's goal is more modest than Alice's. Bob doesn't desire that his paper *will* be published; he merely wishes that it is *possible* that it be published. Bob is aware that he is a rather talentless scholar – much less talented than Alice. And he is also aware of the fact that it's better to keep one's desires modest and realistic. To him, it would already be an achievement if it was *possible* for him to have his paper accepted for publication. It would be too much to hope for acceptance, Bob thinks. Hoping for the *possibility* of acceptance seems a much more attainable goal, given Bob's current poor philosophical skills.

Bob is initially determined to work on his philosophical skills in order to achieve his modest goal. He delves into the relevant literature, practices his writing skills, incorporates feedback from more experienced philosophers, and so forth. However, some reasoning stops Bob in the middle of his enterprise. Bob reasons that either it is possible that his paper will be published, or it is not. If it is possible, then it is *necessary* that it is possible. If it is not possible, then it is impossible that it is possible

that his paper will be published. Given that one way or the other it seems a matter of necessity whether it is possible for him to have his paper published, Bob decides to give up on improving his philosophical skills to achieve his modest goal.

The argument that persuades Bob bears obvious similarities to the fatalistic one that convinced Alice. Given that arguments such as Alice's are normally considered to be wrong, one should then have the same attitude towards Bob's argument. However, I argue, whereas branching time offers a satisfactory rebuttal of Alice's argument, it cannot rebut the one run by Bob. If so, then we have a problem for branching time, as branching time cannot explain what is wrong with a fatalistic-like argument that intuitively should count as wrong. In the rest of the paper, I am going to analyze in more detail Alice's and Bob's arguments. To do so, I will first consider the natural language version of their arguments (Section 2), and I will then consider these arguments through the lenses of three different semantics for branching time: Ockhamism (Section 3), Peirceanism (Section 4), and Supervaluationism (Section 5). Ultimately, I will discuss some objections (Section 6) and in Section 7 proceed to draw a moral from the analysis of Alice's and Bob's arguments.

2 The Two Arguments in Standard Form

To better assess Alice's and Bob's arguments, let us first clearly articulate their respective premises and conclusions.

Alice's argument.
P1. Either her paper will be accepted, or it won't be.
P2. If it will be, then it is necessary that it will be.
P3. If it won't be, then it is impossible that it will.
CA. Either it is necessary that her paper will be accepted, or it is impossible.

Bob's argument.
P4. Either it is possible that his paper will be published, or it is not.
P5. If it is possible, then it is necessary that it is possible that his paper will be published.
P6. If it is not possible, then it is impossible that it is possible that his paper will be published.
CB. Either it is necessary that it is possible that his paper will be published, or it is impossible that it is possible that his paper will be published.

The two arguments share important similarities. For starters, they have the same structure. Moreover, they both employ the same concept of necessity, viz. the notion

of historical necessity, which captures what is necessary – inevitable, unavoidable, settled – or possible at a certain point of time, given the background of the past-up-to-the-present. Finally, in both cases, the arguments appear to reach a kind of fatalistic conclusion with respect to the future. Whereas we certainly have a fatalistic conclusion in Alice's case, insofar as her conclusion claims that her publication is either necessary or impossible (with no room for contingency), we do *prima facie* seem to have a fatalistic conclusion in Bob's case too. In his case, it is the possibility for publication that enjoys a modal status that rules out contingency.

I will now proceed to analyze their arguments from a formal point of view. I begin by introducing the standard Ockhamist semantics that often accompanies branching conceptions of time (Øhrstrøm and Hasle 2020; Prior 1967).

3 Alice, Bob, and Ockhamism

Let us start by introducing the following standard symbols to express a tempo-modal language L (see among others, Meyer 2015; Øhrstrøm and Hasle 1995; Goranko 2023). L includes an infinite set of non-tensed atomic sentence letters $p, q, r\ldots$, the standard connectives $\rightarrow$ and $\neg$, the temporal operators P ('it was the case that…') and F ('it will be the case that…'), and the necessity operator $\Box$. L also includes the metric tense operators $F(x)$ ('it will be the case in x units of time that…') and $P(x)$ ('it was the case x units of time ago that…'). The dual operators H ('it was always the case that…'), G ('it will always be the case that…'), and the possibility operator $\Diamond$ are defined in the usual manner as $\neg P\neg$, $\neg F\neg$, and $\neg\Box\neg$, respectively.

