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An Objection to the Branching Model for Time

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Abstract

Future Contingency has been an old debate between philosophers throughout history. On one hand, Aristotle thinks events of the future happen contingently. On the other hand, Diodorus believes what happens in the future is now determined. Diodorus has presented an argument for determinism based on a few premises. Logicians and philosophers try to avoid determinism by denying the first premise of Diodorus, which is the necessity of the past. However, they only regard a qualified version of this premise based on the medieval argument for determinism while some other philosophers consider this premise in a general way. A new argument shall be presented in this paper for determinism similar to the medieval one based on the general version of the premise which is not rejected by systems which reject the medieval argument. This flaw originates in a few properties of the branching model for time. We shall show what this property is and how it would be possible to resolve the problem this property creates.

Keywords: Metric tense logic, Ockham system, Thin red line, Branching model, Necessity of the past.

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Introduction

Aristotle believes events pertinent to the future happen contingently. He, in his book "*On Interpretation*," presents his theory about future contingency with an example. Now, it is not determined that the sea battle will happen tomorrow or not. The only fact which could be said about it is that tomorrow the sea battle will happen or tomorrow the sea battle will not happen are both true (*On Interpretation*, 18 b 23 ff.).

Diodorus declines this belief. From his point of view, it is determined now whether the sea battle will happen tomorrow. He presents an argument as an opposition to Aristotle's opinion. Unfortunately, this argument, which is called "Master Argument", is not now available (Gaskin 1995; Nabavi 2010, p. 41). However, there is a consensus about the premises for this argument. With regard to Diodorus' view, these three propositions are not consistent.

Every true proposition about the past is necessary

An impossible proposition cannot follow from a possible one

There is a proposition that is possible which neither is nor will be true

Diodorus accepted the first two premises and rejected the third one. The reason is likely to be his deterministic view. It must be mentioned the negation of the third premise is acceptable by Diodorus. In fact, the definition of the possibility is the negation of the third premise. A possible proposition, from his point of view, is a proposition which is true or will be true in the future (Ohrstrom and Hasle 1995, p. 15 ff.).

Diodorus' premises were considered by medieval philosophers. That propositions about the future happen necessarily is very close to arguments for determinism. God's knowledge of our action, on the one hand, and our free will, on the other hand, are topics relevant to determinism in which medieval philosophers were interested. They presented arguments for determinism based on Diodorus' premises (Gaskin 1995, p. 351 ff.).

Contemporary logicians and philosophers have been trying to formalize these arguments with formal logic. Then proponents of indeterminism or free will have tried to find a way, whose cost is low, to refute the arguments. One of the approaches to refute determinism is partially refuting the first premise of Diodorus' necessity of the past. This way is acceptable because only a part of the first premise, which is by the way against intuition, is refuted (Ohrstrom 2009, p. 24 ff.). This solution suggests that if the content of a proposition is about the future and the proposition is given by a past operator, then it cannot be necessary. Actually, what could be accepted by the first premise of Diodorus' common sense is if the content of a proposition (meaning the content of the proposition's final event) is pertinent to the past, then, the proposition is necessary. Otherwise, it could not be necessary. For example, if we say, "yesterday was the case that two days later **e** (a symbol for an event) will happen," then nothing about the past is said, in spite of the fact that prima facie the proposition is about the past. As a result, the proposition is not necessary. This conclusion is compatible with our intuition about indeterminism. In addition, we need less modification in our logical systems.

On another hand, in many logical systems which are built to reconstruct the arguments for determinism, only a special case of the first premise is considered. The first premise is generally like this: every event is necessary after it takes place. But these systems concern only with a special case of it. The special case is this: every proposition about the past is necessary. The semantics of these systems only consider the special case. I will present an argument similar to the medieval arguments based on the general version. In the following, I will show that some logical systems which are successful in refuting the special case of the first premise cannot refute the general version of the first premise based on my argument.

