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and Philosophy of Science

Alessio Santelli *Editor*

# Ockhamism and Philosophy of Time

Semantic and Metaphysical Issues  
Concerning Future Contingents



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Editor

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# Preface

The present volume aims to critically assess *Ockhamism*, a theory according to which future contingents are true or false, without being neither determinately true nor determinately false. Ockhamism so understood is opposed to *Aristotelianism* – a theory that goes back at least to Aristotle – according to which, in order to secure the contingency of the future, future contingents must be deemed neither true nor false. Over the past few years, Ockhamism has received significant attention among scholars. This has generated an intensive debate whose primary interest was to explore Ockhamism’s semantic and metaphysical implications. This volume intends to introduce the reader to such a debate, and also to investigate several important issues that are still in need of further articulation and clarification.

Almost all the chapters it contains were presented at “Ockhamism and Philosophy of Time,” an international workshop funded by the project “Dipartimento di Eccellenza 2018/2022 – Arti, Linguaggi e Media: tradurre e transcodificare,” and held in the Department of Human Studies at the University of L’Aquila in September 2018. My hope is that they will contribute to push forward and further clarify the complex and lively debate about Ockhamism, especially in relation to the semantic and metaphysical issues concerning one of the central topics of philosophy, namely that of future contingency. For this, I would like to thank the authors for their insightful and invaluable papers, the reviewers for their precious work, and the editors of Springer for their patience. Many thanks to Simone Gozzano for supporting this project from the beginning, and to Giorgio Mazzullo who read a previous version of my article and contributed to amending many mistakes. A special thank you goes to Andrea Iacona for his generous advice and helpful conversations during this last year of work. Last but not least, I would like to thank Giorgio Lando who helped me to organize the workshop. His precious suggestions, without a doubt, spared me a lot of unnecessary work.

L’Aquila, Italy

Alessio Santelli

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## About the Editor

**Alessio Santelli** Completed his PhD at Ca' Foscari, University of Venice. He carried out research activities at LOGOS, University of Barcelona (UB), and at the University of L'Aquila. His main interests are in semantics, temporal logic, and in philosophy of time, with a particular focus on the problem of future contingents.

# Chapter 1

## From William of Ockham to Contemporary Ockhamism and Back Again: An Overview



Alessio Santelli

**Abstract** Ockhamism’s main tenet is that future contingents are either true or false, even if they are neither determinately true nor determinately false. It is inspired by some ideas of William of Ockham, and in particular by his solution to the problem of future contingents. In the modern branching time setting, Ockhamism is frequently associated with the so-called *Thin Red Line*, a view according to which among the many possible futures only one is the *actual* future – namely, the one that will be realized. Despite its apparent simplicity, however, there is still no unanimous consent between scholars on just how to make sense of Ockhamism. This paper illustrates some fundamental features of Ockhamism and describes its semantic and metaphysical implications within the debate on future contingents.

According to a line of thought that goes back to Arthur Prior (1967) – who, in turn, developed a suggestion received from Saul Kripke in a letter dated September 3, 1958 (see Ploug & Øhrstrøm, 2011) – the best way to make sense of indeterminism consists in representing temporal reality as having a tree-like structure in which the “trunk” represents the past, understood as unchangeable or fixed, while the multiple “branches” are meant to account for the alternative ways in which the universe may evolve from a given moment (i.e., the present). The universe, following this metaphor, will be indeterministic if there exists more than one branch in the tree of possibilities. Not surprisingly, this way of modeling indeterminism has become known as “branching time” – where the core conjecture is that indeterminism entails branching.

The tree model, among other things, has been extensively adopted in order to capture our pre-theoretic thought that the future, unlike the past, is *open*. The leading idea was that the future is *genuinely* – i.e., objectively or ontologically, as opposed to epistemically – open if there are branches on which, say, tomorrow a sea-battle will occur and others on which it won’t – and no branch can be privileged over the

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others. What this usually means is that if we were to posit such a privileged branch, then time would be linear, and hence the future would be as *closed* as the past. As some advocates of branching in fact are fond of putting it, “branching rules out actuality”, that is, the possibility of picking out one particular future as the *actual* future, namely the one containing the course of events that will be realized. The future in question is what Belnap and Green (1994) has called the *Thin Red Line*.

Even though the tree model has triggered valuable research both in logic and philosophy, over the past few years some scholars began questioning its apparent attractiveness. In particular, Andrea Iacona and Fabrice Correia – among the many who took part in the *Language and Temporality* workshop held in L’Aquila (Italy), in September 2009 – felt the need to reassess the role of the tree model in order to deal with some important issues, both semantic and metaphysical, that such a model, on their view, has left unsettled. That need, more shared than expected, later grew into a volume entitled *Around the Tree* (2013), also edited by Springer, in which the authors gathered prominent contributions from different philosophical backgrounds aimed mainly at provoking a substantive discussion about the tree model and its possible alternatives, as well as at providing additional insights on central topics often connected with it.

In this respect, the present volume intends to further develop Iacona and Correia’s project. Indeed, its main purpose is to introduce and critically assess *Ockhamism*, namely the theory that in *Around the Tree* has repeatedly emerged as one of the main alternatives to the view, already mentioned, that positing a Thin Red Line forces us to give up objective indeterminism. To this end, it also brings together established scholars in the fields of metaphysics of time, semantics and temporal logic, history of medieval philosophy, and philosophy of physics, all linked by the common goal of clarifying the nature of the Ockhamism, its historical roots, and the role it plays in the current debate on future contingents.<sup>1</sup>

The problem of future contingents, as is well known, is the problem of how to assign a definite truth value to sentences regarding events whose occurrence is not inevitable. Traditionally, its first formulation dates back to Aristotle who, in the famous *De Interpretatione IX*, seems to claim that bivalence entails fatalism, the metaphysical doctrine according to which everything that happens, happens with necessity (where “necessity” here stands for “historical necessity”, that is, necessity with respect to our past and present). Aristotle’s conviction is that, since fatalism has the unacceptable consequence of denying human freedom, it must be concluded that the only way to secure the contingency of the future consists in rejecting the

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<sup>1</sup> It is important to understand that it is beyond the scope of both the present work and the volume to explore in detail issues such as the nature of (in)determinism, fatalism or the openness of the future, and how these notions are connected with one another. Although they are all relevant issues, I believe that they are related to contemporary Ockhamism only generically, and also that a proper discussion of their connection would very likely require us to write another volume.

validity of bivalence. On his view, then, at least some sentences regarding future contingent events are to be deemed neither true nor false.<sup>2</sup>

Ockhamism, on the contrary, proposes a solution to this puzzle that is diametrically opposed to that of Aristotle, in that it assumes that future contingents can indeed be either true or false, even though neither determinately true nor determinately false. More specifically, Ockhamism's way out from Aristotle's dilemma consists in driving a wedge between truth and determinate truth (at least if the latter is defined, as is often the case, as truth in all possible futures). The distinction between truth and determinate truth mimics the distinction between actuality and necessity: a future contingent can be true if it is true in the actual future without being determinately true. In this way, Ockhamism is able to resist Aristotle's line of reasoning according to which the present truth of future contingents entails that the future is necessary.

Ockhamism, as a semantic theory, was first introduced by Prior (1967), and further clarified by R. Thomason (1970). It is inspired by some ideas of William of Ockham (1285–1347), who, in his *Tractatus de praedestinatione et de praescientia Dei respectu futurorum contingentium*, argued that it is possible to reconcile, without contradiction, Divine Foreknowledge and human freedom. In particular, Ockham claimed that God knows in advance the truth of all future contingents, while at the same time maintaining that we, *qua* human beings, are free to choose between alternative (future) possibilities (see Øhrstrøm, 1984). For example, although God knew in advance that Peter would disown Him three times before the rooster crows, it was nonetheless true, according to Ockham, that Peter could have refrained from doing what God predicted. The fact that Peter disowned Him, in other terms, does not mean that Peter could not have done otherwise. The theological and philosophical lesson that one could learn from Ockham's solution is therefore that God's knowledge of what will happen does not make the future inevitable (and our actions causally inefficacious). More specifically, Ockham believed that the truth of each future contingent is known to God since it depends on what will happen in the "true" future (*de vero futuro*, in Ockham's mouth), namely the future part of the actual course of events.<sup>3</sup>

Despite its simplicity, however, it should be stressed that there is no general consensus among experts on just how to make sense of Ockhamism. In the modern branching time setting, the term "Ockhamism" has been indeed used in so many ways that one may even begin to lose track of what really lies behind that term (see

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<sup>2</sup> Aristotle's view has been endorsed by many philosophers and logicians. The three contemporary and most influential accounts that follow Aristotle in dropping bivalence are Thomason's *Supervaluationism* (1970), Belnap et al.'s *Double-time reference semantics* (2001), and MacFarlane's *Relativist Post-semantics* (2003). Another theory in line with Aristotle's solution is Łukasiewicz's *three-valued logic* (1920) even though its approach differs in some important aspects from the three theories just mentioned.

<sup>3</sup> Note that, as Øhrstrøm (1984, 2009) has pointed out, it seems that some of the conceptual elements of Ockham's solution were already present in the reflections of Anselm of Canterbury (1033–1109) on the same topic.

Wawer & Malpass, 2018). Of course this is not to say that the task of detecting a suitable definition of Ockhamism is doomed from the start. Rather, it suggests (perhaps less radically) that the contemporary discussion on future contingents has reached a level of complexity that needs to be not only acknowledged, but also critically re-examined – and this volume intends specifically to be at the service of such an endeavour.

Starting in particular with Prior’s seminal work on temporal logic *Past, Present and Future* (1967, Chap. 7), Ockhamism has been used to indicate a formal apparatus whose essential feature is that each future-tensed sentence, due to indeterminism, must always be evaluated with respect to a pair of parameters: a moment,  $m$ , and a history,  $h$ , passing through  $m$ , thus suggesting that the notion of truth proposed by Prior’s Ockhamism should be characterized as *history-dependent* – in the sense that what is true not only depends on the moment in which the sentence is uttered, but also on the history selected as the value of the history parameter. Quite recently, Ockhamism has been also defined as the straightforward semantic thesis that all future contingents are either true or false, or that there simply are true future contingents, without any reference to the actual history as a formal feature of the model (see Iacona, 2014; Rosenkranz, 2012). Interestingly, one may accept the former definition, without assuming the latter. One of the most vivid examples along these lines is surely Nuel Belnap who convincingly adheres to Prior’s Ockhamism, while remaining hostile to the idea that future contingents can have a truth value (see Belnap et al., 2001). However, as Peter Øhrstrøm has pointed out, Ockham was very likely not an Ockhamist in Prior’s sense of the word insofar as Prior’s Ockhamism does not include a formal representation of Ockham’s most important notion, namely the actual future (see Øhrstrøm, 2009, 2014).

In light of this, one may ask what exactly makes Prior’s Ockhamism an Ockham-inspired semantics. As is commonly assumed, there are two main reasons. The first is that Prior’s Ockhamism validates, among others, a semantical principle known as *principle of retrogradation of truth*.<sup>4</sup> This principle, which should be accepted without restriction according to the historical Ockham, states that if it is now true that  $p$ , then it was true in the past that it would have been the case that  $p$ . In compositional semantics, this means that if  $p$  is true at a moment  $m$ , then  $Fp$  is true at every moment  $m'$  earlier than  $m$ . For instance, if there is a sea-battle today, then it is natural to believe that it was also true that “there will be a sea-battle tomorrow” was the case yesterday.

The second reason is that, following Ockham in “flesh and bones”, Prior’s Ockhamist semantics rejects the general validity of the so-called *principle of the necessity of the past*.<sup>5</sup> Intuitively, this principle affirms that what happened in the

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<sup>4</sup> In terms of Prior’s formal language this principle can be expressed as  $p \supset H F p$  where  $H$  and  $F$  are the usual temporal operators that, respectively, stand for “It has always been the case that” and “it will be the case that”.

<sup>5</sup> In symbols:  $Pq \supset \Box Pq$ , where “ $\Box$ ” stands for the (historical) necessity, operator while  $P$  stands for the temporal operator “It was the case that”.

past cannot be undone, that is, that the past cannot now be changed. Therefore, if it is now true that there was a sea-battle yesterday, any attempt to alter this fact today is bound to fail. In more technical terms, this means that past tensed truths are *ipso facto* necessary truths. However, according to Ockham not every past truth is necessary in this sense. In fact, there seem to be past truths that only apparently are about the past. Such truths are somehow peculiar because, although they feature in sentences that are verbally in present and past tense, they are metaphysically about the (contingent) future. This is how Ockham states it:

Some propositions are about the present as regards both their wording and their subject matter (*secundum vocem* and *secundum rem*). Where such [propositions] are concerned, it is universally true that every true proposition about the present has [corresponding to it] a necessary one about the past... Other propositions are about the present as regards to their wording only and are equivalently about the future, since their truth depends on the truth of propositions about the future. (*Tractatus*, 46–7)

Thus, according to Ockham there seem to be past-tensed sentences whose truth is not grounded on what happened in the past, but in events that are in the future and are, as such, still unsettled.<sup>6</sup> One possible example of a past-tensed sentence whose truth seems to depend on future events is as follows:

(1) This was my last five-a-side football game

uttered by me, let us imagine, after my umpteenth ankle injury suffered on the playing field. If (1) is true, I will not play five-a-side anymore. More precisely, if (1) were a true past-tensed sentence, then it would follow that I will not necessarily play five-a-side in the future (since past truths are also necessary truths). However, that does not seem to be the case. After all, although it is an open possibility that I will not play five-a-side anymore, it does not seem inevitable that I will not, in that the truth of (1) seems to depend on what I will choose at a later time. In other terms, past-tensed sentences like (1) are, on Ockham's view, exactly those kinds of sentences that are metaphysically about the (open) future – they manifest what Prior (1967, Chap. 7) has called a “trace of futurity” – and must be for this reason considered contingent.<sup>7</sup>

Ockhamism, as we have noted, can also be associated with the view that, among the many possible branches that depart from the same trunk, only one is “our” branch – i.e., the unique course of events that is actually going to happen. This suggests that the branching representation of temporal reality – at least according to those who share this view – would be defective without an explicit representation of the actual branch. All the theories that make a reference to the notion of a distinguished future within the tree model have been called *Thin Red Line* theories by Belnap and Green (1994) and Belnap et al. (2001).

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<sup>6</sup> Note that what Ockham means by “propositions” in the above passage is analogous to what we now mean by “sentences”, so there is no need to be too picky on this point.

<sup>7</sup> See De Florio and Frigerio (2019), chapter 4, for an insightful analysis of the metaphysical consequences of Ockham's rejection of the necessity of the past.