We then define a Branching-Time Model (BTM) as an ordered triple, $\langle T, <, \text{TRUE}\rangle$, where T is a non-empty set of moments, $<$ is a binary, transitive, and irreflexive 'earlier than' relation over T, and TRUE is a two place-function that assigns either 1 (true) or 0 (false) to couples of moments/atomic sentence letters.[1] As it is customary, we impose on branching-time models two conditions: No Backward Branching and Connectedness. The first condition prescribes that the relation $<$ satisfies the condition that for any moment m, m', m'' in T, if $m < m''$ and $m' < m''$, then either $m = m'$ or $m < m'$ or $m' < m$ (the tree cannot branch towards the past). As for connectedness, it is imposed that for any moments m, m' there is a moment m'' such that $m'' < m$ and $m'' < m'$. (This ensures that all moments are part of the same branching universe). *Histories* are then defined as maximally ordered sets of $<$-related moments of T (intuitively, a history is one of the many possible complete developments of the universe.)

1 I will assume throughout the paper that time is endless both towards the past and the future. Given the scope of this paper, nothing substantial hinges on it.

The Ockhamist evaluation function V assigns truth values to well-formed formulas relative to a BTM-model and a pair of a moment m *and* a history h passing through m. Where ϕ and ψ are any wff of L:

- if ϕ is an atomic sentence letter, $V(\phi) = 1$ at m/h iff TRUE(ϕ, m) = 1.
- $V(\neg\phi) = 1$ at m/h iff $V(\phi) = 0$ at m/h.
- $V(\phi \rightarrow \psi) = 1$ at m/h iff $V(\phi) = 0$ at m/h or $V(\psi) = 1$ at m/h.
- $V(F\phi) = 1$ at m/h iff $V(\phi) = 1$ at m'/h for some $m' \in h$ with $m < m'$.
- $V(P\phi) = 1$ at m/h iff $V(\phi) = 1$ at m'/h for some $m' \in h$ with $m' < m$.
- $V(\Box\phi) = 1$ at m/h iff for all h' such that $m \in h'$, $V(\phi) = 1$ at m/h'.

We can also define semantic clauses for metric temporal operators. To do so, we first add a duration function (see Øhrstrøm and Hasle 2020). Let dur(m, m_1, x) stand for 'm is x time units before m_1'.

- $V(P(x)\phi) = 1$ at m/h iff $V(\phi) = 1$ at m'/h for some $m' \in h$ such that dur(m', m, x).
- $V(F(x)\phi) = 1$ at m/h iff $V(\phi) = 1$ at m'/h for some $m' \in h$ such that dur(m, m', x).

One of the most relevant features of the Ockhamist semantics is that it evaluates sentences at moment/history pairs, as opposed to moments alone. So, in evaluating a sentence where the future operator is the main operator, we move forward along the history *of evaluation*, and ignore what happens on other histories passing through the moment. On the other hand, when the necessity or possibility operators are the main operators, we check what happens on all the histories passing through the moment in question.

The Ockhamist semantics arguably achieves some desirable results. For starters, bivalence holds, as true and false are the only truth values. The principle of Excluded Middle ($\phi \vee \neg\phi$) is Ockham-valid, and so is the Future Excluded Middle ($F(x)\phi \vee F(x)\neg\phi$). The two principles $\phi \rightarrow HF\phi$ and $\phi \rightarrow GP\phi$ are both Ockham-valid. Finally, the Ockhamist semantics offers a principled response to the fatalistic arguments like the one run by Alice. Here is the formalization of Alice's argument, where a stands for *Alice's paper is accepted*, and assuming the decision on her manuscript will be taken x units of time hence.

Alice's argument under Ockhamism.
P1. $F(x)a \vee F(x)\neg a$
P2. $F(x)a \rightarrow \Box F(x)a$
P3. $F(x)\neg a \rightarrow \Box F(x)\neg a$
CA. $\Box F(x)a \vee \Box F(x)\neg a$

To appreciate why this is a correct translation of the argument in natural language in Section 2, it suffices to observe that we can move the negation outside the scope of the future operator in the consequent of P3 and in the second disjunct of the conclusion, and then apply some simple modal equivalences so that $\Box F(x)\neg a$ becomes $\neg \Diamond F(x)a$ – it is impossible that Alice's paper will be published.