The main defected system with regards to my argument is the system called Ockham System. This system is devised by

Arthur Prior based on William Ockham's approach. He thinks in spite of the free will of humans, God knows about the actual world in the future (Prior 1967, p. 121). The lack of existence of the actual world in the Ockham system was a reason for the invention of another system by Peter Ohrstrom which is called the Thin Red Line (Ohrstrom 2009). He tries with considering history as the actual world to eliminate the problem of Ockham System. I will show that both systems cannot reject the general version of the first premise. I will show that the problem of these systems is the property of backward linearity for time for the future time points. This property causes the past for every point in the models to be necessary.

Tense Logic System

Metric tense logic

The logical system I introduce for formalizing the determinism argument is the metric tense logic presented by Arthur Prior (Prior 1967, pp. 97-100). In this system, there are two tense operators in addition to other operators. The first one is $F_{(x)}p$ which means in x time units in the future we will have p. The second one is P(x)p which means in x time units in the past we had p. We have also these postulates:

FN1: $F(n)\neg p \supset \neg F(n)p$

FN2: $F(n)p \supset F(n)\neg p$

FP1: $F(m)P(n)p \supset F(m-n)p$ for $m>n$

FP2: $F(m)P(n)p \supset P(n-m)p$ for $n>m$

FP3: $F(n)P(n)p \supset P$

FC: $(F(n)(p \supset q)) \supset (F(n)p \supset F(n)q)$

FF: $F(n)F(m)p \supset F(n+m)p$

F∀: $\forall m F(n)F(m)p \supset F(n)\forall m\, F(m)p$

FP∀: $\forall m F(n)P(m)p \supset F(n)\forall m\, P(m)p$

In addition, there are two rules. First the **RF** rule which is the following:

RF: $\vdash \alpha \rightarrow \vdash F\,(n)\alpha$

The second one is the image mirror rule. This rule declares that in the postulates we can replace F(n) with P(n) and vice versa (this rule enables us to ignore presenting certain postulates). In the postulates above, n in F(n) and P(n) could be every natural number. It could also be 0. But we only work with natural numbers which will not problematic.

Branching model for time

The semantics of the branching model for time was presented by Kripkie. He proposed the branching model in a letter to Prior (Ploug et al. 2012; Prior 1967, pp. 27-31). He claims that to model time, we must suppose that for every temporal point related to the future there exist some possible future points. These possible futures are formed based on possible events in the future. For example, consider an event like the sea battle. Two possible futures present themselves for tomorrow by considering this event. First, it is possible that tomorrow the sea battle will happen. Second, it is possible that tomorrow the sea battle will not happen.

If we consider now with level t_0, then we get certain situations related to t_1 in the future. Generally, for every temporal point in our model we have certain possible futures. We can show this in the following figure:

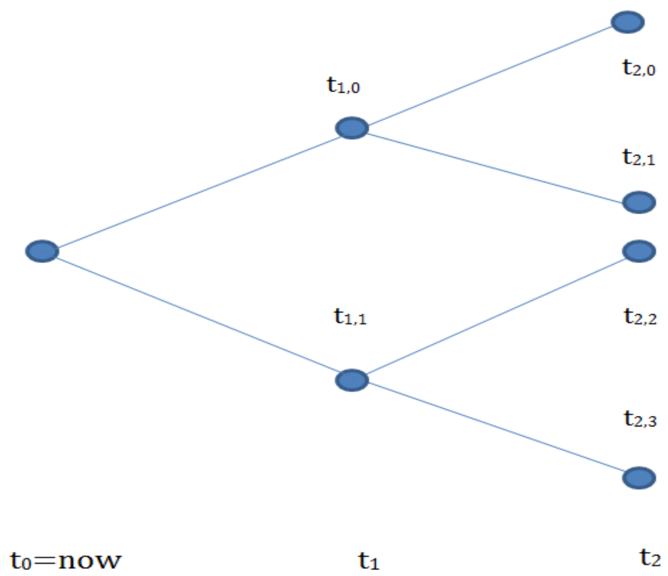

Figure 1

Branching time semantics is based on a structure (T, ≤, C, True) (Ohrstrom 2015). T is the set of all temporal points. The relation ≤ is a dyadic relation defined on members of T. (T, ≤)

is a tree structure and contains partially ordered sets of temporal points. The set C forms maximal ordered sets of temporal points. We call every member of C a history. Every two members of C have some points in common. The relation $\leq$ is backward linear on temporal points. This means:

$(t_1<t_0 \wedge t_2<t_0) \supset (t_1<t_2 \vee t_2<t_1 \vee t_1=t_2)$

We could also define an equivalent relation on histories like this (Ohrstrom and Hasle 1995, p. 212) :

$(C_1,t) \approx (C_2,t)$

This relation is defined in this way: two histories C_1 and C_2 in the time t are equivalent if and only if they are equal before t. Namely:

$$\{t'\in C_1 \mid t' \leq t\} = \{t'\in C_2 \mid t' \leq t\}$$

In metric tense logic, we define function **dur** on set of temporal points. This function is ternary and **dur**(t_1,t_2,x) means the temporal distance between t_1 and t_2 is x (Ohrstrom 2015).

A main concern in this semantics is the definition of necessity and possibility. In these models (In the following we will define them), it seems there are various interpretations of possibility and necessity. Naturally and with respect to the intuition which exists in the branching model, the possibility of a proposition in a temporal point considering a special history means the proposition is true in a history at the same time which is equivalent to the first history at the time point of consideration. This definition complies with the Ockham system of Prior (Ohrstrom 2015). In fact, based on the first shape, for having a possible proposition in $t_{2,0}$, it is sufficient to have the proposition in a world of its equivalent possible worlds.

On the other hand, based on the Ohrstrom's definition, all temporal points which are equal are possible worlds for each other (Ohrstrom 1995, p. 190). For example, in Figure 1, the points $t_{2,0}$, $t_{2,1}$, $t_{2,2}$ and $t_{2,3}$ are possible temporal worlds for time

t_2. Although prima facie the combination of these two views seem bizarre, this combination is totally consistent. The proposition that is now and in the time t_2 necessary, must be true in all 4 possible worlds in t_2 (because all of them are accessible for t_0). But if the necessity of a proposition in t_2 with regard to $t_{2,0}$ is under consideration, then it is enough for this proposition to be true in two equivalent possible worlds $t_{2,0}$ and $t_{2,1}$. I do not want to present a contradiction between these two views. In fact, there is no such thing. Conversely, this modeling of time is an elaborated design of our intuition about the future and its events. Investigating now the truth of the necessity of a proposition at a time is equivalent to the truth of it in all possible worlds at that time. But if investigating the truth of the necessity of a proposition with regards to the truth of an event prior to it is under consideration (also in a special history), then the necessity of the proposition is confined to situations and histories with maximum similarity to the time point of the first event and its history.

This modeling seems acceptable. Based on it, the Prior's Ockham system and Ohrstrom's Thin Red Line system are presented (Ohrstrom 2015).

Formalization of the necessity of the past

The first premise of Diodorus is regarded frequently like this:

Every true proposition about the past is necessary

In a formal interpretation we could consider it (Prior 1967, p. 117) like this: $Pp \supset \Box Pp$ But in my opinion, this is only a special case of the Diodorus's premise. We could also consider other forms of this premise. For example, one of them could be that whatever happens now will be necessary tomorrow or whatever will happen tomorrow will be necessary two days later. Generally, we could present Diodorus's first premise like this:

Every true proposition at a time will be necessary afterwards

Formally in first order logic we can present this premise as Rescher did like this (Rescher and Urquhart 1971, p. 191):

$$\forall t \, \forall t' \, \{[T_t(p) \; \& \; t<t'] \supset N_{t'}(p)\}$$

Here $T_{t(p)}$ means that p happens at time t and $N_{t'(P)}$ means that p is necessary at time t'. It must be mentioned that in Rescher's formalization proposition could be tensed. Equivalently, based on Prior formalization for this premise, we have these three formulas:

$P_{(x)}p \supset \Box P_{(x)}p$

$F_{(m+n)}P_{(n)}p \supset F_{(m+n)}\Box P_{(n)}p$

$p \supset F_{(x)}\Box P_{(x)}p$

The first formula is considered in all systems. Many solutions only reject this formula. In fact, they think if the proposition which is in front of a past operator presents an event about the future, it must not be necessary. However, this is not the only case of necessity of the past which must be rejected. One of the best criteria for weighing the necessity of the past is proposed by Plantinga (1986). He differentiates between hard facts which are about something that has happened in the past and soft facts which are about something that will happen in the future. From his point of view, every proposition presents an event which is related to a time. If the event of a proposition is pertinent to the past, then the proposition is a hard fact. But if the event of a proposition is pertinent to the future, then the proposition is a soft fact. Hard facts must be necessary, yet the soft fact is not necessarily necessary. With this approach, the second formula must be rejected, unless the proposition p is about an event related to the past before m time units earlier. The third formula is acceptable, although it depends on our view to the present time. The present time is considered often as the last thing which belongs to the past. In all tensed theories about time, the present is all or one part of the actual world. Its events are actual and necessary. Indeed, accepting the third formula is rudimentarily without problem, unless the proposition p is about an event related to the future. As a result, the logical systems must not try to reject the third formula.

I do not want to show Diodorus' premise based on a historical perspective. Indeed, my goal is discussing other forms of this premise. I want to examine if current systems accept these forms or reject them. If these forms conclude determinism for the future, these systems must reject them for indeterminism. In the Ockham and Thin Red Line systems which incline to reject the first premise, only the first formula is rejected. The second formula is accepted by them generally. Therefore, in some circumstances they conclude determinism. Further, I will present two arguments. The first one is given by Lavenham and I introduce the version of Ohrstrom (Ohrstrom 2009). This argument is based on the first formula above. The second one which is very similar to the first one belongs to me. But it works with second formula above. I will show that the Ockham and Thin Red Line systems reject the first but accept the second.

Arguments for Determinism

Challenging Diodorus' claim has affected various domains in Philosophy like Ethics, Logic and Determinism. During the medieval ages, with regard to the importance of free will and determinism, a few arguments for determinism were presented based on his premises. Lavenham has presented one of them. I show the formal version of this argument which Ohrstrom has given (Ohrstrom 2009, p. 18). Assume that **e** is an event, for instance, sea battle.

Either **e** is going to take place tomorrow or **non-e** is going to take place tomorrow. (Assumption)

If a proposition about the past is true, then it is necessary now, i.e., inescapable or unpreventable. (Assumption)

If e is going to take place tomorrow, then it is true that yesterday it was the case that **e** would take place in two days. (Assumption)

If **e** is going to take place tomorrow, then it is now necessary that yesterday **e** would take place in two days. (Follows from 2 and 3)

If it is now necessary that yesterday **e** would take place in two days, then it is now necessary that **e** is going to take place tomorrow. (Assumption)

If **e** is going to take place tomorrow, then **e** is necessarily going to take place tomorrow. (Follows from 4 and 5)

If **non-e** is going to take place tomorrow, then **non-e** is necessarily going to take place tomorrow. (Follows by the same kind of reasoning as 6)

Either **e** is necessarily going to take place tomorrow or **non-e** is necessarily going to take place tomorrow. (Follows from 1, 6 and 7)

Therefore, what is going to happen tomorrow is going to happen with necessity. (Follows from 8)

With a little reflection we could see another similar argument could be presented simply with short and acceptable changes. The main assumption which is needed for this new argument is the first premise of Diodorus in the general figure. This argument is like this:

Either **e** is going to take place tomorrow or **non-e** is going to take place tomorrow. (Assumption)

If a proposition is true at a time, then it is necessary afterwards. (Assumption)

If **e** is going to take place tomorrow, then it is true that two days later it will be the case that **e** would have taken place yesterday. (Assumption)

If **e** is going to take place tomorrow, then it is now the case that two days later, it will be necessary that **e** would have taken place yesterday. (Follows from 2 and 3)

If it is now the case that two days later it will be necessary that **e** would take place yesterday, then it is now necessary that two days later **e** would have taken place yesterday. (Assumption)