Although Prior was rather critical towards the idea of an actual future on the basis of its alleged inability to comply with indeterminism, many philosophers and logicians after him have pursued the thought that in order to account for Ockham's original doctrine, hence to be faithful to the historical Ockham, the tree model would have to include a formal representation of the actual future (see McKim & Davis, 1976; Øhrstrøm, 1981, 2009; Brauner et al., 1998; Malpass & Wawer, 2012). The reason, however, was not only metaphysical but rather semantic. In fact, all these esteemed scholars – call them TRL-theorists – agreed that the Priorian semantics, according to which the truth of a future contingent at a moment is always relative to the histories passing through that moment, was not entirely satisfactory in that it would make the evaluation of future-tensed sentences somewhat arbitrary. However, the truth-value of a given future contingent is arguably not arbitrary in the way Prior's Ockhamism suggested since, as TRL-theorists have insisted, it is ultimately grounded on what happens in the future part of the actual course of events. For this reason, TRL-theorists maintain that each future contingent must be deemed either true or false only relatively to a moment, and their truth-value will have to depend exclusively on what the future will bring.<sup>8</sup>

Since its first appearance, the notion of the actual future has generated a considerable number of semantic and metaphysical objections. For what concerns metaphysics, the main criticism was that its very existence is hardly compatible with indeterminism, and in particular with the view that many futures are equally possible. After all, it might be contented, if we take for granted that among the many possible futures only one will be actualized, how can the other futures be *real* alternatives? How, in other terms, can our future be *genuinely* open? (See MacFarlane, 2003, 2014). As for the semantic objections, it has been argued that any tree model equipped with a TRL (TRL-models) is forced to deny well-established logical principles, and is also unable to assign the expected truth value to counterfactual predictions, thus making our counterfactual reasoning about the future utterly inaccurate (see Thomason 1970; Belnap & Green, 1994; Belnap et al., 2001).

In order to avoid these difficulties, most proponents of TRL modified in depth their original theory. This gave rise to different versions of the TRL semantics which, however, do not seem to be in line with the doctrine originally advocated by Ockham. In view of this, many attempts have been made to fix all the formal objections advanced against TRL-models, and the debate between the friends and enemies of TRL is perhaps more alive today than ever in the past. Be that as it may, a detailed description of such important debate would go far beyond the scope of this paper. Rather, its main concern was to provide a general overview of the complex issues concerning Ockhamism understood as a viable solution to the problem of

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<sup>8</sup> It is important to note that Prior himself was not entirely convinced by his relativist approach, since he called the branch-dependent ascription of truth value “*prima facie*” (1967, p. 126). It is also very interesting that in some of his papers in the mid-60s, in order to respect Ockham's own view on future contingency, Prior briefly considered (and rejected) what he called “the single designated route” which seems to correspond to the actual future. See Øhrstrøm (2014) for a discussion.

future contingents (see Wawer, 2014 and Wawer & Malpass, 2018 for a critical exposition of the various TRL-semantics).

The present volume continues with Cecilia Trifogli's paper "Ockham on Time" in which she offers a detailed and insightful description of William of Ockham's doctrine of time and motion. Ockham's view is critically assessed in its ontological and methodological assumptions and compared both with the standard Aristotelian doctrine and the overall Medieval debate. Peter Øhrstrøm and David Jacobsen's article "Ockhamistic Inspirations in Modern Tense-Logic" instead provides a thorough explanation of how Ockham's doctrine of future contingents, and in particular the notion of the actual future, along with his argument against the necessity of the future, were a fundamental source of inspiration for Arthur Prior, unanimously recognized as the founding father of modern tense logic.

In "Ockhamism Without Molinism" Jacek Wawer goes at the heart of the formal objections mounted against TRL semantics. Contrary to a widely held assumption, he claims that in order to interpret future tense in non-actual circumstances there is no reason to strengthen Ockhamism by endorsing Molinism – a theory introduced by Luis de Molina (1535–1600) according to which some counterfactual future contingents are true. To motivate his claim, Wawer presents his own semantic view (Non-Molinist Ockhamism) and shows how to formally model counterfactual contingents without abandoning the original Ockhamist set-up.

In "Future Contingents in a Branching Universe" Mitchell Green addresses the so-called *Assertion Problem*, namely the issue of how to assert future-tensed statements in the face of indeterminism. After having described and contrasted the Thin Red Line (TRL) approach and the Open Future approach (OF), the author puts forward his own approach according to which future contingents can have determinate truth conditions at the moment of utterance (and therefore express a determinate content), although they lack a determinate truth value at that very moment. In addition, Green shows that even if we assume the "knowledge norm" as the norm of assertion, we are not forced to accept a reading on which assertions of future contingents must violate it on OF.

In their paper "A Too Thin True Future: The Problem of Grounding within presentist TRL semantics", Ciro De Florio and Aldo Frigerio compare TRL semantics with two opposed metaphysics of time, that is, Presentism and Eternalism, and offer a very detailed line of reasoning purporting to show that, no matter how TRL semantics is defined, Presentism can in no way be associated with it. The upshot is thus that TRL semantics is viable only within an eternalist framework.

In "Presentism, Ockhamism and Truth-Grounding", Sven Rosenkranz and Fabrice Correia deal instead with the so-called Grounding Problem for Presentism – very roughly, the problem of how to account for past truths if, according to Presentism, only present entities exist. After reviewing some of the most recent options advanced to solve the problem, and finding them wanting, the author proposes their own solution which they call "Revolutionary view". Interestingly, the authors claim that such a view can be profitably endorsed by Ockhamists when it comes to the task of grounding (contingent) truths about the future. In "The Metaphysics of Ockhamism", Andrea Iacona points out that – contrary to what

is usually presumed – there is no necessary connection between Ockhamism and the Thin Red Line. He also observes that Ockhamism is both consistent with four different ontologies of time, and neutral with respect to the distinction between branching and divergence, and finally shows how each of the theory considered is able to account for the claim that the future is open, at least on some plausible interpretation of that claim.

Finally, in their paper “The Metaphysics of Passage in Dynamical Reduction Models of Quantum Mechanics” Giuliano Torrenço and Cristian Mariani argue that it is possible to exploit an Ockhamist approach on the nature of indeterminacy in order to secure a realist account of temporal becoming within a specific interpretation of Quantum Mechanics, the so-called “Dynamical Reduction Models” (DMR).

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## Chapter 2

# Ockham on Time



Cecilia Trifogli

**Abstract** William Ockham is a reductionist about time. He maintains that time somehow exists but is not a basic thing in his ontology. In this paper I present the specific nature of Ockham's reductionism, setting it in its relevant medieval context. The main ingredient of this context is the issue of the distinction between permanent and successive things. Permanent things are those the parts of which can all exist at the same time, whereas successive things are those the parts of which can only exist one after another in time. Time, together with change, is classified as a successive thing. What is matter of debate is the ontological status of successive things. Medieval realists (for example, Walter Burley, Ockham's fiercest enemy) maintain that successive things are distinct from and not reducible to permanent things. Some of them also argue that change and time are two distinct and irreducible successive things. Ockham denies both the claim that successive things are distinct from permanent things and the claim that change and time are two distinct (successive) things. In his view, both change and time are reducible to permanent things and to the same set of permanent things, so that there is not a mind-independent distinction between change and time. In this paper I first explain the notions of permanent and successive things. I then present the two main lines of attack of Ockham against successive things. I finally focus on his reductionism of time and change to permanent things.

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## 2.1 Introduction

William Ockham<sup>1</sup> is a reductionist about time.<sup>2</sup> He maintains that time somehow exists but is not a basic thing in his ontology. The basic things in Ockham's ontology are particular substances and particular qualities: standard medieval examples are Socrates and his whiteness respectively. Therefore, since time somehow exists, its existence should be reduced to that of particular substances and particular qualities, and accounted for in terms of these basic things. Thus, Ockham's position about the ontological status of time consists of two main theses: (i) time is not a basic thing in the ontology, that is, neither a particular substance nor a particular quality; (ii) time is reducible to the basic things.

This concise presentation of Ockham's position is one resulting from a comprehensive view of his treatment of a large variety of highly controversial ontological issues (including universals and the status of Aristotle's categories), but does not correspond to the nature of the discussions that he specifically devotes to the ontological status of time. When he deals with time, Ockham does not offer any substantial argument in support of the negative thesis (i). He takes it as established in other sections of his works that the only basic things are particular substances and particular qualities, and takes it as evident that time is not a particular substance or a particular quality. As to the reductionist thesis (ii), Ockham does not explicitly argue for the ontological reduction of time to particular substances and qualities. Rather he argues for the reduction of time to the so-called permanent things. Since particular substances and particular qualities are permanent things, the reduction of time to permanent things that Ockham argues for can be regarded as an intermediate step in his overall reductionist program: so that the first step of such program consists in reducing time to permanent things, and the second step consists in reducing permanent things to particular substances and qualities. This second step, however, does not concern us here, since it contains nothing specifically about time. The focus of this paper is on the first step: Ockham's reductionism of time to permanent things.<sup>3</sup>

Ockham's own approach and its emphasis on the reduction of time to permanent things reflect the way in which the question about the ontological status of time was addressed at his times. In the medieval context, permanent things are contrasted with successive things. The distinction between permanent and successive things is the fundamental feature of the medieval debate about the ontological status of time and of change too. Realists about time and change maintain that there are successive

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<sup>1</sup> On Ockham's life and works, see Courtenay (1999).

<sup>2</sup> For a comprehensive presentation of Ockham's discussion about time (and change), see McCord Adams (1987), vol. 2, 799–899.

<sup>3</sup> In this article I offer a reconstruction of Ockham's reductionism that aims at a concise presentation of those aspects of it that I regard as the most crucial ones. I do not undertake, however, a systematic critical assessment of Ockham's view. For such an assessment, see McCord Adams (1987), vol. 2, 819–821, 873–874, 886–888. I essentially agree with McCord Adams's assessment.

things distinct from and not reducible to permanent things, and that time and change are paradigmatic cases of successive things. It is this realist view that is the main polemical target of Ockham in his discussion of time and change.<sup>4</sup> He argues that there are no successive things in addition to permanent things, and in particular that time and change are not such things; rather both time and change can be reduced to permanent things.

In this paper I will first explain the notions of permanent and successive things. I will then present the two main lines of attack of Ockham against successive things. I will finally focus on his reductionism of time and change to permanent things.<sup>5</sup>

## 2.2 Permanent and Successive Things

Despite their central role in the debates about the ontological status of time and change, the notions of permanent thing and successive thing are not themselves matter of dispute or subject to any accurate analysis.<sup>6</sup> There is a dominant tendency among medieval philosophers to use these notions without specifying how they should exactly be understood. They believe that the distinction between the two kinds of thing has an Aristotelian origin. This is a passage of *Physics* III in which Aristotle contrasts the mode of being of a statue with the mode of being of a day and an athletic contest.<sup>7</sup> In the medieval interpretation the contrast is that between the mode of being of permanent things -a statue- and the mode of being of successive things -a day and an athletic contest. The Aristotelian examples are also taken as an indication that time and change are paradigmatic cases of successive things: a day is a period of time and an athletic contest is a change. Furthermore, the Aristotelian passage suggests the most popular formulation of the distinction between permanent and successive things. This formulation is the one given, for example, by Walter Burley, Ockham's contemporary and fiercest enemy in ontological matters:

(T1) This is the difference between permanent and successive things: that a permanent thing exists all at once, or at least can exist all at once, whereas it is incompatible with a successive thing to exist all at once.<sup>8</sup>

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<sup>4</sup> The realist view that Ockham attacks is the dominant one in the English tradition. It was endorsed by the large majority of the Oxford commentators on Aristotle's *Physics* around the middle of the thirteenth century, and later on by Thomas Wylton and Walter Burley. For this realist view see Trifogli (2000), 37–86, 203–261; Trifogli (2013). With the sole exception of Walter Burley, however, it is not clear which other exponents of this realist tradition are the deliberate targets of Ockham's criticism.

<sup>5</sup> The primary source I have used is the Commentary on Aristotle's *Physics* (Ockham 1985a and Ockham 1985b). The English translation of the passages quoted from this work is mine.

<sup>6</sup> For an extensive discussion of the medieval views about successive things see Pasnau (2011), 374–398.

<sup>7</sup> Aristotle (1983), III.6, 206a18–24.

<sup>8</sup> Quote from Pasnau (2011), 375.

Thus, in the Aristotelian examples, a statue is a permanent thing because it (can) exist all at once whereas a day and an athletic contest are successive things because they cannot exist all at once.

To get a better grasp of the ideas at work here, it is helpful to introduce the notions of part and whole in explaining what existing all at once means. A thing exists all at once if it is such that all its parts (can) exist at once, that is, at the same time. Accordingly, a permanent thing is defined by the condition that its parts are such that they can all exist simultaneously, whereas a successive thing is a thing that does not satisfy this simultaneity-requirement: it has parts but its parts are such that they cannot exist simultaneously; rather they exist one after the other, that is, in temporal succession. Thus, a permanent thing is a whole such that all the parts composing this whole (can) exist at the same time, whereas a successive thing is a whole such that any two distinct parts composing this whole cannot exist at the same time but only in succession.

It is crucial to get a firm grasp on the question of what counts as a part of a thing in order to understand clearly the distinction between the two kinds of being. And it is especially relevant in the case of permanent things. If things like human beings and statues must count as permanent things, then there must be some restrictions as to what counts as their parts. For, as Pasnau correctly remarks, “if ‘part’ is understood broadly enough ... only God counts as permanent.”<sup>9</sup> This question, however, is not raised in the medieval debate. Human beings and statues are presented as obvious examples of permanent things. The tacit understanding is that the relevant parts of which permanent wholes are composed are the essential ones, that is, the parts that define the kind of thing that something is. Thus, in the case of a human being, such parts would be its matter and its (substantial) form. The question of the extension of the class of permanent things is not explicitly raised either. The tacit understanding here is that this class includes a large variety of things in Aristotle’s ontology: all substances (both material and immaterial) and their qualitative and quantitative properties (accidents belonging to the categories of quality and quantity), things like colour, heat, and bodily extension.

As to successive things, at least in the case of the two paradigmatic cases of such things, namely change and time, the question of what counts as the parts that define them as successive wholes is more straightforward, at least within an Aristotelian context. The relevant property of change and time is that of being continua, that is, divisible into parts ad infinitum. The parts that define change and time as continua are also those that define them as successive wholes. For example, consider a locomotion (change with respect to place) along a bodily extension. In this situation there are three continua: the bodily extension, the locomotion occurring along it, and the time taken by this locomotion. There is also a one-to-one correspondence between the parts of these three continua: to each part P of the bodily extension there corresponds the part (or phase) of the locomotion that occurs along P and the part of time taken by this part of the locomotion, and the other way around. These

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<sup>9</sup> Pasnau (2011), 376.

three continua, however, are not completely isomorphic: while the bodily extension is a permanent continuum, the locomotion and its time are successive continua. To see this, focus on any two non-overlapping parts of the bodily extension, say AB and BC. These two parts, like any other similar parts of it, exist at the same time. The two corresponding parts of the locomotion, that is, the phase along AB and that along BC, however, do not exist at the same time, but one after the other: while the body is moving from A to B is not also moving from B to C; it first moves from A to B and then from B to C. Similarly, the two corresponding parts of the time taken by this locomotion -the time of the locomotion from A to B and that of the locomotion from B to C- do not exist together but one after the other.

