

Against Lewis: branching or divergence?

Tomasz Placek *

Abstract:

I address some interpretational issues of the theory of branching space-times and defend it against David Lewis' objections.

1. Introduction

Following Belnap (1992), in Kowalski and Placek (1999), Placek (2000a,b), and Müller and Placek (2001), we developed a framework of stochastic outcomes in branching space-times (SOBST) and applied it to some issues in the philosophy of quantum mechanics. The SOBST framework is an alternative to David Lewis' possible worlds, and is particularly suited to discuss questions like determinism or causality. The models have much to recommend them: (1) branching can be interpreted both ontologically and epistemically, (2) the models are local in the sense of concentrating on rather events and their outcomes than histories (or possible worlds), and finally, (3) crucial structures, called families of outcomes of events form Boolean algebras, and this permits the introduction of Kolmogorovian probabilities. Yet, there appears to be a serious philosophical problem with these models: these are *branching* models and that goes against the majority opinion, as eloquently voiced by Lewis, that branching is highly problematic. Thus, it is the assessment of Lewis' arguments against branching that this talk is about. To prepare the grounds for this discussion, we will begin with a non-technical sketch of SOBST models.

2. Stochastic outcomes in branching space-times

The underlying perception of the SOBST models is that possibility is a relative concept, as the phrases: 'one event makes another event possible' or 'given that one event occurs, some other event is possible' suggest.¹ We say, for instance, that + and – are two alternative possible results of a measurement event, meaning that if, as a matter of fact, the measurement event occurs, one of two alternative continuations of it, one with the + result or the other with the – result, is to follow. A natural model of a measurement with two possible continuations consists of two possible histories that share a common initial segment containing the measurement event, but differ in their future parts, as one contains the + result, and the other the – result. A history is identified with a space-time taken together with an assignment of states to all its regions. Thus, branching histories are built upon branching space-times. Accordingly, the question comes to the fore of what exactly the shape of a

shared segment of two space-times is. With respect to this, we draw a distinction between choice points, i.e., point-like chancy events responsible for a separation of histories, and surfaces of divergence, along which the separation propagates globally. As an illustration, consider a point-like particle hitting a translucent medium, with two possible outcomes of it: the particle being transmitted or the particle being reflected. We take two Minkowski space-times, stipulate that a point in one and a point in the other represent the coordinates of our choice point, and then paste the two space-times at these two points and ‘below’ them, while keeping the space-times separate ‘above’ them. Following the argument of Belnap (1992, 411–414), we take it that the shared region consists of the backward light cone of a choice point and the wings, i.e., the totality of points space-like separated from the choice point. Importantly, if we allow for more than a single choice point, the resulting surface of divergence will be more complicated (see Placek (2000b), yet, it will still guarantee that the relations ‘lying on (below or above) a surface of divergence’ are Lorentz-invariant.

Next, an event is defined as a region of a space-time that is bounded from above and has a state assigned. Each event has outcomes, i.e., possible continuations of it, and the family of outcomes of an event forms a Boolean algebra. This fact permits one to assign Komogorovian probabilities to outcomes of an event. Given that some other constraints are fulfilled, we interpret these probabilities ontologically, i.e., as weights of objective possibilities (chances).

Finally, a SOBST model has an attrition function, which represents the idea that actualisation of one outcome of an event makes other outcomes of this event no longer possible. We call this ‘attrition’ since the fact that some outcomes become no longer possible means that some possible histories cease to be possible, i.e., they undergo attrition.

3. Branching vs. divergence

I sketched above a branching framework whose two essential elements are outcomes of events and attrition of non-actualised outcomes, from which attrition of histories follows. Now we can turn to interpretational issues, and in particular, to the investigation of Lewis’ objections to branching.

To begin with, observe that a SOBST model usually has a number of histories, which raises the question of whether all these histories are believed to be real? To answer this, take a note that SOBST offers a technique of deciding whether a given stochastic experiment allows a deterministic description. If it does, then the experiment has a deterministic model, i.e., one that contains a single history only. Thus, the question of reality of histories is troublesome only if we have a model that cannot be extended to a deterministic one. In such cases we may indeed say that SOBST is committed to many histories. However, since the other side of proliferating branching histories is the attrition of those branches of histories that have not been actualised, it is still better to say that SOBST is committed to the vision of an open future, according to

which an event, though perhaps not every event, has more than one alternative outcomes. In other words, there may be many alternative future possibilities of an event, and this we may express by saying that there are many alternative *possible* futures. Yet, as time passes, at most one atomic outcome of an event becomes actualised, which agrees with our intuition that the event has exactly one *real* future, and that we have exactly one real future. Yet the question of why from among our many possible futures, this one rather than some other one becomes real, is not something that can be answered, at least if indeterminism is true.