If it is now necessary that two days later **e** would have taken place yesterday, it is now necessary that **e** will take place tomorrow. (Assumption)

If **e** will take place tomorrow, it is now necessary that **e** will take place tomorrow (Follows from 4, 5 and 6)

If **non-e** is going to take place tomorrow, then **non-e** is necessarily going to take place tomorrow. (Follows by the same kind of reasoning as 6)

Either **e** is necessarily going to take place tomorrow or **non-e** is necessarily going to take place tomorrow. (Follows from 1, 6 and 7)

Therefore, what is going to happen tomorrow is going to happen with necessity. (Follows from 8)

For accepting this argument, we must have these assumptions:

A1) $F_{(x)}p \vee F_{(x)}\neg p$

A2) $F_{(x)}P_{(x)}p \equiv p$

A3) $F_{(x+y)}P_{(y)}p \supset F_{(x+y)}\Box P_{(y)}p$

A4) $F_{(x)}\Box p \supset \Box F_{(x)}p$

The assumption A3 is the second formula of the first premise. Every proposition relevant to the future, in every future after taking place, is necessary. With considering the above assumptions, we could formalize this argument like this:

$F_{(x)}p \vee F_{(x)}\neg p$	(A1)
$F_{(x)}F_{(x)}P_{(x)}p \supset F_{(x)}F_{(x)}\Box P_{(x)}p$	(A3)
$F_{(x)}p \supset F_{(x)}F_{(x)}P_{(x)}p$	(A2, substitution)
$F_{(x)}p \supset F_{(x)}F_{(x)}\Box P_{(x)}p$	(2,3)
$F_{(x)}F_{(x)}\Box P_{(x)}p \supset \Box F_{(x)}F_{(x)}P_{(x)}p$	(A4)
$\Box F_{(x)}F_{(x)}P_{(x)}p \supset \Box F_{(x)}p$	(A2, substitution)
$F_{(x)}p \supset \Box F_{(x)}p$	(4,5,6)
$F_{(x)}\neg p \supset \Box F_{(x)}\neg p$	(similar to 1-7)
$\Box F_{(x)}p \vee \Box F_{(x)}\neg p$	(1,7,8)

Further, I will show that the Ockham and Thin Red Line systems do not reject the above argument. As a result, we must follow alternative systems like Nishimora's System which Ohrstrom called the Leibnizian system (Nishimora 1979). Also we could accept the first premise and follow the solutions based on rejecting other premises like the Principle of Future Excluded Middle (These solutions are not regarded here).

Appraisal of the Ockham and Thin Red Line systems

The Ockham system

The Ockham system, which is presented by Arthur Prior, is based on the branching model (Prior 1967, p. 126 ff.). This system does not accept the first premise of Diodorus. Consequently, it does not accept Lavenhum's Argument. This means it can be a solution against determinism.

Based on Ohstrom's formalization, in this system there is a function called **TRUE** (Ohrstrom 2015). It assigns every proposition at every point of time the value 0 or 1. The truth function called **Ock** is defined as the following:

(a)	$Ock(t,c,p) = 1$	Iff	$TRUE(p,t) = 1$
(b)	$Ock(t,c,p \wedge q) = 1$	Iff	both $Ock(t,c,p) = 1$ and $Ock(t,c,q) = 1$
(c)	$Ock(t,c,\neg p) = 1$	Iff	not $Ock(t,c,p) = 1$
(d)	$Ock(t,c,F_{(x)}p) = 1$	Iff	$Ock(t',c,p) = 1$ for some $t \in c$ with $dur(t,t',x)$
(e)	$Ock(t,c,P_{(x)}p) = 1$	Iff	$Ock(t',c,p) = 1$ for some $t' \in c$ with $dur(t',t,x)$
(f)	$Ock(t,c,\Diamond p) = 1$	Iff	$Ock(t,c',p) = 1$ for some $c' \in C(t)$

Time in the future is branching, while in the past it is linear. Every C, which is a maximal ordered set of time points, is a history. In the definition of possibility, $C_{(t)}$ is meant all time points which are equivalent to the time point in which the truth is considered. As we defined before, two equivalent histories are identical in the past of the time of consideration. For every two histories, their intersection is not null. This semantics system has a tree structure and the necessity in it means happening in all histories equivalent to the history under consideration at the same time.