### 2.3 Ontological Problems with Successive Things

One main line of attack that Ockham uses against successive things consists in pointing out that the notion of successive thing is an incoherent one and so does not define a sound ontological category. In the realist understanding, a successive thing is a whole, so something composed of parts, but a whole such that its existence does not require the existence of all the parts belonging to it. For Ockham, this realist notion of successive thing is seriously wrong. It ascribes incompatible properties to such a thing, namely, being a whole, and having existence as a whole independently of the existence of all its parts. Furthermore, it violates what seems to be a natural criterion for the existence of a whole, according to which for a whole to exist all its parts must exist. In Ockham's words:

(T2) It is impossible that some one thing distinct as a whole from all other things exists in nature unless all its parts exist in nature. Accordingly, if just one part of it does not exist in nature nor does the whole. For, if this were not the case, then I could say that a dead man exists because its matter exists, which is saying nothing.<sup>10</sup>

This criterion reflects the plausible principle that a being cannot be composed of non-beings. As Ockham puts it in another passage:

(T3) what does not exist is not a part of a thing.<sup>11</sup>

With Ockham's example in (T2), if we give up this criterion and admit that for a whole to exist it is sufficient that some part of it exists, then since one part of the corpse of a human being, namely matter, is also part of the human being, the existence of the corpse of a human being would entail the existence of the human being itself, a conclusion that everyone would consider absurd. According to

<sup>10</sup> Ockham (1985b), 199.122–126: "... impossibile est quod aliquid unum secundum se totum distinctum ab aliis sit in rerum natura nisi quaelibet pars eius sit in rerum natura. Unde si una sola pars non sit in rerum natura, nec ipsum totum est. Aliter enim possem dicere quod homo mortuus est, quia materia sua est, quod nihil est".

<sup>11</sup> Ockham (1985a), 431.15: "illud quod non est non est pars alicuius rei".

Ockham's criterion then, only permanent wholes are genuine wholes and so genuine composite things because only the parts of permanent wholes are such that they can all exist simultaneously. On the contrary, in our example, the locomotion from A to C through B does not exist as a whole composed of the locomotion from A to B and of that from B to C because these two phases do not exist together and thus cannot compose a whole. We cannot build a whole starting from these phases, so to say, because they do not add up: when one occurs, the other does not. Similarly, the time of this locomotion is not a whole composed of the time of the locomotion from A to B and the time of the locomotion from B to C because these two periods of time do not exist simultaneously.

This apparently damning objection of Ockham against the soundness of the notion of successive thing would hardly have impressed a realist. Indeed, in his criterion for the existence of a whole Ockham implicitly assumes that existence should be understood as simultaneous existence, so that the criterion says that for a whole to exist all its parts should exist simultaneously. This assumption, however, simply begs the question against the realist claim that there are wholes that do exist but the parts of which do not exist simultaneously but one after the other, or, more generally, against the realist claim that simultaneous existence is not the only kind of existence, as there is also successive existence.

To reach a better insight into Ockham's line of attack against successive things it is helpful to set it in its historical context. The main feature of this context are two arguments against the existence of time that Aristotle presents in *Physics* IV.10 at the very beginning of his extensive discussion specifically devoted to time.<sup>12</sup> It is with reference to these arguments that Ockham introduces his criterion for the existence of a whole in text (T2):

(T4) Therefore, I say that the arguments that Aristotle adduces are sufficient to prove that time is not something outside the soul distinct as a whole from all past and future permanent things and from all permanent things... *it is impossible that some one thing distinct as a whole from all other things exists in nature unless all its parts exist in nature...*<sup>13</sup>

Likewise, it is in reply to the Aristotelian arguments that the realists invoke the distinction between permanent and successive things. The Aristotelian arguments are indeed the *locus classicus* of the medieval debate about the ontological status of change and time. It is worthwhile to quote them:

(T5) <1> One part of it (i.e., of time) has been and is not, another part of it will be and is not yet. From these are composed both the infinite and whatever time is on any given occasion taken. But what is composed of non-beings might seem to be incapable of participating in being.

<sup>12</sup> Aristotle (1983), IV.10, 217b32–218a8.

<sup>13</sup> Ockham (1985b), 199.115–123: “Sic igitur dico quod rationes quas hic adducit Philosophus sufficienter probant quod tempus non est aliquid extra animam, distinctum secundum se totum ab omni re permanente, praeterita et futura et ab omnibus rebus permanentibus ... impossibile est quod aliquid unum secundum se totum distinctum ab aliis sit in rerum natura nisi quaelibet pars eius sit in rerum natura”.

<2> In the case of anything divisible, if it is, it is necessary that when it is, either all or some of its parts must exist. But of time, though it is divisible, some parts have been, some parts are to come, but no part is. The now is not a part. For the part measures and it is necessary that the whole is composed from the parts. But time is not thought to be composed out of nows.<sup>14</sup>

The two arguments present the same idea, which is the following. In both arguments time is viewed as a whole composed of parts: something analogous to a line, a one-dimensional extension. Then both arguments assume a criterion for the existence of a whole composed of parts. This criterion is clearly expressed in the major premise of the second argument: for a whole composed of parts to exist, at least some of its parts must exist. Finally, both arguments claim that no part of time exists. The arguments obviously assume that the ultimate parts of time, those of which any period of time is ultimately composed, are past parts and future parts. The past parts have been but are not and the future parts are to come but are not yet; thus neither the past parts nor the future parts are or exist. The conclusion then is that time, being composed of parts that do not exist, does not exist. The remarks about the now, that is, the present instant, at the end of the second argument are meant to provide a reply to an implicit objection against the assumption that the only parts of time are the past and the future. The objection is that this assumption neglects another kind of part of time, namely the present; and the present, unlike the past and the future, does exist. The reply of Aristotle is that the present is only the present indivisible instant and an instant, being analogous to a point, is not a part of time. What is implicit in this reply is the Aristotelian assumption that continua are not composed of indivisibles. For example, a line contains points but it is not composed of points in the sense that points are not parts of a line. Indivisibles, like points and instants, are boundaries of the continua to which they belong but are not their parts.

Aristotle presents these arguments as considerations one may provisionally advance against the existence of time, but he does not think that these arguments are conclusive. Indeed, he goes on to establish what time is, but there would be no point in establishing what time is if time did not exist. Furthermore, it is quite clear that these arguments can be reformulated also in the case of change, and Aristotle never raises doubts against the existence of change. Aristotle, however, leaves these arguments without any explicit solution and to his interpreters the task of finding a solution to them. In the absence of an authoritative solution from Aristotle's himself, it is not surprising that there is not universal agreement about their solution, which is indeed matter of debate in the Aristotelian tradition.<sup>15</sup>

Ockham's position in this debate is highly original. In contrast with the dominant tendency among Aristotelian commentators to consider Aristotle's arguments as inconclusive, Ockham thinks that they do establish a true conclusion about time (and change):

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<sup>14</sup> Quote from Coope (2005), 18–19.

<sup>15</sup> For the solutions of some modern Aristotelian scholars, see Coope (2005), 19–26; for the debate in the medieval Latin tradition, see Trifogli (2000), 205–219.

(T6) It must here be understood that these arguments are not absolutely sophistic, but to some extent conclusive. Indeed, they sufficiently prove that time is not some one thing distinct as a whole from all permanent things and from every permanent thing.<sup>16</sup>

Ockham's idea here is that, although the arguments do not conclude that time does not exist at all, they at least conclude that time is not some kind of thing distinct from permanent things, and the kind of distinct thing that he has in mind is obviously a successive thing. Thus, in his view, the arguments are not completely sophistic in the sense that they do demonstratively prove a negative conclusion about a type of being commonly ascribed to time, that is, a successive being.

Let us examine Ockham's original interpretation in some detail. For this purpose it is convenient to reformulate Aristotle's arguments as follows:

- (i) For a whole to exist it is necessary that some or all of its parts exist;
- (ii) Time is composed of past and future;
- (iii) Past and future do not exist;
- (iv) Therefore, time does not exist.

As to the first premise (i) the common realist solution to the argument consists in denying that this premise is universally valid. It is valid for permanent things but not also for successive things. That is, while for a permanent thing composed of parts to exist, it is necessary that some of its parts exist, this is not also true for successive things. A successive thing does exist even if none of its parts exist now or simultaneously. It is in reaction to this common realist reading that Ockham says that Aristotle's arguments are not sophistic. For in the realist view the arguments are indeed sophistic because they apply to time a criterion of existence that does not hold for time or for any successive things. Ockham takes the opposite way. He thinks that the criterion of existence of a whole expressed by premise (i) is universally valid: there are no exceptions to it. Furthermore, he reinforces the criterion. While in the original formulation of Aristotle, there is the alternative that for the existence of a whole it is necessary that some of its parts, although not all of them, exist, Ockham thinks that there is not such an alternative. The only way for a whole to exist is for all its parts to exist. He maintains that if one part only of a whole does not exist in nature, then the whole does not exist either. In text (T2) quoted earlier he gives the very poignant example of a dead human being to illustrate the evidence of this principle.

The contrast between Ockham's and the realist reading of the Aristotelian arguments is not only about premise (i) but also about premise (ii), i.e., the claim that time is composed of past and future. The realists do not see any major problems with this premise. They take it as a genuine feature of time that it is a whole and that the parts of which it is ultimately composed are past and future parts. The problem

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<sup>16</sup> Ockham (1985b), 195.17–20: "Intelligendum est hic quod istae rationes non sunt simpliciter sophisticae, sed aliquo modo concludunt. Probant enim sufficienter quod tempus non est aliqua res per se una, secundum se totam distincta ab omnibus rebus permanentibus et ab omni re permanente."

of the realists rather is to find a criterion of existence that this kind of whole satisfies. For Ockham instead premise (ii), at least in the realist reading, is false. There cannot be a whole composed of past and future parts: past and future are not the kind of items that add up to a whole. Although this premise is part of Aristotle's original arguments, in Ockham's interpretation Aristotle does not endorse it in the realist sense, as he explains in the following passage:

(T7) [1] But when it is said 'time is composed of those things that are not, i.e., from past and future', it must be said that two senses of this proposition must be distinguished. One sense is that time is some one thing distinct from all the other things, and is really composed by the past and the future as by its parts. And this sense is false because time is not something of this kind. Another sense is that time signifies that something is past and something is future. Therefore in the nominal definition of time both past and future must be posited. And because of this past and future are said to be parts of time. Nor when they say that time is composed of past and future and that past and future are parts of time Aristotle and Averroes understand something else than the fact that past and future are posited in the nominal definition of time. And if the minor premise is understood in this sense, the conclusion that time does not exist does not follow -if this conclusion is understood as opposite to the sentence 'time exists', when this sentence is understood in the sense in which Aristotle does- but there is a fallacy of amphiboly.

[2] In the same way one must reply to the second argument, when it is said that 'if something divisible exists, then either all its parts or some of its parts exist'. It must be said that this proposition can be conceded. But when it is said 'some parts of time are past and others future', it must be said that two senses of this proposition can be distinguished. One sense is 'some of the parts that really compose time as something distinct from all permanent things and from every permanent thing are past, and this sense is false because time is not this kind of composite, as has been said before. The other sense is 'some of the things imported by the name 'time' are not or are not joined with other things or are not in the same place in which they were', just as something that does not exist is imported by the verb 'becomes white' and by the verb 'becomes hot'. And this sense is true, but then the conclusion does not follow.<sup>17</sup>

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<sup>17</sup> Ockham (1985b), 200.151–201.182: "[1] Sed quando dicitur 'tempus componitur ex illis quae non sunt, scilicet ex praeterito et futuro', dicendum quod ista propositio est distinguenda penes amphiboliam. Unus sensus est quod tempus sit aliquid unum distinctum ab omnibus aliis, compositum vere tamquam ex partibus ex praeterito et futuro. Et iste sensus falsus est, quia tempus non est aliquid tale. Alius sensus est iste quod tempus significat aliquid esse praeteritum et aliquid esse futurum. Et ideo in definitione exprimente quid nominis ipsius temporis debet poni tam praeteritum quam futurum. Et praecise propter hoc dicitur tempus componi ex praeterito et futuro, et pro tanto praeteritum et futurum dicuntur partes temporis. Nec aliud intendunt Philosophus et Commentator dicere quandocumque dicunt quod tempus componitur ex praeterito et futuro, et quod praeteritum et futurum sunt partes temporis, nisi quod praeteritum et futurum ponuntur in definitione exprimente quid nominis temporis. Et sub isto sensu accepta minore, non sequitur quod tempus non est, sub illo sensu accepta conclusione sub quo opponitur isti 'tempus est', ista accepta in sensu quem habet Aristoteles de ea. Sed est in argumento manifeste fallacia amphiboliae. [2] Consimiliter respondendum est ad secundum argumentum quando dicitur 'si aliquid divisibile est, vel omnes partes vel aliquae ipsius sunt'. Dicendum quod ista potest concedi. Sed quando dicitur 'temporis aliquae partes factae sunt et aliae futurae sunt', dicendum est quod ista potest distingui secundum amphiboliam. Unus sensus est 'aliquae partes vere componentes tempus distinctum ab omnibus rebus permanentibus et a re permanente factae sunt', et iste sensus falsus est, quia tempus non est tale compositum, sicut dictum est prius. Alius sensus est iste 'aliqua, quae importantur

This passage contains what can be regarded as Ockham's official solution to the two Aristotelian arguments against the existence of time of *Physics* IV.10. These arguments conclude without qualification that time does not exist; but for Ockham, like for any other Aristotelian philosopher, time somehow exists; thus, there is something wrong with these arguments. According to Ockham, what is wrong with them, however, is not the criterion for the existence of a whole in premise (i), as the realists think, but the identification of time with a whole composed of past and future as parts in premise (ii). This is the premise that must be denied to block the inference to the conclusion that time does not exist. More precisely, what is wrong and false is the claim that time is composed of past and future understood in the realist sense. As Ockham points out, however, there is also a correct and true sense of this claim, a 'nominalist' sense: past and future are not parts of time as thing but are parts of the nominal definition of time, that is, of the linguistic formula that expresses what the term 'time' means. This term signifies past and future things, although there is not a thing 'time' composed of past and future things as parts. I shall return to the semantics of the term 'time' later in this paper when I will present Ockham's reductionism of time to permanent things.