Now, openness of the future is temporal, that is, an outcome of an event that might have been actualised once this event occurred, but did not, is no longer possible. How is this represented in SOBST? The answer is that the degree of openness of the future depends on time, that is, once a given outcome of some event is actualised, the actualisation of any of its alternative outcomes is no more possible. This idea is captured in the concepts of the branching of histories and the attrition of those branches that have not been actualised—see Placek (2000b). To represent an open future, histories are assumed to branch along surfaces of divergence. As time passes, those branches that are not actualised are erased.

At this point one may ask how attrition of branches propagates in space-times, or, in other words, what the surface is along which attrition occurs? Yet, it is exactly the same surface along which histories branch and along which all but one branch are erased. In the special case of a single choice point of Minkowski space-times, histories branch and undergo attrition along the future light cone of this point, but in general surfaces of divergence and attrition are more complicated. Note also that there is no twilight zone between a still possible history and an already impossible history: attrition is razor sharp.

Branching is an alternative to the much more popular Lewisian view of possible worlds that diverge but do not branch. The difference is that branching histories do overlap, which means that they have a common initial segment, whereas Lewis' divergent worlds are analysed in terms of duplication. Duplicates are separate, that is, non-overlapping, objects that agree with respect to natural properties and relations. Two worlds are then said to diverge iff they are not duplicates but an initial segment of one world and an initial segment of the other are duplicates (Lewis, 1983, 359).

It is commonly believed that Lewis showed that branching is problematic in a way that diverging worlds are not. Lewis' objections are related to the task of representing the semantics of modal discourse in models with branching, and we have not built a SOBST semantics for modal (and temporal) discourse yet. Thus, whatever I say on this topic is still tentative.

Lewis' first argument against branching concerns individuation, so I need to say what individuals are in the SOBST framework. SOBST models do not distinguish between natural and artificially carved individuals, and hence an individual is just a part of a history, that is, an event. An individual is

thus contained in many histories, in general. To illustrate, Gottlob Frege, in his spatiotemporal entirety and as he really was, belongs to many histories that have branched or will branch after his death, *viz.* histories that have not yet been erased. However, only one of these histories will ultimately survive the process of the attrition of branches—this is the real history. Further, to accommodate for the intuition that Frege could have been different, we postulate that some possible histories split in Frege’s lifetime, and that each of these histories contained some initial segment of the real Frege. As Frege is long deceased, all but one of the branches that split ‘in’ Frege were erased. But, significantly, the histories that split in real Frege’s lifetime contained, strictly speaking, different individuals (events), their common feature being that they shared some initial segment of the real Frege. This should answer the first argument of Lewis (1986, 199), the hero of which, though, is Hubert Humphrey and not Gottlob Frege:

He could have had six fingers on his left hand. There is some other world that so represents him. We are supposing now that representation *de re* works by trans-world identity. So, Humphrey, who is a part of this world and here has five fingers on the left hand, is also a part of some other world and there has six fingers on his left hand. *Qua* part of this world he has five fingers, *qua* part of that world he has six. He himself [. . .] has five fingers on the left hand, and has not five, but six. How can this be?

To reply, we need to distinguish two ways of understanding someone’s saying that Humphrey could have had six fingers on his left hand. First, someone can say this without believing that there was once a time at which it was indeterminate and chancy whether or not Humphrey would grow a sixth finger on his left hand. One asserts the statement on the basis of there being some human individuals, e.g., Ann Boleyn, who had six fingers on one hand, which is taken as the evidence that Humphrey’s having six fingers on his left hand would not contravene laws of nature. This kind of possibility is what in branching frameworks is called *conceivability*. And, if Humphrey’s having six fingers on the left hand is understood as a merely conceivable state of affairs, we are not in any conflict with Lewis’ framework since to account for conceivability, SOBST assumes real Humphrey and his counterparts in alternative histories, none of them overlapping with another. On the other hand, the statement could mean that as a matter of fact, there was once a possibility that Humphrey should grow six fingers on his left hand—this is called a *possibility based on reality*.² In this case, to think that Humphrey could have had six fingers on his left hand is to think that at some earlier stage of his life, say, in his stage *S* before Jan. 1, 1913,³ the sixth finger could have grown on the left hand of that stage of Humphrey’s. To represent this, one builds a model with one event, Humphrey in stage *S*, that is shared by at least two histories, which split immediately above this event. The two histories contain different continuations of Humphrey in stage *S*, one continuation with five fingers on