Now consider the main premise of my argument, namely $F_{(x+y)}P_{(y)}p \supset F_{(x+y)}\Box P_{(y)}p$. Assume that in the Ockham system we have $F_{(x+y)}P_{(y)}p$. This means the antecedent is true in the history C_1 and at the present time. This means at the x+y time units in the future, p is true at y time units before. This time point is in the history C_1. If we do not have this premise, then we must have the negation of its consequence. Therefore, we must have $\neg F_{(x+y)}\Box P_{(y)}p$. This means at a point x+y time units later in the C_1 we must have $\Diamond P_{(y)}\neg p$. This means at least at a time point concurrent with the considered time (x+y time unit later) whose history is equivalent to C_1 we must have $P_{(y)}\neg p$. But this proposition links all the points to the same point in which p holds. Therefore, the premise is not rejected.

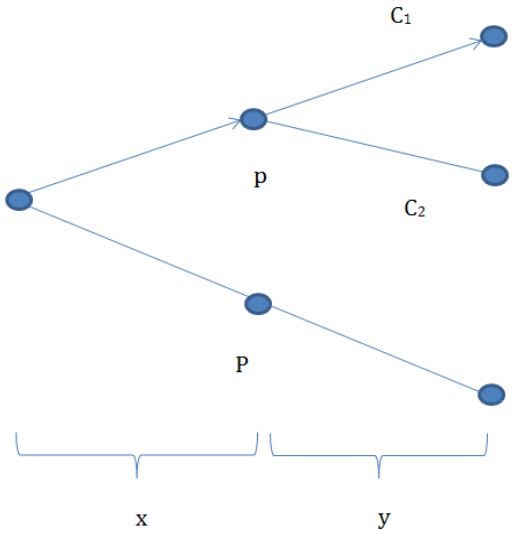

Figure 2

3-2.Thin Red Line system

The Thin Red Line system in its simple and first version is similar to Ockham System (Ohrstrom 2009). The difference between two systems is that in the Thin Red Line, one history is considered as the actual world. The defect of Ockham system is the lack of harmony with Ockham approach. Indeed, in Ockham solution we have a line or world which is representative of the actual world. The omniscient is aware of this world. But the Ockham system does not have such world. The Thin Red Line system which is suggested by Ohrstrom wants to solve this problem. The semantics in this system is alike Ockham system. The only difference is in the definition of $F_{(x)}p$:

$Trl(t,c,Fp) = 1$ Iff $Trl(t',TRL,p) = 1$ for some $t' \in c$ with $t < t'$

The Trl is the truth function in this system. I must mention the TRL is the actual world or history.

Again consider the main premise namely:

$$F_{(x+y)}P_{(y)}p \supset F_{(x+y)}\Box P_{(y)}p.$$

Assume in the Thin Red Line system we have $F_{(x+y)}P_{(y)}p$. This means the antecedent is held in a history C_1 which must be the actual world namely TRL. This means in the actual world at x+y time units later we would have in y time units earlier p is held. This point is on the actual world. If we would not have this premise, we must have its negation of its consequence. Then, we have $\sim F_{(x+y)}\Box P_{(y)}p$. This means in a point x+y time units later in the TRL history we should have $\Diamond P(y)\neg p$. This also means in at least one point whose history is equivalent to TRL history at that time, we have $P_{(y)}\neg p$. But such proposition links all points to a same point. Therefore, my premise could not be rejected.