## 2.4 Successive Things and the Razor-Principle

As I said, Ockham's attack against the coherence of the notion of successive thing is not as compelling as he thinks it is; for his crucial claim that the existence of a whole requires the existence of all its parts is basically question-begging. More forceful, in my view, is another kind of objection that Ockham raises against successive things. The objection is that successive things are superfluous, in the sense that they are not needed as basic things in the ontology. And if they are not needed, then we should not posit them, as Ockham argues by appealing to his famous Razor-principle.

In the passage below Ockham gives a very incisive formulation of this objection in the case of change:

(T8) Therefore, it must be said that change is not such a thing distinct as a whole from a permanent thing. (i) *For it is in vain to do with more things what can be done with fewer;* (ii) *but without any such thing we can save change and all the claims about change;* (iii) *therefore, it is in vain to posit such other thing.*<sup>18</sup>

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per hoc nomen 'tempus' non sunt, vel non sunt coniuncta cum aliis, vel non in eodem situ in quo fuerunt', sicut aliquid quod non est importatur per hoc verbum 'dealbatur', et per hoc verbum 'calefit'; et iste sensus verus est, sed tunc non sequitur conclusio."

<sup>18</sup> Ockham (1985a), 432.53–56: "Ideo dicendum est quod motus non est talis res distincta secundum se totam a re permanente. Quia frustra fit per plura quod potest fieri per pauciora, sed sine omni tali alia re possumus salvare motum et omnia quae dicuntur de motu, ergo talis alia res frustra ponitur."

The major premise (i) of this argument is one of the standard formulations of Ockham's Razor-principle: a principle of ontological parsimony. It is to this principle that Ockham appeals in some of his most powerful arguments against a variety of popular forms of realism at his time: in addition to the realism about successive things, also and more crucially the realism about universal things, as well as the realism about quantitative things and relative things. It is a principle that invokes parsimony about kinds of things, not about numerically distinct things of one and the same kind.<sup>19</sup> This principle is now known as Ockham's Razor, but it was not invented by Ockham himself. Some versions of it are found in Aristotle (e.g., nature does nothing in vain) and also among medieval philosophers Ockham was not the only one to appeal to it. However, as Adams remarks, the label 'Ockham's Razor' that associates the principle with Ockham is appropriate, in the sense that, in comparison with his predecessors and contemporaries, Ockham's metaphysical conclusions are what one would expect from a philosopher who lets the principle be his guide.<sup>20</sup> Ockham takes the truth of the Razor-principle as axiomatic, as not requiring any proof. As to the nature of this principle, Adams raises the question of whether the principle says something about reality or about our way of approaching reality, i.e., of formulating explanatory theories about reality. Adams thinks that the principle is methodological and should therefore be taken as an exhortation to look for a simple explanatory theory.<sup>21</sup> Thus, in our case, the Razor-principle states that we should look for a simple/parsimonious explanatory theory of time and change.

There are interesting issues concerning the Razor-principle but they do not need to concern us here. For the Razor-principle is accepted without any qualifications or clarifications by all parties in the medieval debate: both nominalists and realists. Very significant in this respect is the reply to the Razor-argument in passage (T8) given by Ockham's main enemy, Walter Burley:

(T9) To the third argument, (i) when it is said that it is futile to do with more things what can and so on, I concede this. (ii) And when it is said that change and the things said about change are equally well saved by positing that change is not a thing distinct and so on, I reply by denying this, because unless change is a thing distinct from permanent things neither change nor the things said of change are saved.<sup>22</sup>

Thus, Burley simply concedes the truth of the Razor-principle without devoting any special attention to it. He strongly rejects, however, the application of this principle to the case of change that Ockham proposes in the minor premise (ii) of his Razor-argument. While for Ockham change can be saved without positing successive things, for Burley we do need successive things to save change. In this version, then, like in all the other versions of Ockham's Razor-argument, the controversy is not about the Razor-principle itself but about its application.

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<sup>19</sup> On Ockham's Razor see McCord Adams (1987), vol. 1, 156–161.

<sup>20</sup> McCord Adams (1987), vol. 1, 157.

<sup>21</sup> McCord Adams (1987), vol. 1, 158.

<sup>22</sup> Quote from Trifogli (2013), 282.

Let us then have a closer look at Ockham's controversial application of the Razor-principle in the minor premise (ii) of the argument in (T8). In denying that change and time are successive things, Ockham does not mean to support the Eleatic view that change and time do not exist at all. As a true Aristotelian, Ockham believes that the physical world is a world of change. Bodies (material substances) do really change. Change and its temporal aspects are not an illusion but something real. Thus, the existence of change and time is agreed both by Ockham and by his realist opponents. It is a datum to be saved and accounted for by all parties in the debate. The controversial issue, however, is about what we need to save change and time. Do we need to posit a kind of things, successive things, in addition to permanent things? The realist answer to this question is 'yes', and Ockham's answer is 'no'.

Let me illustrate these contrasting answers with our example of the locomotion of a body from an initial position A to a final position C. With some simplification, in order to account for this change in the realist view we need not only the mobile body and the space (bodily extension, for an Aristotelian) traversed by it, which are permanent things, but also one or two successive things (change and time). Why do we need them? Because -the realists insist- this locomotion occurs successively, not simultaneously; but succession or non-simultaneity cannot be accounted for in terms of the permanent things alone involved in this change, like the body and the space. More generally, if the only things involved in a change were permanent things, we could not account for the succession that necessarily accompanies any change. To account for succession then, we need to posit things that are successive by their nature. Accordingly, in our example, the body is first in A and then in B and finally in C in virtue of a successive thing inhering in it, just like it is white (for example) in virtue of a quality whiteness inhering in it.

Ockham thinks that this realist view is wrong, and that it is indeed a violation of the Razor-principle, because, he argues, change (and time) can be accounted for simply in terms of permanent things. He explicitly offers such a reductionist account for each kind of change (local, qualitative, quantitative change) in support of the minor premise of his Razor-argument in (T8). In the case of our favourite example of a locomotion it goes as follow:

(T10) For, if we posit that a body first is in a place and afterwards in another place, and that this body proceeds in this way without any rest and without any intermediate thing or a thing other than the body itself and the agent that moves it, we truly have locomotion. Therefore, it is in vain to posit such other thing.<sup>23</sup>

In Ockham's reductionist account then only three kinds of thing are required for locomotion: the mobile body, the positions or places occupied by this body, and the agent of change. These are all permanent things. The intermediate thing Ockham refers to in this passage is locomotion as a successive thing in the realist account. This thing is not needed, Ockham argues, because locomotion of a body simply

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<sup>23</sup> Ockham (1985a), 432.59–62: "Ponendo enim, quod corpus sit primo in uno loco et postea in alio loco et sic procedendo sine omni quiete et omni re media vel alia ab ipso corpore vel ipso agente quod movet, vere habemus motum localem; ergo frustra ponitur talis alia res."

consists in the body's successive occupation of distinct places. This is an 'at-at' view of locomotion: locomotion is nothing else than a body being first at this location and then at another location.

Very illuminating are some objections that Ockham raises against his reductionist view. One objection says that mobile body and places are not sufficient for locomotion. For if they were sufficient, then whenever there are a mobile body and places, there would be locomotion, and this is evidently false. A mobile body can well be at rest in a place without occupying different places. The objection omits the agent of change, which is one of the things required for change in passage (T10), but we can implicitly add it and the objection would still be valid.

In reply to this objection Ockham concedes that the mobile body and places are not sufficient for locomotion in the sense that the following inference is not formally valid: a mobile body and places exist, therefore locomotion of this body exists. Since they are not sufficient, something must be added to them to account for locomotion. But what must be added is not a thing, but a condition that a mobile body and places must satisfy, namely, that the mobile body must first be in a place and then in another place.<sup>24</sup> And, as Ockham explains, to satisfy this condition no additional thing is required:

(T11) Because of the fact that a body is first in *a* no thing other than *a* is posited; similarly, because of the fact that a body is first not in *b*, no thing other than *b* and the body is posited; similarly, because of the fact that a body is then in *b* no thing other than *b* and the body is posited. And proceeding in this way in the other cases it is evidently manifest that in addition to the body, the parts of place and the other permanent things it is not necessary to posit another thing. It is necessary, however, to posit that a body is at some time in this place and in any part of that place and at another time it is not there. And this is to be subject to locomotion, namely, to occupy first one place and, without positing any other thing, to occupy afterwards another place without any intervening rest and without any other thing apart from place and body and the other permanent things, and to proceed in this way. And consequently, in addition to those permanent things, there is not some other thing, but it is only necessary to add that a body is *not simultaneously* in those places and that it was not at rest in those places. *And because of these negative propositions no other thing is posited in addition to permanent things* nor is another thing distinct from permanent things, that is, places, body and the like, posited by affirmative propositions like 'the body was in those places'.<sup>25</sup>

<sup>24</sup> Ockham (1985a), 432.63–71: "Si dicatur, quod non sufficiunt ad motum localem corpus et locus, quia tunc quodcumque essent corpus et locus, tunc esset motus, et ita corpus semper moveretur, dicendum quod corpus et locus non sufficiunt ad hoc quod sit motus ita quod ista consequentia non est formalis 'corpus et locus sunt, ergo motus est.' Sed tamen praeter corpus et locum non requiritur aliqua alia res, sed requiritur quod corpus prius non sit in hoc loco sed in alio loco et postea in hoc loco et sic continue ita quod numquam in toto illo tempore quiescat in aliquo loco. Et patet quod per omnia ista non ponitur aliqua alia res a rebus permanentibus."

<sup>25</sup> Ockham (1985a), 433.72–86: "Unde per hoc quod corpus primo est in *a*, non ponitur aliqua alia res ab *a*; similiter per hoc quod primo non est in *b*, non ponitur aliqua alia res a *b* et a corpore; similiter per hoc quod secundo est in *b*, non ponitur aliqua alia res a *b* et a corpore. Et sic procedendo de aliis patet evidenter, quod praeter corpus et partes loci et ceteras res permanentes non oportet ponere aliam rem, sed oportet ponere quod corpus aliquando sit in illo loco et in qualibet parte loci et aliquando non sit. Et hoc est moveri localiter: primo habere unum locum, nulla

In this passage the crucial additional condition, the non-simultaneity condition, is treated by Ockham as ontologically innocent and parsimonious. But matters are more complicated than the way Ockham presents them. Indeed, a realist could easily object to Ockham's reductionist account that by adding the condition that places are not occupied simultaneously by the mobile body we have in fact added another thing to the set of basic permanent things, a thing that is in some way responsible for the non-simultaneity of the locations of the body: a successive thing.

Ockham is aware of this objection. One way in which he deals with it consists in pointing out the negative character of the non-simultaneity condition. It expresses the negation of simultaneity. Being a negation, we do not need to posit a thing - something 'positive' - to satisfy it, as he points out in the sentence printed in italics towards the end of (T11).

This move of treating non-simultaneity as a negation, however, would hardly convince a realist. For example, a realist would say that non-simultaneity is in fact succession and succession at least grammatically is not a negation. 'Parts are not simultaneous' is a negative sentence but 'Parts are successive' is not negative and is equivalent to the first sentence. Thus, it seems that Ockham's appeal to the negative character of non-simultaneity is taken by itself rather weak. For at the ontological level, non-simultaneity does not seem to be the negation of a positive state, at least in the case of change. The only way a body can be in different places is by being not simultaneously in each of them. Similarly, in a case of alteration involving different forms. A body can be both white and black only if it is not white and black simultaneously. So a realist would not quickly dismiss non-simultaneity as a negative state as Ockham does. And if non-simultaneity is not a negation but something positive, the question arises again of whether another thing is needed to account for it.

Ockham addresses this question too. He replies:

(T12) ... for any non-simultaneity of the parts of change the non-simultaneity of the parts of a permanent thing is sufficient. Indeed, if in a permanent thing a part were not before another or if the thing that changes were not first in one part of place than in another, there would in no way be many parts of change that are not simultaneous. And this non-simultaneity of permanent things without any other thing is sufficient for the parts of change not to be simultaneous, and therefore because of the non-simultaneity of the parts of change it is not necessary to posit a thing distinct from permanent things.<sup>26</sup>

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alia re tunc posita, postea habere sine quiete media alium locum sine omni alia re praeter locum et corpus et cetera quae manent, et sic procedendo. Et per consequens praeter istas res permanentes non est aliqua alia res, sed solum oportet addere quod corpus non est simul in illis locis et quod non quievit in illis locis. Sed per tales negativas nulla alia res ponitur, nec per affirmativas tales 'corpus fuit in illis locis' ulla alia res ponitur praeter res permanentes, puta praeter loca et corpus et huiusmodi".

<sup>26</sup> Ockham (1985a), 441.36–43: "... ad omnem non simultatem partium motus sufficit non similtas partium rei permanentis. Nisi enim in re permanente una pars esset ante aliam vel nisi mobile prius esset in una parte loci quam in alia, nullo modo essent plures partes motus non simul existentes. Et talis non similtas plurium rerum permanentium praeter omnem rem aliam sufficit ad hoc quod

There are two main distinct claims in this passage: (i) one is that permanent things are not incompatible with succession or non-simultaneity so that there can be permanent things such that they or their parts exist one after the other or acquire properties one after the other; (ii) the other is that the succession of permanent things is enough to account for the succession in a change. To illustrate Ockham's view with our example of a locomotion, the whole body (all its parts) will eventually have left the initial position A and have come to occupy the final position C, but this body leaves the initial position and occupies another gradually, part after part, that is, successively. Furthermore, the succession in this change is nothing over and above the body's being first in A, then in B and each of the intermediate locations, and finally in C, so that this succession requires nothing else apart from the body and the space traversed by it. More precisely, what is also required is an efficient cause of this change, for example, another body that moves the initial body from one position in space to another, that is, something responsible for the moving body's being first here and then there from the point of view of efficient causality. However, it is not also required something responsible for this from the point of view of formal causality, so to say, like whiteness is formally responsible for something's being white. In more abstract terms, according to Ockham, the succession that belongs to permanent things in a change is a primitive property of them, not one that they acquire in virtue of something else.