The Ockhamist semantics straightforwardly explains what goes wrong in Alice's fatalistic reasoning. The argument structure is valid and P1 is Ockham-valid, since it is an instance of the Future Excluded Middle, which is Ockham-valid. However, neither P2 nor P3 are Ockham-valid. For there can be a Branching-Time Model where m belongs to two histories, h and h_1. Suppose that Alice's paper will be accepted on h, x units of time hence, but not on h_1. At the pair m/h, $F(x)a$ is true but $\Box F(x)a$ isn't, thus making the conditional false. Likewise for the formula P3. At the pair m/h_1, $F(x)\neg a$ is true, but $\Box F(x)\neg a$ isn't.

We thus have a principled diagnosis of what goes wrong in Alice's argument, namely, that two of her premises are invalid under Ockhamism. Even if it turns out that her paper gets accepted, that was not necessary. It might have not been accepted. In sum, we have a conception of time, and an accompanying semantics, on which Alice's argument fails and fatalism is avoided. Alice should complete her paper before submitting it, as it seems reasonable.

However, the situation is different in the case of Bob's argument. The formalization of his argument is as follows, where b stands for *Bob's paper is accepted*. In translating Bob's argument, I use non-metric future tense operators, as Bob's desire to publish is paper is not tied to any specific future moment.

Bob's argument under Ockhamism.
P4. $\Diamond Fb \vee \neg \Diamond Fb$
P5. $\Diamond Fb \rightarrow \Box \Diamond Fb$
P6. $\neg \Diamond Fb \rightarrow \neg \Diamond \Diamond Fb$
CB. $\Box \Diamond Fb \vee \neg \Diamond \Diamond Fb$

Let us evaluate the argument under the Ockhamist semantics. First, the argument structure is again valid. As for the premises employed, P4 is just an instance of the Excluded Middle, and is thus Ockham-valid. P5 and P6 are both Ockham-valid too. The proof of P5 is straightforward. Suppose that $V(\Diamond Fb) = 1$ at an arbitrary m/h pair. Then there is a h', with $m \in h'$, such that $V(Fb) = 1$ at m/h'. Suppose for reductio that $V(\Box \Diamond Fb) = 0$ at m/h. Then, there is a h'', with $m \in h''$, such that $V(\Diamond Fb) = 0$ at m/h''. This implies that for any history h''' passing through m, $V(Fb) = 0$ at m/h'''. Contradiction. The proof of P6 is similar. Suppose that $V(\neg \Diamond Fb) = 1$ at an arbitrary m/h pair. This means that $V(\Diamond Fb) = 0$ at m/h. In turn, this means that for all h' such that $m \in h'$, $V(Fb) = 0$ at m/h'. Suppose for reductio that $V(\neg \Diamond \Diamond Fb) = 0$ at m/h. This means that

$V(\Diamond \Diamond Fb) = 1$ at m/h. So, there is a h'', with $m \in h''$, such that $V(\Diamond Fb) = 1$ at m/h''. Thus, there is a h''', with $m \in h'''$, such that $V(Fb) = 1$ at m/h'''. Contradiction.

The result is that Bob's argument, under Ockhamism, turns out to be sound. So, whereas branching time coupled with the Ockhamist semantics provides a principled reason to rebut Alice's fatalistic argument, it cannot rebut the (somewhat similar) argument run by Bob. His argument turns out to be formally flawless under Ockhamism. In the next two sections, I will show what happens when we move to the Peircean and the supervaluationist semantics.