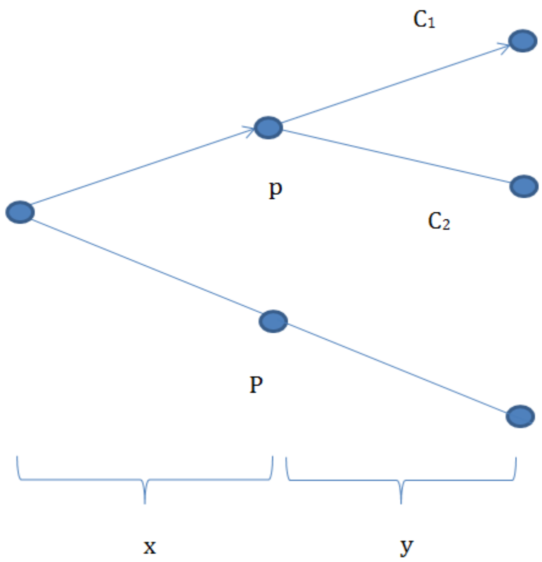

Figure 3

There are also other versions of the Thin Red Line. Belnap and Green proposed that we have for every time point (actual or nonfactual) a thin red line (Belnap et al. 2001, p. 169; and Ohrstrom 2015). Therefore, we have a function which defines for every time point a thin red line and has these conditions:

(TRL1) $t \in TRL(t)$

(TRL2) $(t1 < t2 \wedge t2 \in TRL(t1)) \supset TRL(t1) = TRL(t2)$

There are two approaches for the exact definition of semantics in this system. The first approach suggests similar definitions to the Ockham system unless in the definition of $F_{(x)}q$:

$T(t,F_{(x)}q) = 1$ Iff there is some $t' \in TRL(t)$ with $t<t'$ and $T(t',q) = 1$

This approach also accepts my argument. In fact, in this system, for all points relative to the past, there exists but one history.

Another approach in semantics which is introduced for the Thin Red Line system is a semantics which is independent of histories. In this approach, we do not define semantics with regard to histories (Ohrstrom 2015). The semantics is as follows:

(a) $T(t, p) = 1$ Iff TRUE $(p,t) = 1$, where p is any propositional constant.

(b) $T(t, p \wedge q) = 1$ Iff both $T(t,p) = 1$ and $T(t,q) = 1$

(c) $T(t,\neg p) = 1$ Iff not $T(t,p) = 1$

(d) $T(t,Pq) = 1$ Iff there is some t' with $t'<t$ and $T(t',q) = 1$

(e) $T(t,Fq) = 1$ Iff there is some $t' \in TRL(t)$ with $t<t'$ and $T(t',q) = 1$

This approach rejects my argument. In the definition of Pq, we have Pq at a time point t if in a world which is in the past with regard to t we have q. Conspicuously, this definition does not contain the condition of linearity relative to the past. Hence, this model rejects my argument.

However, this system has some serious problems. Some of them have been proposed by Ohrstrom (Ohrstrom 2015). For Instance, $q \supset PFq$ is not held in this system. Even $q \supset P_{(x)}F_{(x)}q$ is not held in this system. On the other hand, $P_{(x)}F_{(x)}q \supset q$ is not held either. In fact, there is no symmetry between the past and the future. For example, that tomorrow will be rainy is not equivalent to the fact that two days later yesterday will have been rainy. From this fact that two days later yesterday will have been rainy, we could not conclude that tomorrow will be rainy. Although this system rejects my argument, its cost would be too much. Some intuitional truths which comply with our everyday arguments would be rejected if we accepted it.

Improvements for the branching model

What has caused these systems to accept other versions of the first premise of Diodorus is that time is linear with regards to the past in their branching semantics, on the one hand, and the definition of necessity based on histories we face, on another. In every point of time (actual time or nonfactual time) if we see the past, we would see only one option and consequently we have one possible time point. As a result, if we see the past, possibility and necessity would be the same. This approach is held for every time point. This means every time point which belongs to the future in the branching model has also this feature. Time in the branching model has the property of backward linearity. But our intuition rejects the necessity of the future. Consequently, we could not say now what will happen in the future is necessary afterwards.

Indeed, for rejecting other versions of the first premise of Diodorus, we must inevitably avoid the branching time model. My criteria for rejecting other versions are the criteria which Plantinga presented and I introduced earlier.