In the following passage Ockham gives a very neat presentation of his reductionist interpretation of the distinction between permanent and successive things:

(T13) ...when authors consider propositions like 'no successive is permanent' and 'successive and permanent are opposite', they mean in fact the following propositions 'nothing that is successive acquires or loses something simultaneously, but acquires or loses it successively'; similarly they mean propositions like 'everything that is acquired by something either is simultaneously acquired and not part before part, or successively, that is, part before part'. Therefore, when it is argued as follows 'no successive is permanent; change is successive; therefore change is not permanent', the conclusion must be conceded under this sense 'that which is part by part acquired or lost is not acquired or lost simultaneously as a whole'. *But this is compatible with the claim that in addition to past, present, and future permanent things there is no other thing distinct as a whole from them.* And this is precisely our main intention.<sup>27</sup>

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partes motus non sint simul, et ita propter non simultatem partium motus non oportet ponere aliam rem a rebus permanentibus."

<sup>27</sup> Ockham (1985a), 445.185–446.197: "... quando auctores accipiunt istam propositionem 'nullum successivum est permanens' et similiter quod successivum et permanens ex opposito dividuntur, intelligunt tales propositiones 'nihil quod est successivum, acquirit vel deperdit aliquid simul, sed successive acquirit vel deperdit illud', similiter tales 'omne quod acquiritur alicui, vel simul acquiritur et non pars ante partem, vel successive, hoc est pars ante partem'. Et ideo quando arguitur sic 'nullum successivum est permanens, motus est successivus, igitur motus non est permanens' debet concedi conclusio sub isto sensu 'illud quod partibiliter acquiritur vel deperditur, non acquiritur vel deperditur totum simul'. Cum hoc tamen stat quod praeter res permanentes praeteritas, praesentes et futuras nulla est res distincta secundum se totam ab eis, et hoc praecise est principale intentum".

As the sentence printed in italics indicates, in Ockham's view what is needed to accommodate succession within the class of permanent things is simply to extend the class as to include not only the present permanent things but also past and future ones. Ockham's implicit assumption here is that to account for things being present, past or future we do not need to posit time as a successive thing. This is an assumption, however, that realists would reject.

## 2.5 Reductionism of Change and Time to Permanent Things

Ockham not only formulates general arguments, like those presented in the previous section, for the reductionism of change and time to permanent things, but also provides specific indications about how this reductionism is to be understood. The version of reductionism advocated by Ockham is a very strong one. Its force and originality can be better appreciated if Ockham's view is set in its historical context and compared with the dominant kind of reductionism at Ockham's time.

According to the dominant reductionist position, successive things are not ontologically distinct from permanent things but they do have the ontological status of things. Consider, for example, the reductionist claim about change that change is not a thing distinct from permanent things. This claim would have been accepted by any medieval reductionist before Ockham (for example, Thomas Aquinas) but it would normally be understood in the following sense: change is not a thing distinct from permanent things because it is really identical with one of the relevant permanent things. In the case of the qualitative change of a body from being cold to being hot, for example, the relevant permanent things are the body that changes, the two qualities of coldness and heat, which are the initial and final state of the change, and the agent of the change. In the pre-Ockhamist views, the change of a body from being cold to being hot is one of these permanent things. Which one? The most popular view is that the change is in fact essentially the same as the final terminus of the change, namely, heat in our example.

This view was suggested to Latin medieval philosophers by the Arabic commentator Averroes, who maintained that a change differs only in degrees of completion from the final permanent state to which it is directed.<sup>28</sup> Thus, in Averroes's words "to go towards heat - i.e., becoming hot- is somehow heat itself".<sup>29</sup> What is important for us in Averroes's view is that, while it denies that change is a thing distinct from permanent things, it does not deny that change is a thing. Becoming hot is indeed a thing, namely, heat in some incomplete state or heat in the process of being acquired.

At the semantic level, the Averroistic view can be put as follows. Consider the terms 'becoming hot' and 'heat'. These are both proper names in the sense

<sup>28</sup> On Averroes's view and its reception in the Latin tradition, see Trifogli (2000), 47–66.

<sup>29</sup> Averroes (1962), V, t.c. 9, fol. 215ra: "ire ad calorem est calor quoquo modo".

that both of them signify things; but although these names are distinct the things signified by them are not distinct, but in fact the same thing, namely, heat. The difference between the two names is not a difference in the things signified by them but in the way in which the two names signify the same thing. While ‘heat’ signifies heat as such without further qualifications, ‘becoming hot’ signifies heat as successively acquired. In Medieval terms, ‘becoming hot’ primarily signifies heat and co-signifies or connotes that heat is being successively acquired. Thus, in the pre-Ockhamist kind of reductionism change and time are things, although not successive things, and correspondingly the terms ‘change’ and ‘time’ have real semantic values: they are terms that signify things.

This is not what Ockham thinks. His reductionism is much more radical. It is well-condensed in his claim that:

(T14) Thus, it is evident that these terms ‘change’ and ‘time’... are invented for the sake of brevity.<sup>30</sup>

that is, the terms ‘change’ and ‘time’ are not naturally significant terms in the sense that they are not terms that signify things. Rather, they are simply conventional linguistic devices used to give a more concise and elegant formulation to sentences that express facts about (permanent) things that change.

Ockham illustrates his claim about the linguistic role of the terms ‘change’ and ‘time’ with the examples of two standard sentences about change and time in Aristotle’s natural philosophy. The first sentence is ‘change is in time’. In a naive realist reading, this sentence signifies that there are two distinct things -those signified by the terms ‘change’ and ‘time’- and that one of them is contained in (/measured by) the other. In Ockham’s view, instead, the way to reach the correct reading of the sentence is not by identifying which things the two terms signify, because there are not such two things, but by identifying the linguistic items of which the two terms are supposed to be abbreviations. In Ockham’s reading, the sentence ‘change is in time’ abbreviates the sentence ‘when something changes, it does not acquire or lose all the things that it acquires or loses simultaneously but one after another’. It is this longer sentence that the philosophers mean, according to Ockham, when they use the sentence ‘change is in time’. But in this longer sentence the terms ‘change’ and ‘time’ do not appear at all. All the terms in the longer sentence are terms for permanent things. The other example offered by Ockham is the sentence ‘change is in the thing that changes’. Again, in a naive realist reading, this sentence signifies that there are two distinct things -those signified by the terms ‘change’ and ‘the thing that changes’- and one of them is contained in (inheres in/is a property of) the other. For Ockham, instead, this sentence must be understood as an abbreviation of the longer sentence ‘the thing that changes acquires or loses something’.<sup>31</sup> In this case too, all the terms in the expanded sentence signify

<sup>30</sup> Ockham (1985a), 435.163–164: “Et ita patet quod ista nomina ‘motus’ et ‘tempus’ ... sunt inventa causa brevitatis”.

<sup>31</sup> Ockham (1985a), 435.163–436.172: “Et ita patet quod ista nomina ‘motus’ et ‘tempus’ ...sunt inventa causa brevitatis, ut totum quod importatur per istam longam orationem ‘quod movetur,

permanent things: the body that changes and the permanent properties involved in its change (e.g., qualities in the case of a qualitative change, and locations in the case of locomotion).

Given that the terms ‘change’ and ‘time’ are invented for the sake of brevity, it is not surprising that they can be replaced by a great variety of items in the corresponding expanded sentences, as Ockham explains about ‘change’ in the following passage:

(T15) As to the way of speaking, when we posit in a sentence the term ‘change’ it must be said ... that sometimes ‘change’ supposit for the verb ‘to be changed’ and for the single modes and tenses of it, sometimes it supposit for the thing itself that changes, sometimes for the terminus or the thing acquired when something changes, sometimes it supposit for the sentence ‘that which is changed’ or ‘when it is changed’ or for some similar sentence. Likewise, the things that are added in a sentence to the term ‘change’, either on the side of the other extreme or sometimes on the side of the same extreme, are to be exposted in different ways.<sup>32</sup>

The notion of supposition that Ockham uses in this passage is a technical one in medieval semantic theories.<sup>33</sup> Supposition is a property that belongs to terms when they are used in sentences. The supposition of a term in a sentence is the item that term stands for in that sentence. Ockham’s examples in the passage above are illustrations of the supposition of the term ‘change’. The point he wants to make is that its supposition includes items with very different ontological status: both things, like the body that changes and the properties it acquires and loses when it changes, and linguistic items of various complexity, atomic ones like verbs but also whole sentences. For example, in the sentence ‘change is in time’, the two terms ‘change’ and ‘time’ supposit for whole sentences rather than for things. For, as we have seen, Ockham’s suggested expansion of the sentence reads ‘when something changes, it does not acquire or lose all the things that it acquires or loses simultaneously but one after another’, and the terms ‘change’ and ‘time’ of the abbreviated sentence corresponds to the two sentences of which the expanded sentence consists, namely ‘when something changes’ and ‘it does not acquire... another’ respectively.

Ockham’s view is in short the following: given any sentence in which the terms ‘change’ or ‘time’ appear, this sentence is equivalent in signification to a sentence, normally longer, in which these terms do not appear. Thus, ‘change’ and ‘time’ are pseudo-names. Although they make our way of talking about things changing more

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non acquirit vel deperdit omnia quae acquirit vel deperdit, simul sed unum post aliud’ importetur per istam brevem orationem ‘motus est in tempore’... Similiter ista propositio ‘motus est in moto’ debet sic exponi ‘quod movetur, acquirit vel deperdit aliquid.’”

<sup>32</sup> Ockham (1985a), 435.152–160: “Circa modum loquendi ponendo in oratione hoc nomen ‘motus’ est proportionaliter dicendum, ... Quia aliquando ‘motus’ supponit pro hoc verbo ‘moveri’ et pro singulis modis et temporibus eius, aliquando supponit pro ipso mobili, aliquando pro termino sive pro re acquisita quando aliquid movetur, aliquando ponitur loco talis orationis ‘quod movetur’ sive ‘quando aliquid movetur’ vel loco alicuius talis consimilis. Et similiter illa quae adduntur in oratione huic nomini ‘motus’ ex parte alterius extremi et aliquando ex parte eiusdem, sunt diversimode exponenda.”

<sup>33</sup> On Ockham’s theory of supposition, see McCord Adams (1987), 327–382.

concise and elegant, Ockham maintains that we should try to avoid their use because they can easily generate confusion in simple-minded people. As Ockham laments:

(T16) And therefore in modern times because of the errors originated by the use of such abstract terms it would be better in philosophy for simple-minded people not to use such abstract terms, but only verbs, adverbs, prepositions, conjunctions, syncategorematics, as they were primarily instituted, rather than to invent such abstract terms and use them. Furthermore, if such abstract terms, like ‘change’, ‘mutation’, ‘mutability’, ‘simultaneity’, ‘succession’, ‘rest’ and the like, were not used, there would be little difficulty about change, mutation, time, instant and the like.<sup>34</sup>

The simple-minded people Ockham refers to in this passage are the realist philosophers of his time. Ockham’s charge against them is that they are deceived by their own use of the simple abstract terms ‘change’ and ‘time’. Such terms, unlike their expanded equivalents, can be easily taken as terms signifying basic things in the ontology; therefore, their use naturally lends itself to raise difficult ontological questions about what kinds of thing change and time are. As Ockham explains in another passage on this topic:

(T17) (i) And therefore such propositions ‘change exists’, ‘time exists’, and the like are not to be understood in the same way as the propositions ‘a man exists’, ‘an animal exists’, ‘whiteness exists’, and the like. They must instead be resolved into other propositions, so that saying ‘change exists’ is the same as saying ‘something is changed’. Similarly, saying ‘time exists’ is the same as saying ‘something is changed so that the soul can know how much something else is changed’. (ii) And for the simple-minded people who imagine that as names are distinct so distinct things always correspond to them it would be better to use this way of speaking rather than the other one. Since, however, we must talk as the majority of people do, therefore I want to use a similar way of speaking, but I never understand that time is some one thing distinct as a whole from all permanent things. Rather by this proposition ‘time exists’ we must only understand that something is changed so that the soul can understand how much something else is changed.<sup>35</sup>

In the first part (i) of this passage Ockham intends to point out that the use of the abstract terms ‘change’ and ‘time’ results in a linguistic parallelism between the

<sup>34</sup> Ockham (1985a), 434.110–118: “Et ideo in modernis temporibus propter errores subortos ex usu talium abstractorum melius esset propter simplices in philosophia non uti talibus abstractis, sed tantum verbis, adverbis, praepositionibus, coniunctionibus et syncategorematicis sicut primario fuerunt instituta, quam fingere talia abstracta et uti eis. Immo nisi esset usus talium abstractorum ‘motus’, ‘mutatio’, ‘mutabilitas’, ‘simultas’, ‘successio’, ‘quies’ et huiusmodi, parva esset respectiva difficultas de motu et mutatione, tempore, instanti et huiusmodi.”

<sup>35</sup> Ockham (1985b), 199.127–139: “Et ideo tales propositiones ‘motus est’, ‘tempus est’, et huiusmodi non sunt eodem modo recipiendae sicut tales ‘homo est’, ‘animal [est]’, ‘albedo est’, et consimiles, sed debent resolvi in alias, ut idem sit dicere ‘motus est’, et ‘aliquid movetur’. Similiter idem est dicere ‘tempus est’ et ‘aliquid movetur unde potest anima cognoscere quantum aliud movetur’. Et propter simplices qui imaginantur quod sicut nomina distinguuntur, ita correspondent [eis] semper distinctae res, melius esset uti tali modo loquendi quam alio. Quia tamen loquendum est ut plures, ideo volo uti consimili modo loquendi, numquam tamen intendo quod tempus sit aliquid unum secundum se totum distinctum ab omnibus rebus permanentibus. Sed per talem propositionem ‘tempus est’ non est aliud intelligendum nisi quod aliquid movetur unde anima potest intelligere, quantum movetur aliud.”

sentences ‘change exists’ and ‘time exists’, on one hand, and the sentences ‘man exists’ and ‘whiteness exists’, on the other. This linguistic parallelism, however, conceals a deep semantic difference. The latter couple of sentences signifies the existence of two basic distinct things in the ontology: individual substances and individual qualities, e.g., Socrates and his whiteness. But the former couple of sentences signifies neither basic things in the ontology nor distinct things altogether. In Ockham’s expansion, the sentence ‘change exists’ is not at all about a thing ‘change’ but it is about the body that changes (a permanent thing). Similarly, the sentence ‘time exists’ is not about a thing ‘time’ distinct both from permanent things and from the thing ‘change’, but it is again a sentence about the body that changes and our activity to measure the duration of its change.

In the second part of the passage (ii) Ockham focusses on the distinction between the two abstract terms ‘change’ and ‘time’. This is source of further confusion: the confusion between a linguistic distinction and an ontological distinction, i.e., the assumption that to distinct terms there always correspond distinct things. According to Ockham, it is this kind of confusion - ‘reification’ of linguistic distinctions, so to say- that gives rise to many forms of realism at his time. In particular, it gives rise to a realist interpretation of the distinction between change and time: the view that change and time are two distinct things.