4 Alice, Bob, and Peirceanism

The Peircean semantics differs from the Ockhamist one with respect to the definition of the semantic clause for the future operator F and its metric version $F(x)$.[2] In the Peircean semantics, $F\phi$ is true at a moment m if and only if ϕ is the case at some moment later than m, *for all histories* passing through m. Given the nature of the Peircean future operator, it is possible to give the semantics clauses by evaluating formulas at *moments* alone, as opposed to moment/history pairs like it happens in the Ockhamist semantics. However, for the sake of uniformity, and to better illustrate comparison between the semantics discussed here, I will relativize evaluations of formulas to moment/history pairs. The Peircean evaluation function V assigns truth values to well-formed formulas relative to a moment/history pair in the following way – here I will skip the obvious assignments. Where ϕ and ψ are any wff of L:

- $V(F\phi) = 1$ at m/h iff for all h' such that $m \in h'$, there is a m' such that $m < m'$ and $V(\phi) = 1$ at m'/h'.
- $V(F(x)\phi) = 1$ at m/h iff for all h' such that $m \in h'$, there is a m' such that $\mathrm{dur}(m, m', x)$ and $V(\phi) = 1$ at m'/h'.
- $V(\Box\phi) = 1$ at m/h iff for all h' such that $m \in h'$, $V(\phi) = 1$ at m/h'.
- $V(f\phi) = 1$ at m/h iff for some h' such that $m \in h'$, there is a m' such that $m < m'$ and $V(\phi) = 1$ at m'/h'.

f is the dual of the future operator F. It is read as 'it is possible in the future that …' and captures the notion of possible future.

Under the Peircean semantics, future contingents turn out to be all false – when ϕ is contingent, $F(x)\phi$ is false, and so is $F(x)\neg\phi$. As in the Ockhamist semantics,

2 For the Peircean semantics see Prior 1967. For a recent defence of the Peircean semantics see Todd 2021. Although Todd distances himself from Priorean Peirceanism on metaphysical grounds, the behavior of the resulting semantics is the same as classical Priorean Peirceanism.

bivalence holds and the Excluded Middle ($\phi \vee \neg\phi$) is valid. However, the Future Excluded Middle ($F(x)\phi \vee F(x)\neg\phi$) is *not* valid – when ϕ is contingent, both disjuncts are false. Furthermore, whereas $\phi \rightarrow FP\phi$ is Peirce-valid, $\phi \rightarrow PF\phi$ is *not* – it could be true at this moment that ϕ, but if you move back in time on the tree, ϕ might not have been the case in all future branches. Ultimately, whereas $F(x)\neg\phi \rightarrow \neg F(x)\phi$ is Peirce-valid, the converse is not, since if ϕ is contingent, $\neg F(x)\phi$ is true but $F(x)\neg\phi$ is false.

As it was the case with the Ockhamist semantics, the Peircean semantics offers a principled response to Alice's fatalistic argument. The formalization of her argument remains the same as in the previous section, despite the changes in the underlying semantics. The argument structure is again valid.

Alice's argument under Peirceanism.
P1. $F(x)a \vee F(x)\neg a$
P2. $F(x)a \rightarrow \Box F(x)a$
P3. $F(x)\neg a \rightarrow \Box F(x)\neg a$
CA. $\Box F(x)a \vee \Box F(x)\neg a$

Whereas both P2 and P3 are Peirce-valid, given the peculiar interpretation of the future operator F, P1 is Peirce-invalid, as it is an instance of the Future Excluded Middle, which is Peirce-invalid. Like with Ockhamism, we have a principled way, albeit of a different kind, to explain to Alice why her argument is faulty. One of her premises is an instance of an invalid principle.

As for Bob's argument, if we want to correctly formalise its natural language counterpart from Section 2, the formalization is going to be different from the one we used under Ockhamism. In particular, we are going to use the operator f, viz. 'it is possible in the future that …'.

Bob's argument under Peirceanism.
P4. $fb \vee \neg fb$
P5. $fb \rightarrow \Box fb$
P6. $\neg fb \rightarrow \Box\neg fb$
CB. $\Box fb \vee \Box\neg fb$