the left hand, and the other with six fingers on the left hand. Accordingly, one history has the individual (event) with five fingers on his left hand in his after-stage S life and the other history has the individual (event) with six fingers on his left hand in his after-stage S life. Thus, the two contradicting properties, of having five fingers and having six fingers on the left hand, refer to two different individuals that share some initial segment, and only one of them is in a history that has not been erased. Hence, no contradiction ensues. Of course, this is only a sketch of a full reply, since we need to be precise as to what the continuations are; otherwise your reading this paper is a continuation of Humphrey at stage S as well. Yet, even without elaborating any further on this problem, I believe, the answer suffices to disarm Lewis' objection.

One may nevertheless say that the problem resurfaces once we consider Humphrey before stage S , say pre- S -Humphrey. It appears that pre- S -Humphrey has five fingers on his left hand *qua* being in one history and has six fingers on his left hand *qua* being in another history. However, this conclusion follows in a non-tensed picture of language, where we consider sentences like 'Pre- S -Humphrey, who finishes on Jan. 1, 1913, has five fingers on his left hand on Oct. 1, 1969'. SOBST is not committed to non-tensed semantics, but, on the contrary, naturally suggests tensed semantics. So, in accord with our everyday way of speaking, from the fact that 'Humphrey could have had six fingers on his left hand' is represented by there once being a continuation of pre- S -Humphrey with six fingers on his left hand, it does not follow that pre- S -Humphrey had six fingers on his left hand.

Lewis' second worry concerns the demarcation of worlds—see Lewis (1983, 360):

[O]verlap of worlds interferes with the most salient principle of demarcation for worlds, *viz.* that two possible individuals are part of the same world iff they are linked by some chain of external relations, *e.g.* of spatiotemporal relations.

There is an easy answer to this in the SOBST framework. The crucial relation of SOBST models is that of two space-time points being orthogonal relative to an event, written $x \perp_E y$ and interpreted as saying that x and y belong to different histories that split in event E , and hence x and y cannot be causally connected. This trivially yields this special demarcation principle: two point-like individuals x and y are part of the same world iff (1) for any event E , it is not the case that $x \perp_E y$ and (2) there is a z such that $z \leq x$ and $z \leq y$. Clause (1) appears to incorporate the intuition that Lewis voices. Clause (2) is rather technical, and is needed to account for histories that do not have any segment in common. The principle easily extends to other individuals.

The final, and I think most serious, of Lewis' arguments against branching concerns the meaning of the future:

[A]n inhabitant of the shared segment cannot speak unequivocally of *the* world he lives in. What if he says there will be a sea

fight tomorrow, meaning of course to speak of the future of his own world, and one of the two worlds he lives in has a sea fight the next day and the other does not? (Lewis, 1983, 359–360).

Supposedly the branching theorist is in for trouble with the phrase ‘the future of . . . ’. Grammatically, it looks like a definite description, and this standardly involves two things: there should be exactly one object that is the future of . . . (call this the uniqueness condition), and the property of *being the future of . . .* should suffice to pick out this single object (dub this the sufficiency condition). In branching models, there is no problem with uniqueness, since there is exactly one real history, and hence anything real has exactly one real future. But sufficiency appears to be a problem: if indeterminism is the case, no matter how much we extend the phrase ‘the future of . . . ’ and how well we understand it, we will not be able to say what this future is. Moreover, if there is no end to the world, no one will ever be able to do so. Metaphorically, even God, whose predictive capacities are limited by indeterminism, cannot do so. Yet, in my view, it is a mistake to take ‘the future of . . . ’ as a description.

Lewis (1986, 207) considers three ways of understanding this phrase:

If there are two futures, and both are equally mine with nothing to choose between them, and one holds a sea fight and the other doesn’t, what could it mean for me to say that *the* future holds a sea fight? Not a rhetorical question: we have three options. (1) It is false that the future holds a sea fight; because ‘the future’ is a denotationless improper description. (2) It is true that the future holds a sea fight; because ‘the future’ denotes neither of the two partial futures but rather their disunited sum, which does hold a sea fight. (3) It is neither true nor false that the future holds a sea fight; because ‘the future’ has indeterminate denotation, and we get different truth values on different resolutions of the indeterminacy.

But, as Lewis shows, none of these three options is tenable.