The relationship between change and time is a major issue in Aristotle’s philosophy of time and matter of controversy among his medieval commentators.<sup>36</sup> It is worth taking a closer look at Ockham’s position about it. Traditionally, this issue was formulated as a question about the real distinction between time and change, that is, the question of whether time and change are two distinct things or not. The realist view that Ockham attacks gives a positive answer to this question: time and change are indeed distinct things, and more precisely two distinct successive things. Time is seen as a successive quantity that inheres in any change -an accident of change in Aristotelian terms- a successive quantity that accounts for the temporal extension of a change. The dominant reductionist view at Ockham’s time denies that change and time are distinct extra-mental things. It treats time not as a mind-independent thing that inheres in a change, but as simply the result of the mental operation of measuring the duration of a change. What makes the difference between a change and the time associated to it is a mental operation -an operation of the soul, in medieval terms.<sup>37</sup>

Ockham finds the realist view totally wrong. On the contrary, he is very sympathetic with the reductionist view. However, he cannot simply accept it in its dominant formulation as a negative reply to the question of whether time and change are two distinct things. For, as we have just seen, according to Ockham, neither time nor change is a thing and so it does not make sense to him in the first place to ask whether time and change are the same thing or not. The traditional question itself

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<sup>36</sup> On this topic, see Trifogli (2000), 219–237.

<sup>37</sup> The idea that time depends on the human soul is put forward by Aristotle. On Aristotle’s view, see Coope (2005), 159–172.

needs to be reformulated. Ockham's reformulation goes like this: whether the set of extra-mental things signified by the term 'time' is the same set of extra-mental things signified by the term 'change'. Equivalently, take all the sentences in which the term 'time' appears and all the sentences in which the term 'change' appears. The question then is whether the extra-mental things that are needed to verify the time-sentences are the same as those needed to verify the change-sentences. Ockham's answer to the question reformulated in this way is that the same set of extra-mental things is needed in the two cases. There is actually an additional thing that is required in the case of time and not of change. But, following the dominant reductionist view of his time, Ockham claims that this is an operation of the soul, and not an extra-mental thing:

(T18) ... time is not an extra-mental thing distinct from change. But every extra-mental thing that one can imagine and that is imported by the name 'time' is also imported by this name 'first motion'. However, in addition to this, the name 'time' connotes, or co-signifies or makes one understand, the soul itself that numbers the before and after in a change, so that one of these two complex expressions 'the soul that numbers the before and after in a change' or 'the soul that can number the before and after in a change' falls in the nominal definition of time.<sup>38</sup>

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<sup>38</sup> Ockham (1985b), 291.4–12: "... tempus non est aliqua res extra animam distincta a motu. Sed omnis res imaginabilis extra animam importata per hoc nomen 'tempus' importatur per hoc nomen 'motus primus'. Tamen hoc nomen 'tempus' connotat vel consignificat seu dat intelligere vel forte significat ipsam animam numerantem prius et posterius in motu, ita scilicet quod alterum istorum totorum 'anima numerans prius et posterius in motu', 'anima potens numerare prius et posterius in motu' cadit in definitione exprimente quid significat hoc nomen 'tempus'."

# Chapter 3

## Ockhamistic Inspiration in Modern Tense-Logic



Peter Øhrstrøm and David Jakobsen

**Abstract** The logic and philosophy of William of Ockham (ca. 1285–1347) was a very important inspiration to the founding father of modern tense-logic, A. N. Prior (1914–69). This paper offers a discussion of four aspects of the Ockhamistic inspiration in modern tense-logic: (1) the criticism of the analysis of future contingents in terms of three-valued logic, (2) the discussion of Ockham’s rejection of the classical argument from divine foreknowledge to determinism, that is, from the truth of a statement regarding the future to the necessity (unpreventability) of the statement, (3) Ockham’s understanding of time, including his notion of true future and (4) the use of Ockham’s ideas in modern tense-logic.

**Keywords** William of Ockham · future contingency · three-valued logic · tense-logic · divine foreknowledge · determinism · A. N. Prior · Luis de Molina

The father of modern tense-logic, A. N. Prior (1914–69), found much inspiration in medieval philosophy and logic. In fact, he presented his approach to logic and reasoning on temporal matters as a rediscovery of ancient and, in particular, scholastic ideas regarding logic and time (cf. Øhrstrøm & Hasle, 1993; Jakobsen, 2019). Above all, Prior found inspiration in the logic and philosophy of William of Ockham (ca. 1285–1347). Prior found Ockham’s reflections on the logic of future contingents fascinating, and he studied Ockham’s analysis in *Tractatus de praedestinatione et de praescientia Dei et de futuris contingentibus* in the edition by Philotheus Boehner (1945). Boehner’s volume also contains an edition of a part of Ockham’s commentary on Aristotle’s *De Interpretatione*, and based on his study of this text, Prior made his own annotated translation from Latin of a portion of Ockham’s commentary. He referred to this source several times after 1953 and apparently continued to expand his annotations of it.

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Ockham's book deals with the doctrine of divine foreknowledge. This topic is a central focus of theology and philosophy (see, e.g., Craig, 1988; Hasker, 1998; Beiby & Eddy, 2001). However, in Ockham's book, the focus is mainly on the relevance of the doctrine in logic.

A statement about the future is said to be contingent if the predicted event, state, action or whatever is at stake is neither impossible nor inevitable (Øhrstrøm & Hasle, 2015). Ockham stated his problem in his commentary on Chap. 9 of Aristotle's *De Interpretatione*, where Aristotle famously argued that if a statement about the future (e.g., 'tomorrow, there will be a sea-fight') is true today, then it is also necessary today.

Prior constructed his tense-logic in order to deal with problems like this classical challenge and its theological counterparts, which deal with the apparent conflict between the doctrines of divine foreknowledge and human freedom. Prior presented his tense-logic for the very first time in his Presidential Address given at the New Zealand Congress of Philosophy, Victoria University, Wellington, on 27 August 1954. His paper was published 4 years later in *Franciscan Studies* (cf. Prior, 1958). However, in 1953 Prior had already published a paper on the Aristotelian ideas of future contingency, with a clear reference to Ockham's work (cf. Prior, 1953). According to Jan Łukasiewicz, Ockham had understood the famous Aristotelian text in terms of an idea that closely corresponds to modern three-valued logic. Clearly, it can be questioned whether Ockham actually could have made use of something similar to the rather sophisticated idea of three-valued logic. After all, it is a notion normally conceived as integrated in modern symbolic logic. However, Prior accepted Łukasiewicz's interpretation of Aristotle and Ockham, and he carefully considered this version of the Aristotelian view in his 1953 paper; this analysis also played an important role when, in 1954, he presented his formal tense-logic for the first time. He clearly held that the approach to future contingents in terms of three-valued logic had to be taken into serious consideration. Prior continued this line of investigation in his *Formal Logic* (1955). According to Ockham, acceptance of a theory of future contingents in terms of a three-valued logic might be said to challenge the doctrine of divine foreknowledge. In consequence, Ockham rejected the Aristotelian view.

Prior was very interested in the Aristotelian argument that if statements concerning the future are true, then they also must be necessary. In theological terms, Ockham had pointed out that this argument may be conceived as an attempt to prove that determinism (and lack of human freedom) follows from the doctrine of divine foreknowledge. Prior himself was ready to accept the Aristotelian argument as valid, but he also devoted much attention to Ockham's rejection of the relevance of this argument, and he discussed Ockham's reasons for taking this position. In his papers as well as in his books (cf. Prior, 1955, 1957, 1966, 1967), Prior carefully addressed the various versions of the Aristotelian argument and their consequences.

In his book *Past, Present and Future* (1967), Prior presented a detailed analysis of Ockham's response to the Aristotelian argument and its later elaborations, such as the Master Argument of Diodorus (Prior, 1967, p. 32 ff.). Although Prior eventually rejected Ockham's response to the classical argument, it is obvious that he found

this response attractive and interesting as a possible position regarding the status of future contingents.

The study of future contingents and, in particular, the formulation of tense-logic are topics that call for fundamental reflections on the very nature of time. Arguably, one of the most interesting aspects of tense-logic is that the logic of past, present and future turns out to establish a conceptual framework for a systematic presentation of the notion of time itself. As we will suggest, early steps towards a conceptual analysis of this kind can be found in the works of Ockham and even more explicitly in Prior's elaborations of Ockhamistic ideas.

The first section of this paper focuses on the analysis of future contingents in terms of three-valued logic. Ockham's medieval as well as Prior's modern and critical analysis of this approach are considered. The section investigates Ockham's and Prior's reasons for rejecting the account of future contingents in terms of three-valued logic. Section 3.2 examines the classical argument from the doctrine of divine foreknowledge to the claim of determinism as well as Ockham's rejection of this argument and his emphasis on the importance of the doctrine of divine foreknowledge (corresponding to the modern idea of 'the true future'). The third section considers Ockham's notion of time, arguing that Prior found much inspiration in Ockham's nominalistic approach to the understanding of time and clearly understood that Ockham had insisted on what is now termed 'the true future'. However, Prior himself rejected Ockham's notion of a true future, and Prior even tried to use some of Ockham's ideas in his construction of an Ockhamistic model of branching time. In Sect. 3.4, it is argued that from a philosophical and conceptual point of view, this model is far from Ockham's own conception of time and that it would be more natural to relate Ockham's logical ideas to another tense-logical model, which bears a close similarity to ideas later suggested by Luis de Molina (1535–1600).

Some of the topics considered in the present paper were also discussed in Øhrstrøm and Jakobsen (2018), and it should be seen as a continuation and elaboration of the previous paper. However, in order to make the present paper self-contained, there is some overlap between the two studies.

### 3.1 The Analysis of Future Contingents in Terms of Three-Valued Logic

From the early 1950s and at least until after the publication of his book *Formal Logic*, Prior was interested in Ockham's commentary on Aristotle's *De Interpretatione*. He even produced an annotated translation from Latin of a portion of this text. Prior never published this work, but it is now a part of Prior's Nachlass (Prior, 2019) which has been digitally published. Prior translated a central part of

Ockham's comments on *De Interpretatione*. The following passage is included in Prior's translation of Ockham's text,

The clear understanding of this whole chapter depends on one realising, firstly, that the Philosopher's view is that with these contingent future-tense propositions neither member of a contradictory pair is true or false, just as the reality referred to is no more set to come to pass than it is not to come to pass. Hence he would have said that God no more knows one of the contradictories than he knows the other, or rather that neither contradictory is known to God; for according to the view under consideration neither of the two contradictories is true, and according to the first of the Posteriors nothing is known but what is true, so it follows that neither contradictory is known. However, in truth and according to the theologians we ought not to speak thus, for we ought to say that God definitely knows one of the two contradictories. Just how this comes about, it is up to the theologian to make clear. (Prior 2019, p.3)

Ockham described the problems that may arise in Christian theology if the doctrine of divine foreknowledge is denied. Using the proposition 'this will be white' to represent an arbitrary future contingent, he considered what he called a 'contradiction' about the contingent future, such as 'this will be white tomorrow and this will not be white tomorrow'. He pointed out that the Aristotelian view entails that no part of such a 'contradiction' is true. Furthermore, what God knows must be true. Consequently, an Aristotelian theologian cannot hold that God foreknows contingent propositions about the future. It is likely that Aristotle held that the logic of future contingents should be handled using a third truth-value (undecided) along with the traditional truth-values of true and false. In his discussion of the problem, Prior (1953) analysed how such an account can be carried out in detail.

The Aristotelian view that 'neither of the two contradictories is true' can be illustrated in terms of the contradictories  $F(I)p$ : 'there will be a sea-battle tomorrow' and  $F(I)\sim p$ : 'there will not be a sea-battle tomorrow', where we introduce Prior's tense-logical operator,  $F$ , corresponding to future in its metric form. Similarly, Prior introduced a past operator,  $P$ . The meanings of the metric versions of these tense-operators can be stated as follows:

$F(n)p$  should be read 'in  $n$  time units it is going to be the case that  $p$ '.

$P(n)p$  should be read ' $n$  time units ago it was the case that  $p$ '.

On Ockham's and Prior's interpretation of the Aristotelian text, the claim is that neither  $F(I)p$  nor  $F(I)\sim p$  is true. Furthermore, it also has to mean that neither  $F(I)p$  nor  $F(I)\sim p$  is false. The truth-value of both  $F(I)p$  and  $F(I)\sim p$  has to be 'neuter', that is, neither true nor false. Ockham pointed out that on this view, Aristotle would have to hold that God cannot know either  $F(I)p$  or  $F(I)\sim p$ , that is, that God does not know whether there will be a sea-battle tomorrow or no sea-battle tomorrow. As pointed out by Ockham, this is not acceptable from a classical theological point of view according to which 'God definitely knows one of the two contradictories'. However, Ockham also maintained that this is a complicated matter and that it is difficult to explain, and he left it up to the theologians to clarify the problem.

In his 1953 paper on the analysis of future contingency in terms of three-valued logic, Prior discussed some of the problems to which such an approach gives rise. One of the key problems has to do with the disjunction  $F(I)p \vee F(I)\sim p$ , that is,

‘Either there will or there will not be a sea-battle tomorrow’ (Prior, 1953, p. 326). Based on Łukasiewicz’s and Ockham’s interpretation of the Aristotelian text, the truth-value of any future contingent is  $\frac{1}{2}$ , that is, ‘neuter’. Apparently, if the truth-value of both  $F(I)p$  and  $F(I)\sim p$  is  $\frac{1}{2}$  (‘neuter’), then the truth-value of the disjunction just mentioned will also be ‘neuter’ if the disjunction is assumed to be conceived in a classical, truth-functional manner. However, it is obviously counterintuitive to give ‘Either there will or there will not be a sea-battle tomorrow’ the truth-value ‘neuter’. This disjunction should clearly be conceived as true. But how can  $F(I)p \vee F(I)\sim p$  be true if both parts of the disjunction are ‘neuter’? (In terms of the Polish notation used by both Łukasiewicz and Prior according to which ‘A’ in Polish notation stands for disjunction: How should  $A\frac{1}{2}\frac{1}{2}$  be evaluated?) If the two parts of the disjunction had been identical, as in  $F(I)p \vee F(I)p$ , we would without any hesitation hold that the truth-value should be ‘neuter’. (In terms of Polish notation:  $A\frac{1}{2}\frac{1}{2} = \frac{1}{2}$ ). However, this answer seems obviously wrong in the case of  $F(I)p \vee F(I)\sim p$ , which appears to be true no matter what. (In terms of Polish notation: We would like to have  $A\frac{1}{2}\frac{1}{2} = 1$  in this case.) For this reason, Prior pointed out that if we want to analyse the problem in terms of a three-valued logic, we have to accept that the disjunction is not truth-functional. In his own words,

Would Aristotle, perhaps, have defended his position by so using ‘Either’ that a disjunction of in-determinate propositions is not itself automatically indeterminate, but automatically true? Hardly. It is plain, I think, that Aristotle would not have regarded a disjunction of indeterminate propositions as ‘automatically’ anything—he would have said that usually  $A\frac{1}{2}\frac{1}{2} = \frac{1}{2}$ , but if the ‘q’ in  $Apq$  happens to be ‘Not p’, the disjunction is not indeterminate but true. This amounts to saying that in the three-valued logic of Aristotle, so far as he had such a thing, disjunction was not a truth-function. Or alternatively we may say - and this, I think, is the simple truth - that at this point Aristotle was quite excusably muddled, and was trying to use ‘proposition’, ‘true’, etc., at once in senses in which the logic of these things is two-valued and in senses in which it is three-valued. (Prior 1953, p. 326)

In his *Formal Logic*, Prior also considered the implication ‘If A is going to occur, then God knows that A is going to occur’ (1955, pp. 242, 245). Intuitively, this implication is clearly true no matter what. However, assuming that the antecedent is contingent, its truth-value becomes  $\frac{1}{2}$ , ‘neuter’. Assuming that ‘God knows that p’ is false unless p is true, this leads to a counterintuitive result. In a footnote to his translation of Ockham’s commentary on *De Interpretatione*, however, Prior pointed out that it is mistaken to see ‘God knows that A is going to occur’ as false just because the proposition ‘A is going to occur’ is ‘neuter’. As Prior saw it, the truth-value of ‘God knows that A is going to occur’ will also be ‘neuter’, and he saw no problem in assuming that the conditional in this case is true. He wrote,

Ockham in fact at this point picks his way very skilfully indeed through the consequences of adding a third truth-value while preserving the idea that an implication is true if and only if its consequent is not in a worse case than its antecedent (and formally true if and only if its consequent is in no instance in a worse case than its antecedent). (Prior, 2019, note 5).