How does the argument fare within Peirceanism? The arguments structure is again valid. As for the premises employed, P4 is just an instance of the Excluded Middle – importantly, not an instance of the Future Excluded Middle – hence it is Peirce-valid. How about P5 and P6? Both can be easily proved. The proof of P5 is as follows. Suppose that $V(fb) = 1$ at an arbitrary pair m/h. Then there is a h' passing through m such that $V(b) = 1$ at m_1/h' for some $m' \in h'$ such that $m < m'$. Suppose for reductio that $V(\Box fb) = 0$ at m/h. Then, there is a h'' passing through m such that $V(fb) = 0$ at m/h''. This

implies that for any history h''' passing through m, there is no moment m'' with $m < m''$ such that $V(b) = 1$ at m''/h'''. But there is such a history, viz. h'. Contradiction. Similarly, here is a proof of P6. Suppose that $V(\neg fb) = 1$ at an arbitrary pair m/h. Then there is no h' passing through m such that $V(b) = 1$ at m'/h' for some $m' \in h'$ such that $m < m'$. Suppose then for reductio that $V(\Box\neg fb) = 0$ at m/h. Then, there is a h'' passing through m where $V(\neg fb) = 0$ at m/h'', viz. $V(fb) = 1$ at m/h''. This implies that there is a history h''' passing through m such that $V(b) = 1$ at m''/h''' for some $m'' \in h'''$ such that $m < m''$. Contradiction.

Once again, there is simply nothing formally wrong in Bob's reasoning. The situation is similar to the one of the previous section: whereas branching time coupled with the Peircean semantics provides a principled reason to rebut Alice's fatalistic argument, it cannot rebut the argument run by Bob.

5 Alice, Bob, and Supervaluationism

I will now argue that the same upshot is delivered if we adopt a supervaluationist semantics. In the context of tense logic, supervaluationism was first introduced by Thomason (1970, 1984). Within supervaluationism, truth at a moment is understood as truth at all histories passing through that moment. To see how it works, one can first define Ockham-truth at a moment/history pair by means of the standard Ockhamist evaluation function (see Section 3). One can then proceed to introduce the two supervaluationist clauses that assign truth and falsity (at a moment m).

SUP1. ϕ is SUP-true at m iff ϕ is Ockham-true at m/h, for every h passing through m.
SUP2. ϕ is SUP-false at m iff ϕ is Ockham-false at m/h, for every h passing through m.

Sentences have a truth-value gap if none of the two clauses is satisfied.

A supervaluationist approach has several advantages. First of all, the semantics evaluates sentences at a moment, instead of at a pair moment/history (like it happens in Ockhamism). Secondly, bivalence does not hold, since future contingents turn out to be neither true nor false – this is seen as an advantage by Thomason (1970, p. 270). Moreoever, and perhaps most importantly, both the Excluded Middle ($\phi \vee \neg\phi$) and the Future Excluded Middle ($F(x)\phi \vee F(x)\neg\phi$) are SUP-valid – given that the two principles are Ockham-true at all moment/history pairs in any model, they are SUP-true at all moments in any model. This way, supervaluationism can introduce a third truth value without renouncing to the Future Excluded Middle, which to many

has the force of a logical tautology.[3] Ultimately, both $\phi \rightarrow HF\phi$ and $\phi \rightarrow GP\phi$ are SUP-valid.

The formalization of Alice's and Bob's arguments is going to remain the same as under Ockhamism.

Alice's argument under supervaluationism.
P1. $F(x)a \vee F(x)\neg a$
P2. $F(x)a \rightarrow \Box F(x)a$
P3. $F(x)\neg a \rightarrow \Box F(x)\neg a$
CA. $\Box F(x)a \vee \Box F(x)\neg a$

Bob's argument under supervaluationism.
P4. $\Diamond Fb \vee \neg \Diamond Fb$
P5. $\Diamond Fb \rightarrow \Box \Diamond Fb$
P6. $\neg \Diamond Fb \rightarrow \neg \Diamond \Diamond Fb$
CB. $\Box \Diamond Fb \vee \neg \Diamond \Diamond Fb$

How does supervaluationism assess the two arguments? Alice's argument can again be rebutted. P1 is an instance of the Future Excluded Middle, which, as seen, is SUP-valid. However, P2 and P3 are not SUP-valid. It can be seen by picking again a model where there are two histories going through m. On h, Alice publishes her paper, but she does not on h_1. $F(x)a \rightarrow \Box F(x)a$ is Ockham-false when evaluated at m/h – the antecedent is true, but the consequent is not. $F(x)a \rightarrow \Box F(x)a$ is however Ockham-true when evaluated at m/h_1 – the antecedent is false. Hence P2 is not SUP-true when evaluated at m. Similarly for P3. Consequently, neither P2 nor P3 are SUP-valid. As before, we have an explanation as of why Alice's reasoning is faulty.