‘The future holds a battle’ is not a sentence you will normally hear. It is a transcription in a non-tensed language of usual tensed sentences like ‘There *will* be a battle in the future’, or ‘There *will* be a battle tomorrow’, or ‘There *will* be a battle next year’. SOBST, by supporting a tensed semantics, does not take Lewis’ sentence to be an adequate transcription of any of the tensed sentences exemplified above. It moreover regards ‘The future holds a battle’ as a theoretical construct of non-tensed semantics. Thus, it takes as a task the explication of the functioning of sentences in future tense rather than Lewis’ ‘The future holds a battle’. Moreover, taking the differences between the tenses as fundamental, there is little incentive to believe that the explication of the discourse in future tense should be similar to the explication of discourses in other tenses. In particular, since the assertion of ‘There will be a battle tomorrow’ can mean as different things as my conviction that a battle

tomorrow is highly probable, or my intention to wage a battle tomorrow, or the fact that the battle is necessary, given the present state of affairs, some notions from pragmatics are needed to account for assertions of sentences in future tense, apart from a notion of truth.

Nevertheless, the basic concept needed for a SOBST account of tensed discourse is that of outcomes of an event containing an act of assertion of a tensed sentence, with words like ‘tomorrow’, ‘next year’, or ‘future’ indicating how large a part of an outcome is meant. Thus, I reject Lewis’ question of what ‘the future’ or ‘tomorrow’ stands for, by saying that on their own these words are not referring expressions. Another notion needed is that of attrition, as with this we have the notion of a once, but no longer, possible event, and the notion of the real history. Then one sense of a person’s assertion ‘There will be a battle tomorrow’ has this explanation: in an outcome of some specified event containing the act of assertion in question, there is an event of battle that is located in some specific part of this outcome, and moreover, this event belongs to the history that is not erased.

On this translation, the question of whether ‘tomorrow’ refers to a part of some single outcome, or to parts of many outcomes, is answered by saying that on its own ‘tomorrow’ does not refer. However, ‘tomorrow’s battle’ as uttered in this mode of speaking, refers to an event that is (1) some specific part of an outcome of the event of asserting the sentence and (2) this part of this outcome belongs to the history that is not erased.

To make this analysis precise, we need, however, to first erect a semantics of tensed discourse on the SOBST framework. Since we do not have it yet, what I said above is merely a sketch of answer to Lewis’ objections to branching. Yet, I believe that even at this preliminary stage it can be seen that Lewis fails to show that branching, SOBST style, is more problematic than diverging possible worlds. And, since SOBST is mathematically more precise, has nice mathematical properties, and is applicable to experimental data, it is preferable, I believe, to Lewis’ framework of diverging possible worlds.

Notes

* This paper heavily draws on Chapter 8 of my book *Is Nature Deterministic?*, Jagiellonian University Press, Cracow 2000. Author’s address: Department of Philosophy, Jagiellonian University, Grodzka 52, PL 31-044 Cracow, Poland, *e-mail*: uzplacek@cyf-kr.edu.pl.

¹ In branching framework, the distinction between relative possibility and possibility *simpliciter* is modelled by the distinction between *possibility based on reality* and *conceivability*—see e.g. Xu (1997).

² The distinction comes from Xu (1997).

³ Hubert Horatio Humphrey, Vice-President of the United States under Lyndon Johnson (1965–69), lived from 1911 to 1975.

References

- Belnap, Nuel (1992): “Branching space-time”, *Synthese* 92, 385–434.
- Kowalski, Tomasz and Placek, Tomasz (1999): “Outcomes in branching space-time and GHZ-Bell theorems”, *British Journal for the Philosophy of Science* 50, 349–375.
- Lewis, David (1983): “New Work for a Theory of Universals”, *Australasian Journal of Philosophy* 61, 343–377.
- (1986): *On the Plurality of Worlds*, Oxford: Basil Blackwell.
- Müller, Thomas and Placek, Tomasz (2001): “Against a Minimalist Reading of Bell’s Theorem: Lessons from Fine”, *Synthese* 128, 343–379.
- Placek, Tomasz (2000a): “Stochastic outcomes in branching space-time: Analysis of Bell’s theorem”, *British Journal for the Philosophy of Science* 51 (3), 445–475.
- (2000b): *Is Nature Deterministic? A Branching Perspective on EPR Phenomena*, Cracow: Jagiellonian University Press.
- Xu, Ming (1997). “Causation in Branching Time: Transitions, Events, and Causes”, *Synthese* 112, 137–192.