In this way, Prior showed that it is in fact possible to hold that the implication ‘If A is going to occur, then God knows that A is going to occur’ is true in general, even within an analysis in terms of three-valued logic. However, even if this analysis

is consistent with our intuition when it comes to propositions like the disjunction ‘Either there will or there will not be a sea-battle tomorrow’ and the implication just mentioned, it would still be problematic to hold that neither ‘there will be a sea-battle tomorrow’ nor ‘there will not be a sea-battle tomorrow’ is true now. Although we do not know now which of them is true, it will become clear tomorrow.

Prior certainly found the idea of a three-valued logic very interesting. If the disjunction is understood as not truth-functional, we might of course carry on with the analysis in terms of three-valued logic, maintaining that

$$F(1)p \vee F(1)\sim p \quad (1)$$

is valid in general. However, Prior also realised that this approach to tense-logic gives rise to a number of difficult problems and leads to some rather counterintuitive conclusions.

### 3.2 Ockham’s Rejection of the Argument from Divine Foreknowledge to Determinism

With a specific reference to Ockham’s analysis of Aristotle’s discussion of future contingents in *De Interpretation*, Prior wrote,

Aristotle’s chapter on ‘future contingents’ was the subject of much discussion among the later medieval logicians, who were worried by the problem of reconciling Aristotle’s views here (if this could be done) with the doctrine of God’s foreknowledge. In connection with the Aristotelian statement quoted above, that ‘When it is, whatever is is-necessarily, and when it is not, whatever is not necessarily is-not’, numerous medieval commentators (and some modern ones) have argued that we cannot say that ‘whatever is is-necessarily’, but only that ‘necessarily, whatever is is’. (1953, p. 324)

The conclusion that the medieval logicians primarily wanted to avoid was the following thesis (where  $n$  is an arbitrary positive number):

$$F(n)p \supset LF(n)p \quad (2)$$

Here  $L$  is the operator Prior used for ‘necessity’ – or as he called it, ‘now-unpreventability’. If (2) is valid in general, it means that whenever something is true about the future, it will also be necessary, that is, that the truth of  $F(n)p$  implies that it is impossible for us to prevent  $F(n)p$ . In terms of divine foreknowledge, (2) means that if God knows that  $p$  is going to be the case in  $n$  time units, then nothing we can do can prevent  $p$  from being the case in  $n$  time units. It is necessary (now-unpreventable) that  $p$  will be the case in  $n$  time units. Thus there can be no future contingents.

There is a classical argument in favour of (2) based on some of the logical principles of mixing the tenses of past and future. Prior found a famous example of this kind in Ockham's logic:

The first of these 'mixing principles' I had found in Ockham's *Tractatus de Praedestinatione*, the reprinting of which by the Franciscan Institute in 1945 had helped to make people aware in that decade of some of the scholastic views on logic and time. Ockham says in this work: *Si haec propositio sit modo vera: Haec res est, quacumque re demonstrate semper postea erit haec vera: Haec res fuit* ('If this proposition, *This thing is*, be once true, whatever be the object pointed to, then for ever after will this be true: *This thing was*'). (1967, p. 35)

The very basic tense-logical thesis that Ockham identified in this way can be formalised in terms of Prior's (metric) tense-logic as follows:

$$p \supset F(n)P(n)p \quad (3)$$

Prior also considered what he called the mirror images of (3), that is, the theses

$$p \supset P(n)F(n)p \quad (4')$$

$$P(n)F(n)p \supset p \quad (4'')$$

Clearly, (4') and (4'') are provable from each other if we use contraposition and assume that  $\sim P(n)p$  and  $P(n)\sim p$  as well as  $\sim F(n)p$  and  $F(n)\sim p$  are equivalent.

The classical argument in favour of (2) is based on (4') and (4'') and a few other assumptions. Among the additional premises, the argument presupposes the principle that the past is now-unpreventable, that is,

$$P(n)p \supset LP(n)p \quad (5)$$

(5) means that if  $p$  was the case  $n$  time units ago, then it is now unpreventable that it was so. Furthermore, we need to assume basic propositional logic (PC) and some basic principles of modal logic, including necessitation (i.e., if  $A$  is a thesis, then  $LA$  is also a thesis) and the modal axiom:

$$L(p \supset q) \supset (Lp \supset Lq) \quad (M)$$

Based on these assumptions, we may prove (2) in the following manner:

- |  |   |
|--|---|
| (a) $F(n)p \supset P(m)F(m)F(n)p$          | [from (4') by substitution]                           |
| (b) $P(m)F(m)F(n)p \supset LP(m)F(m)F(n)p$ | [from (5) by substitution]                            |
| (c) $F(n)p \supset LP(m)F(m)F(n)p$         | [from (a) and (b) by (PC)]                            |
| (d) $P(m)F(m)F(n)p \supset F(n)p$          | [from (4'') by substitution]                          |
| (e) $L(P(m)F(m)F(n)p) \supset F(n)p$       | [from (d) by necessitation]                           |
| (f) $LP(m)F(m)F(n)p \supset LF(n)p$        | [from (e) and (M)]                                    |
| (g) $F(n)p \supset LF(n)p$                 | [from (c) and (f) by (PC);<br>(g) identical with (2)] |

Given a general version of (1), it is obvious that we may extend the proof a bit:

$$\begin{array}{ll}
 F(n)\sim p \supset LF(n)\sim p & \text{[from (c) by substitution]} \\
 F(n)p \vee F(n)\sim p & \text{[a general version of (1)]} \\
 LF(n)p \vee LF(n)\sim p & \text{[from (g), (h) and (i) by (PC)]}
 \end{array}$$

It is straightforward to read (j) as a rather strong version of determinism. It means that no matter whether  $p$  or  $\sim p$  turns out to be the case in  $n$  days, what happens will happen by necessity, in the sense that none of us can do anything in order to prevent what happens.

If the above argument is accepted, then a true statement about the future cannot be contingent. This would mean that neither the statement ‘This will be white tomorrow’ nor the statement ‘This will not be white tomorrow’ is contingent. Ockham clearly rejected conclusions of this kind. Consequently, he wanted to question the argument from the truth of a proposition about the future to the necessity of it. Given that the argument is logically valid, we can avoid the conclusion in (g) only if we reject at least one of the assumptions used in the above proof. Very few would question (PC) and the basic assumptions of modal logic. According to Ockham, (5) is the crucial assumption in the argument. He commented on its role in the argument in the following manner:

This argument is based on the proposition that a singular proposition true about the past is necessary. Therefore if ‘this is white’ is true now, ‘“this will be white” was true’ is necessary. Consequently, it is necessary that it happen, and cannot come about otherwise. (Adams & Kretzmann, 1983, p. 99)

Ockham argued that the principle of the necessity (or unpreventability) of the past should be rejected, at least in general, although the principle in some cases is evidently valid. Ockham’s claim is that the principle holds only for a statement about proper past events. He explained,

Some propositions are about the present as regards both their wording and their subject matter (*secundum vocem et secundum rem*). Where such [propositions] are concerned, it is universally true that every true proposition about the present has [corresponding to it] a necessary one about the past—e.g. ‘Socrates is seated’, ‘Socrates is walking’, ‘Socrates is just’, and the like. (Adams & Kretzmann, 1983, p. 46)

In such cases, the principle of the necessity of the past clearly holds, because the negations of the statements in question are now impossible. Ockham put it in the following manner:

Every proposition that is merely about the present, if it is true, has [corresponding to it] a necessary proposition about the past. But by hypothesis ‘the will wills X at  $t_I$ ’ is true, and it is merely about the present. Therefore ‘the will willed X at  $t_I$ ’ will be necessary forever after. Therefore after  $t_I$  ‘the will did not will X at  $t_I$ ’ cannot be true. (Adams & Kretzmann, 1983, p. 73)

On the other hand, Ockham pointed out that some propositions are about the present only with respect to their linguistic form, but actually depend on the future. According to Ockham, the past version of such propositions should not be accepted as necessary. For example, this would be the case for propositions regarding God’s

past foreknowledge about the future, which is related not to the past but rather to the future. In his own words,

Other propositions (than past or present) are about the present as regards their wording only and are equivalently about the future, since their truth depends on the truth of propositions about the future. Where such [propositions] are concerned, the rule that every true proposition about the present has [corresponding to it] a necessary one about the past is not true. (Adams & Kretzmann, 1983, pp. 46–47)

Formally, this solves the logical problem. Given this limitation of the principle of the necessity of the past, Ockham could hold that future contingents can be true (and known by God). The price is, of course, that the logician must make a distinction between two types of statements and that in some cases substitution will be permitted only for one type of statement and not for others. In the modern discussion of Ockham's position, philosophers and logicians have identified a distinction between what have been termed 'hard' and 'soft' facts about the past.

A soft fact depends on the future, whereas a hard fact does not. In particular we focus on the classification of statements regarding God's past foreknowledge. According to *Ciro de Florio and Aldo Frigerio (2016)* divine beliefs are viewed as 'a particular kind of soft facts, whose existence counterfactually depends on future facts' (p. 506). *Alvin Plantinga (1986)* has stated his view on *Ockham's Way Out (1986)* as follows:

Accordingly, let us provisionally follow Ockham in holding that there is a viable distinction between hard and soft facts about the past. The importance of this distinction, for Ockham, is that it provides him with a way of disarming the arguments for logical and theological determinism from the necessity of the past. Each of those arguments, when made explicit, has as a premise ... 'If  $p$  is about the past, then  $p$  is necessary' or something similar. Ockham's response is to deny [that]. (p. 247)

It is in fact not unproblematic to establish a clear distinction between proper statements about the past and other statements formulated in the past tense. It is obvious that some statements in the past tense can be classified as referring to the future. For example, as mentioned, this would be the case for statements regarding God's foreknowledge yesterday about what was going to happen in two days. A statement of this kind would not be about what was the case yesterday but rather about what is going to be the case tomorrow. However, what if yesterday God communicated his foreknowledge to a prophet who was told to proclaim what was going to happen? In this case, it appears that a statement regarding the claim of the prophet would in fact be a proper statement about the past corresponding to what has been called a hard fact. It appears that Ockham was aware of this revealed-prophecy problem. In his book, Ockham discussed the consequences of accepting that 'it is necessary that what is revealed come to pass' (Adams & Kretzmann, 1983, p. 44). Clearly, this suggests that if a prophet reveals a future event according to what God knows, then the future event in question will be necessary, and the corresponding statement about the future cannot be contingent. According to Ockham's view, it follows that if God reveals in advance what a person it is going to choose, then the choice of the person can no longer be free. Thus, the challenge for Ockham was to

identify a way to secure human freedom along with the assumption of true future contingents and the possibility of true prophecies based on divine foreknowledge. He did so by assuming that all prophecies regarding any future contingents are conditionals (Adams & Kretzmann, 1983, p. 44). He illustrated his point with an example related to the Old Testament prophet Jonah, who was told to proclaim to the inhabitants of Nineveh that their city would be destroyed in 40 days. According to the biblical text, Nineveh was not destroyed after 40 days, but because the divine message proclaimed by the prophet must be true, the prophecy must be understood as a conditional, that is, with the addition of ‘unless they would repent’ (Adams & Kretzmann, 1983, p. 44). Because the citizens of Nineveh did repent, the city was not destroyed.

The crucial point of Ockham’s solution is obviously that it depends on the assumption that the divine foreknowledge of future contingents is silent in the sense that no unconditional prophecy corresponding to any of these statements is revealed by God. According to Ockham, it is what is now referred to as a soft fact that God silently knew that a certain future contingent was true, whereas it would become what is referred to as a hard fact if it were revealed to a prophet (or somebody else) in an unconditional manner. Furthermore, Ciro de Florio and Aldo Frigerio (2016) have pointed out that the Ockhamist will be committed to some sort of backward causation since my free decision now determines what God’s knew in the past.