For resolving this problem, some solutions could be presented. We saw that the second version of Thin Red Line rejects the backward linearity of time, but its cost is not worthwhile. The first and simplest way is strengthening the definition of necessity in the branching semantics. We could define necessity independent of following histories. This means we have this definition for the truth of possibility:

$Ock(t,c,\Diamond p) = 1$ iff $Ock(t,c',p) = 1$

The definition above simply solves the problem. But this solution destroys the concept of branching. In the first chapter, I said that the worlds a time point faces are the worlds which exist based on the events which could happen in it. But assume that we have a true proposition like $p \supset F_{(x)}\Box q$. If in a time point we have p, then for having the proposition based on the above definition, we must have q in every time point with distance x. This is not only essential for the possible time points to the first time point, but also for other time points with distance x. But this contradicts the concept of branching.

It seems the problem of the branching model is the lack of difference between now and the future. All features of now are also the features of the future. That now is something which presents us some choices is only a feature of now. The future is something different from now. We now cannot say about choices for the future. About the future, we could only say which proposition in which time based on a specific history would happen. That those ways which we face could have similarities until a point in the future should not impose a feature on our system. Indeed, two histories which are common until a point in the future are anyway different. In my opinion, a defect of the branching time semantics is that future histories come together until a point because of similarity in their events. Based on this similarity for future points, a common past is assumed. As a result, the past points for future points of these histories become necessary, while these points are only for them in the past and indeed, belong to the future.

If we eliminate similarities between future points, the problem would be resolved. Consequently, we are not obliged to accept possible worlds for the future points. In this system before now all histories have the same past; namely, they are similar at all times. The paths we face are without intersection. Finally, our system looks like a fork.

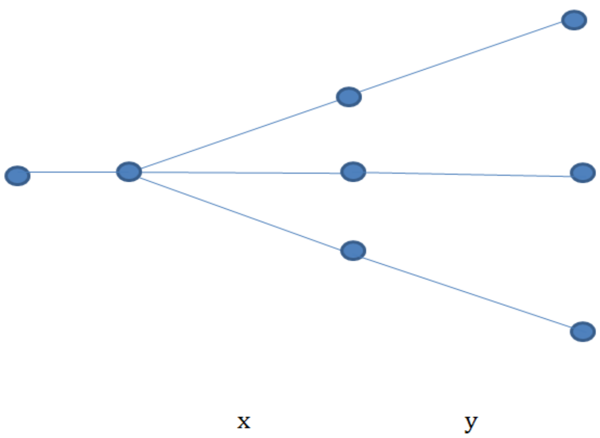

Figure 3

While choosing between possible futures is only a feature of the present time, the histories we face are depicted based on our choices and their consequences. If we show the histories in the future in my way, finally we have simpler and more complete figure of the past, present and the future. This view is compatible with Leibniz's view about free will. We know that Leibniz had a moderate opinion about free will. He believed possible ways and possible histories are figured out now and God is aware of them. The human's will is in choosing one of them.

A system based on Leibniz's approach has been presented by Nishimoura (Nishimoura 1979). In this system which is also compatible with Leibniz's idea about free will, histories are different from each other and do not have intersection. Every history contains some time points which are simultaneous with points in other histories. Therefore, an equivalent relation could be defined in this system. Every maximal linear set of time points is not a history. Every time point belongs to only one history.

Although it seems that considering difference between past histories does not make a defect, considering one common history as past could be more convenient. The past is actual and necessary. Therefore, we have only one unique past. This view (the fork like model) has harmony with common sense.

Conclusion

Solving future contingency problems with considering Diodorus premises could be done in different ways. A few of the solutions are based on rejecting the first premise of Diodorus. We could consider the first premise like Rescher. As a result, systems which reject the first premise of Diodorus can be divided into two groups. The first group rejects the first premise in all conditions. The second group only rejects the premise in a special case. There is an argument for determinism which shows us the second solution cannot completely reject determinism. The first conclusion is that there is a difference between the Ockham and Thin Red Line systems, on the one hand, and Nishimoura's system, on another (Ohrstrom 2015). The second conclusion is that only Nishimoura's system could reject the first premise in all cases. Finally, there is also a fork-shaped model which could reject the first premise in all cases like Nishimoura's system.

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