As for Bob's argument, it turns out again to be formally correct. To see why, it is sufficient to notice that any formula which is Ockham-valid is also SUP-valid. For, if a formula is Ockham-valid, it is going to be true in any model at any moment/history pair. It means that formula is going to be SUP-true at any moment in any model, hence SUP-valid. I showed in Section 3 that P4, P5, and P6 are Ockham-valid, hence they are SUP-valid too.

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3 The SUP-validity of the Future Excluded Middle well illustrates the following fact. Under supervaluationism, disjunctions can be true even if neither of the disjuncts is true. In case ϕ is contingent, $F(x)\phi \vee F(x)\neg\phi$ is SUP-true at any arbitrary m, as the formula holds at any pair moment/history. However, neither $F(x)\phi$ nor $F(x)\neg\phi$ would be SUP-true at m, as $F(x)\phi$ is not true at all h/m pairs, and likewise for $F(x)\neg\phi$.

The verdict on the two arguments is thus the same as in the previous two sections: whereas Alice's argument is formally incorrect – it is unsound in some models – Bob's argument is sound.[4]

6 Objections and Replies

In this section, I am going to discuss some objections to my claim that Bob's argument poses a threat to the way branching time and its most common semantics deal with the modal status of what is possible and not possible in the future. In the next one, I will elaborate more on why I think that Bob's argument is indeed problematic for branching time. But first, some objections.

For starters, one might observe that Bob's argument is fairly convoluted, as it involves nested modalities in its premises and conclusion. It's true that few laymen would speak of something being 'necessarily possible' or 'inevitably impossible'. Yet, one could simply respond by observing that the formalized version of Bob's argument simply employs temporal and modal operators whose grammar and semantics are clearly defined.

Secondly, one could find Bob's desire not legitimate. One could think that it is legitimate to wish for some future events to happen, but it sounds strange to desire for a future event to be *possible*. According to this objection, one can legitimately desire, for instance, that they become a doctor, a renowned physicist, or that their manuscript lands in a peer-reviewed journal. On the other hand, there would be something wrong with desiring the mere possibility of those things. But why endorse such a position? Consider Carol, who is currently doing her PhD in Physics. Not only she desires to become a renowned physicist, she also desires that it's possible for her that she'll win a Nobel Prize. She realizes it's extremely hard to win one, given the enormous competition. She thus desires that her upcoming scientific discoveries will be good enough to make it possible (not guaranteed!) for her to win a Nobel Prize. This seems to point to a case where the desire for a future possibility sounds legitimate.

4 There might be a legitimate worry here with respect to the validity of the argument structure used by Alice and Bob, given that we are here operating with supervaluationism. Given that disjunctions are not truth-functional within supervaluationism, some argument structures that are valid in classical logic might be invalid under supervaluationism (Varzi 2007; Williamson 2018). Without entering into the subtleties of this, we can just notice that this might be a problem for Alice, but not for Bob. In Alice's argument, P1 is exactly one of those cases where the disjunction can be true even if neither of the disjuncts is. The same is not the case for Bob, as his premise P4 works as a classical disjunction.

Or consider desires about future possibilities in the context of branching time, which is the model of time at stake in this paper. For Bob to desire that it's possible for him to publish his paper it's for him to desire that in at least one future branch he *does* publish his paper. So, in the context of branching time, this is a concrete and perfectly understandable desire. Assuming every branch has a certain chance distinct from zero of becoming the actual one, what Bob desires is to have a non-zero chance of publishing his paper, i.e. that at least in one branch he does publish there. So, whereas (maybe!) one can have general doubts about the legitimacy of desires such as Bob's, those doubts should certainly be rejected if one accepts branching time.

Furthermore, one might object that the reason why Bob's argument is formally correct is just that the notion of necessity employed in the semantics discussed obey the principles of S5 modal systems. To this, I just respond that my point is that Bob's argument seems to posit problems for branching time and the tempo-modal semantics we usually associate to it. And, if I am right and indeed there are such problems, then we have a problem with how we have been construing the notion of (historical) necessity within branching time.

Another objection might be directed not at the two arguments themselves, but rather at the moral that Alice and Bob draw from them. Once Alice and Bob get persuaded by the two arguments, they give up on pursuing their goals. To this, one might object that they are committing some sort of fallacy in the vicinity of the classical Lazy Argument, known at least from the Stoics (see Bobzien 1998; Broadie 2001; Buller 1995 for a discussion). Consider again Alice's case. One could say that even if it's *inevitable* that her paper will be accepted, this does not imply that the acceptance will happen *no matter what* she does now. If future acceptance is inevitable, then the necessary steps that will lead her there are inevitable too, and their occurrence might collectively constitute the *cause* of the acceptance. Hence, she shouldn't give up on improving her manuscript. In sum, one could reject the jump from the necessity of the future to the general inefficacy of human action.

I am sympathetic to this objection, and I can happily grant that Alice's and Bob's decisions to give up on their work are faulty, even if the conclusions of their arguments – CA and CB above – were deemed to be correct. However, as a response, we can consider Alice's and Bob's decisions solely as a dramatic device employed to make their stories more vivid. This is because the conclusions they reach are enough of a threat, independently of whether they subsequently decide to abandon the pursuit of their goals. In fact, a conclusion such as CA, assuming it can be generalized to any event, is a sufficient cause of concern. Several philosophers used the fact that a conclusion such as CA is repugnant to motivate the fact that we need to abandon at least one of the premises that brings us to CA (see Andreoletti 2019; Øhrstrøm and Hasle 2020 for a discussion on this). And, it is comprehensible why CA is repugnant.

For one, it implies that of all the things that will happen, none of them is avoidable, nor never was. Moreover, the acceptance of something like CA rules out any possibility for an open future and for contingency in the future, every future event being, under CA, either necessary or impossible. There is notoriously a great deal of different understandings of what the open future exactly is (see Grandjean 2021; Torre 2011 for an overview). However, a common feature of the different theories of the open future seems to be the fact that the future enjoys some degree or another of contingency, which is instead ruled out by CA. Likewise, a conclusion such as CB rules out any room for contingency with respect to what is possible or not possible in the future. So, CA alone, *without* the step from necessitation to laziness, is cause of concern, and perhaps so is CB, given their similarity.

7 Conclusion

After having responded to some objections, I will now make a few points to conclude the paper and draw a final moral from the stories of Alice and Bob.

First, branching time and its most common semantics have the theoretical resources to respond to the kind of fatalistic arguments as the one employed by Alice. That is, we have at our disposal a theory that precisely pinpoints what is wrong with such arguments. The same does not hold in the case of Bob. No matter what semantics we decide to associate to branching time, Bob's argument just turns out to be (formally) impeccable. What type of moral can we draw from this?

For starters, Bob's reasoning brings to the fore one interesting aspect of branching time. Under branching time, if something is not a future possibility, it cannot *become* one over time. The notion of historical necessity in branching time models the fact that what is possible or necessary can change over time, as conditions evolve, so to say. However, the passage from some future event being *not possible* to *being possible* is not one of the changes allowed. This is clear from the validity of the premise P6 in Bob's argument. And, it is also clear from how branching structures work. Although under branching time several alternative future exist, if some event E is now not possible in the future, it means that at no moment on any future branch E *is* the case. Given the fixity of branching time structures (the events on the various branches are not changeable), E can thus never become possible.

So, take an agent and an event E involving the agent. Assume E is now *not* possible in the future. Assuming that the various courses of actions available to that agent – i.e. actions the agent in branching time *can* do – are those actions that *do happen* on the branches ahead of them, it follows that if E is now not possible in the future, then there is nothing the agent *can* do to bring it about that E becomes possible. For, by assumption, E does not happen on any branch, hence nothing the agent does in the

future branches brings it about that *E does happen* on some branch. In other words, if it's now not possible that *E* will happen, it's impossible that it's possible. No one can do anything about it. And that's precisely what P6 in Bob's argument says.

Sometimes, under branching time, people talk of acting as to bring it about that the desired branch becomes the actual one, or that one finds themselves in the desired branch – what one would exactly says depends on the preferred understanding of the metaphysical and ontological status of future branches. For instance, if Alice becomes a believer of branching time, she might want to act in such a way that the branch where she publishes becomes the actual one, instead of the one where she does not publish there. Agents seems to have some power over which future branch gets selected. The power to act in such a way that something that was not possible becomes possible, though, is simply not contemplated, since under branching time nothing can become possible if it was not possible already. I leave it to the reader whether this is a problem for branching time. Perhaps we want a notion of historical necessity that allows for some events that were not possible to become possible, and consequently give an agent the power to act as to bring it about that an event *becomes* possible.[5]

To move on, I want to discuss whether we can rightly talk of fatalism with respect to Bob's argument. Certainly we have a fatalistic argument in the case of Alice. The question is whether we have a fatalistic argument in Bob's case. If this was the case, then there would be a problem, as fatalism is usually considered repugnant, but branching time with its semantics does not have the means to rebut Bob's argument. It is debatable what precisely fatalism amounts to, as it is possible to find several definitions in the literature, or even several kinds of it – logical, ontological, and theological fatalism (see Diekemper 2007; Fischer and Todd 2015 for an overview on the different kinds). Without attempting here to settle the issue of what fatalism is exactly, I will just notice that many elements commonly associated to fatalism are present in Bob's argument.

For starters, as Meyer (2016) points out, fatalism is a modal thesis. Bob's conclusion CB certainly is a modal thesis too, and it has the same structure of the one of Alice's, which certainly is fatalistic, viz. $\Box\ldots \vee \neg\Diamond\ldots$. As noted in the previous section, in the case of Alice, CA rules out any contingency in the future, as future

5 A semantics which allows for the emergence of new possibilities is proposed in Braüner 2023, Brauner, Hasle, and Ohrstrom 1998. Consider also the mutable futurist picture (Andreoletti and Spolaore 2021; Effingham 2021; Todd 2016). Under mutable futurism, it's possible for a future event to become possible even if it was not so before. For, under mutable futurism, we have the occurrence of events in the objective present such that in the past they were not going to happen. The occurrence of these events make the future literally change from how it used to be. It seems natural then to say that, under this view, also what is in the realm of *future possibilities* changes accordingly, opening for the possibility that a future event changes from being not possible to being possible.

events are either necessary or impossible, with no third option (they cannot be possible without being necessary). In Bob's case, what enjoy this non-contingent modal status are not future events, but rather the possibility of their occurrence.

Moreover, it is common to find in the literature the following phrases to characterize fatalism: something not being within the agent's power (Taylor 1962; Widerker 1990), the agent having no choice about an action (Finch and Rea 2008; Merricks 2009), and whatever will happen being (already) unavoidable (Emery, Markosian, and Sullivan 2020). Consider Alice's argument. As said, almost nobody accepts fatalism, but if we *were* to accept her argument, we would then rightly say that Alice *has no choice* about whether she publishes her paper – if she will publish it, it is *unavoidable* that she will. Or, if she will not publish it, then it's not *within her power to bring it about* that she will do so.

As for Bob, if we were to accept his argument – after all, it has been proven to be formally correct – we would then rightly say that Bob *has no choice* about whether it's possible that he will publish his paper – if it is possible, it is necessarily possible. Or, if it's not possible that he will publish, then it's not *within his power* to bring it about that it is possible. The similarities are many. And, to push the point, consider also how Iacona (2007, p. 45) defines fatalism as 'the doctrine according to which if something happens, it is necessary that it happens, and if something does not happen, it is impossible that it happens'. This just corresponds to Alice's premises P2 and P3. And, Bob's premises P5 and P6 just are in the same spirit of Iacona's characterization of fatalism. If something is possible in the future, then it is necessary that it is possible in the future. And, if something is not possible in the future, then it is impossible that it is possible in the future.

So, many elements of fatalism appear in Bob's argument; to the point that it seems right to classify his argument as a fatalistic one, or at least as something in the close vicinity of fatalism. Given that usually fatalistic conclusions are taken to be repugnant and that fatalistic arguments are almost universally considered wrong, it is desirable that branching time offers a reply to arguments such as Bob's. However, whereas branching time provides a principled rebuttal of classical fatalistic arguments such as Alice's, branching time simply cannot diagnose what is wrong with Bob's argument, irrespectively of which semantics we adopt. In result, we have a new fatalistic threat to the branching conception of time.

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