### 3.3 Ockham’s Notion of Time and the Idea of a Thin Red Line

In his Presidential Address given on 27 August 1954 at the New Zealand Congress of Philosophy, Victoria University, Wellington, Prior presented his formal tense-logic as a modern version of medieval logic as opposed to medieval theology. Whereas medieval logic, according to Prior, typically defended a view of time according to which tenses should be taken seriously, he found that mainstream medieval theology supported the view that time should be conceived as a series of dates described in terms of the I-calculus (i.e., the calculus of earlier and later). In his own words,

It seems obvious, indeed, that the I-calculus is deterministic in its whole conception – time is represented in it as spread out once for all, with no ever-moving ‘now’ but only a series of ‘dates’ timelessly characterised in various ways (Socrates eternally sitting down at x but not sitting down at y, and so on). There can really be no ‘neuter’ truth-value for the only kind of ‘proposition’ which this calculus will admit. Time, one might say, figures in the I-calculus not as it does in medieval logic which, as we have pointed out earlier, took tenses far more seriously than our own common logic does, and which already had such laws as our PF1, but rather as it does in medieval theology, in which God is said to behold all events in an unchanging present. (Prior, 1958, p. 117)

There can be little doubt that Prior thought of William of Ockham as a very good representative of the tense-logical view of medieval logic. He referred to PF1, which

is a tense-logical law close to (3) mentioned in Sect. 3.2. Prior probably would have characterised Thomas Aquinas' view of time as typical of medieval theology. In a letter to his wife Mary, written a few hours after he gave his Presidential Address, Prior wrote,

There was a very pugnacious priest at the back who said that he was 'a Thomist & a strict Thomist', that this was the first exhibition he had seen of 'logistics', & that (this very aggressively & totally irrelevantly) he wanted to know if I was a 'realist'. I had a great deal of pleasure in telling him that I was far more of a realist than he was, & that he would in fact classify me as an 'extreme' realist. (Prior, 1954, p. 2)

According to the view that Prior defended with increasing clarity over the years, the tenses represent the proper and important aspects of reality, whereas the before-after calculus is an abstract (but useful) construct based on the tense-logical structures of reality. In other words, time as a series of events is an abstract construction, whereas the distinction between past, present and future is rooted in reality. The basic question regarding reality would in Prior's opinion be 'what is true now about the world as it was, as it is, and as it is going to be?'. Prior held that this view is just a modern version of what was typically defended in medieval logic by philosophers like William of Ockham.

Although time as a linear series of dates (or other temporal units), according to Ockham and Prior, is an abstract construction, it is an idea that is straightforward to establish. As pointed out by Garrett J. DeWeese, Ockham accepted the Aristotelian definition of time as 'the number of motion with respect to before and after', and with his nominalist understanding of numbers, he took Aristotelian time to mean 'the measure whereby we determine the duration of motion, and by extension, the duration also of rest and of the existence of any object subject to generation and corruption' (2004, p. 195). Clearly, this concept of time is easily understood as a linear series of dates, just as the set of numbers gives rise to a linear series. As emphasised by DeWeese, this does not mean that time is a thing in itself, and Ockham probably would have opposed Newton's concept of absolute time as well as Minkowski's space-time geometry (2004, p. 197). But given the assumption of God's knowledge of the unique past and the doctrine of divine foreknowledge, the durational measurements of the events in past, present and future give rise to a linear ordering. In other words: There is a unique past and a unique future.

The assumption that there is a true future known by God is crucial in Ockham's worldview, and in his writings, he stated several times that 'God determinately knows one or the other part [of the contradiction]'. For Ockham, this assumption is something that 'must be said' and one that 'must be explained in theology' (Adams & Kretzmann, 1983, p. 106). According to Ockham, it is impossible that God should not know future propositions:

For if 'A will be' and 'God does not know that A will be' are true together, then 'something true is not known by God' is possible, which seems impossible. (Adams & Kretzmann, 1983, p. 107)

Although Ockham often emphasised his commitment to the doctrine of God's foreknowledge and claimed that it is a view that 'must be held beyond question'

(Adams & Kretzmann, 1983, p. 48), he also stated that the doctrine is given to us as a consequence of ‘the truth of the Faith’ (Adams & Kretzmann, 1983, p. 110). According to Ockham, the problem is that ‘it is impossible to clearly express the way in which God knows future contingents’. This may have to do with the limitation of the human mind and intellect. The qualities of divine cognition and knowledge may simply pass all human understanding. In Ockham’s words,

But to explain this clearly and to describe the way in which He knows all the future contingents is impossible for any intellect in this [present] condition. (Adams & Kretzmann, 1983, p. 110).

Nevertheless, Ockham tried to understand this difficult issue a bit better. He claimed that ‘the divine essence is an intuitive cognition that is so perfect, so clear, that it is an evident cognition of all things past and future’ (Adams & Kretzmann, 1983, pp. 19, 50, 90). He maintained that ‘there is one single cognition in God of complexes and non-complexes, of necessities and of contingents, and universally of all things imaginable’ (Adams & Kretzmann, 1983, p. 91). Still, that God obtains knowledge about all future contingents by his divine essence is a matter of the Faith. In Ockham’s words,

This conclusion, although it cannot be proved a priori by means of the natural reason available to us, nevertheless can be proved by means of the authorities of the Bible and the Saints, which are sufficiently well known. (Adams & Kretzmann, 1983, p. 90)

Regardless of what led Ockham to his conclusion, there can be no doubt that he held that there is a unique future known by God and that the future events can be organised as a linear structure that can be represented in terms of numbers. Similarly, Ockham held that there is a unique past known by God. In this way, it follows from Ockham’s position that there is a unique linear order at any moment in the temporal flow from the past to the future. However, following Ockham’s reasoning, it seems that we can say even more, because it appears straightforward that this conclusion holds not only for actual moments (past, present or future) in the true story about the world, but also for counterfactual moments that might have been parts of the true story about the world. To understand why this seems to follow from the Ockhamistic position, it is helpful to turn again to Ockham’s example of the prophet Jonah. According to Ockham’s understanding of the doctrine of divine foreknowledge, God certainly knew that the citizens of Nineveh would repent as a response to the conditional prophecy. It would be natural to see God’s act of sending Jonah to Nineveh as an expression of His divine mercy. That is, Jonah is sent to Nineveh because God knows how the citizens will respond to the prophecy. Other cities on their way to destruction may not get a similar warning, because God knows that a message of that kind would be ignored by the citizens of those cities if it were communicated to them. On this interpretation, the assumption is that God knows not only how people are going to choose in the true future, but also how they would act and choose in any counterfactual situation. In general, the claim is that for any counterfactual moment, God knows all the details of what would turn out to happen if that counterfactual moment were real. By his use of the example of the prophet Jonah, Ockham seems to come rather close to the position

that Luis de Molina proposed two centuries later arguing that God has so-called ‘middle knowledge’ about every possible situation (see Molina, 1988; Øhrstrøm, 2014; Øhrstrøm, 2018; De Florio & Frigerio, 2019a, 2019b, 2020). Stated in a modern context, this view means that there is a unique linear order from the past to the future at any possible moment – factual or counterfactual. Obviously, it may be questioned whether a step from Ockham’s or Scotus’ ideas to Molina’s view is needed (Dekker, 1998). However, for the reasons just given, it may be argued that important aspects of Ockham’s view on the logic of tenses easily give rise to a Molinistic view on the future.

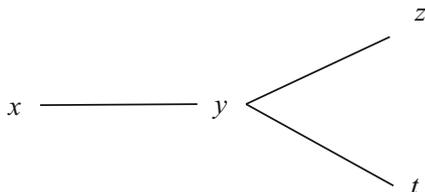
Prior was certainly aware of Ockham’s view on divine foreknowledge and its consequences for an Ockhamistic tense-logic. In ‘Postulates for Tense-logic’ 1966, Prior presented Ockham’s view as implying that there is ‘a single *designated route*’ (1966, p. 157), that is, a designated future. In an undated draft titled *Postulates for Tense-logic*, probably written as an early version of (Prior, 1966) he even suggested that this route might be picked out in red, representing the actual course of events (Prior, 1965, p. 6). Belnap and Green (1994) later introduced the term ‘the thin red line’ with reference to an idea very much similar to Prior’s designated route, ‘picked out in red’. The term suggested by Belnap and Green was not inspired by Prior’s earlier notion (Belnap apparently never received a copy of Prior’s draft, and he was not aware of Prior’s use of the expression [Personal communication, 25 April 2012].) Rather, Belnap and Green’s term was inspired by a report from the Crimean War in the *London Times*: ‘The Russians dashed on towards that thin red-line streak tipped with a line of steel.’

Obviously, the notion of the thin red line is just a modern presentation of the idea of a detailed future foreknown by God. The idea has been the subject of lively discussion since the publication of Belnap and Green (1994). It has been attacked as deeply problematic. It has even been suggested that the thin red line should in fact be conceived as infrared, indicating ‘that the Thin Red Line does not imply that mortals are capable of seeing the future’ (Belnap et al., 2001, p. 139). However, the idea has also been defended in a modern context (Øhrstrøm, 2009).

### 3.4 The Possible Use of Ockham’s Ideas in Modern Tense-Logic

In a letter to Prior dated 3 September 1958, Saul Kripke suggested the use of what was later called branching time in temporal logic. Prior accepted the idea and developed it further (see Ploug & Øhrstrøm, 2012). In his *Postulates for Tense-Logic* (1966), Prior proposed an Ockhamistic system in terms of branching time. As mentioned above, his system incorporated Ockham’s view on divine foreknowledge. Prior did so by including ‘a single *designated route* [*sic*] from left to right, taking one direction only at each fork’. However, this discussion was not included when, the following year, Prior published his famous book *Past, Present and Future* (1967).

**Fig. 3.1** The duration between  $x$  and  $y$  is supposed to be  $m$ , and the duration between  $y$  and  $z$  as well as the duration between  $y$  and  $t$  is  $n$



Prior presented his modern version of Ockham's ideas in terms of branching time. He defined this model as 'a line without beginning or end which may break up into branches as it moves from left to right (i.e., from past to future), though not the other way; so that from any point on it there is only one route to the left (into the past) but possibly a number of alternative routes to the right (into the future)' (Prior, 1967, p. 126). Each point in the diagram represents a possible instant; that is,  $x$ ,  $y$ ,  $z$  and  $t$  in Fig. 3.1 should all be understood as possible instants:

Prior presented the semantics of an Ockhamistic model of this type in terms of both actual truth-values and what he called *prima facie* assignments of truth-values using the following prescriptions (see Prior, 1967, p. 126):

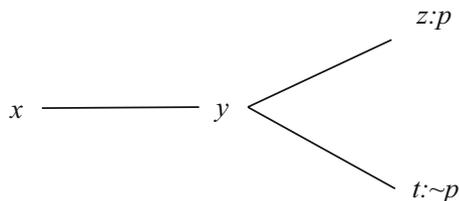
1. Each propositional variable is arbitrarily assigned a single truth-value at each point.
2. A *prima facie* assignment to  $F(n)\alpha$  at a given point  $x$  for a given route to the right of  $x$  gives it the value assigned to  $\alpha$  at the distance  $n$  along that route from  $x$ . (If the line branches within this distance, there may be different *prima facie* assignments to  $F(n)\alpha$  at  $x$ .)
3. The *prima facie* assignment to  $P(n)\alpha$  at a given point  $x$  for a given route for  $\alpha$  to the right of  $x$  gives it the value assigned to  $\alpha$ , for that route, at the distance  $n$  to the left of  $x$ . From the latter point as far as  $x$ , the only rightward route for  $\alpha$  that is considered is the one that passes through  $x$ .
4. The assignment to  $L\alpha$  at  $x$  gives it truth if  $\alpha$  is given truth in all its *prima facie* assignments at  $x$ ; otherwise falsehood.
5. Truth-functions and quantifications as usual.

According to Prior (1967, p. 126), a formula is verified in an Ockhamist model 'if all actual and *prima facie* assignments to it in the model give it truth'. A formula is Ockhamistically valid if it can be verified in any Ockhamist model.

It follows that the formula  $P(m)F(m+n)p \supset LP(m)F(m+n)p$  is Ockhamistically invalid. This is evident in the model shown in Fig. 3.2, because at  $y$ , the proposition  $P(m)F(m+n)p$  is false for  $xyt$  but true for  $xyz$ . Consequently, the implication will be false at  $y$  for  $xyz$ .

This example shows that Prior's Ockhamism falsifies the claim that if something has been the case, it is now necessary that it has been the case. As the example clearly demonstrates, this is not so in general. The rejection of the necessity of the past in general should be expected of any attempt to formalise Ockham's ideas;

**Fig. 3.2** The duration between  $x$  and  $y$  is supposed to be  $m$ , and the duration between  $y$  and  $z$  as well as the duration between  $y$  and  $t$  is  $n$ . Furthermore, it is indicated that the proposition  $p$  is true at  $z$  but false at  $t$



however, there are other requirements that would be reasonable for a semantic theory to qualify as a satisfactory formalisation of Ockham's view.

In fact, it is problematic that statements about the contingent future cannot be true according to Prior's Ockhamism (i.e., they cannot have actual truth-values but only *prima facie* assignments). According to Prior's Ockhamism, such statements can only be true relative to specified courses of events. As argued by Jakobsen, Øhrstrøm and Hasle (2017), this is a rather unsatisfactory representation of Ockham's view of time. According to Ockham, it certainly makes sense to speak about the true contingent future, and hence Prior's branching-time diagram is not an accurate representation of what Ockham would have affirmed (see Øhrstrøm & Hasle, 2015).

As mentioned by M. J. Cresswell, it should be noted that Prior apparently assumed that 'all truths are made up of simple truths, which are about a particular time' (2007, p. 294). William of Ockham seems to have made a similar assumption much earlier.

In addition, we may in fact question the very idea of representing Ockham's tense-logic in terms of branching time, because this kind of thinking seems to be far from the Ockhamistic view on time. It may, of course, seem rather anachronistic to ask whether Ockham would have accepted the concept of branching time. On the other hand, he clearly rejected the idea apparently suggested by John Duns Scotus (1266–1308) regarding different instants of nature at the same instant of time, that is, instants that are not in succession but rather alternatives at which opposite actions would occur. According to Ockham's interpretation, Scotus' instants of nature appear to constitute a medieval parallel to the modern idea of branching time. However, as William Lane Craig (1988, p. 158) pointed out, 'it is doubtful that Ockham has fairly represented Scotus'. It may not have been Scotus' intention to present his ideas of instants of nature in a temporal context. According to Craig, Scotus' instants of nature are unrelated to a development in time and may rather be seen as 'different logical moments in the order of explanatory priority' (p. 134). It is beyond the scope of this paper to discuss the complicated question of what Scotus intended to argue. In the present context, it suffices to note that according to Ockham's interpretation, Scotus suggested that there are different moments of nature at the same moment of time. It seems safe to say that Ockham found that it would be a misunderstanding to refer to non-temporal instants of nature to explain and defend free choice. In his own words:

I do not agree with Scotus as regards that nonevident capacity in the will, for he is mistaken in all those 'instants of nature'. (Adams & Kretzmann, 1983, pp. 75–76)

Such considerations give rise to the following question: Would it be possible to create a formal theory of semantics corresponding to Ockham's view without the use of a Kripke-like branching-time system? In fact, it should be noted that branching time was not used in Prior's early presentations of tense-logic (e.g., in *Time and Modality* [1957]). This suggests that it may be possible to ignore branching time and to formulate a formal semantics corresponding to Ockham's indeterministic logic without the concept of branching time. If this can be done, the ways in which possibility and necessity can be represented without the notion of branching time should be explained. In Øhrstrøm and Jakobsen (2018), we investigated this possibility of creating a semantics corresponding to Ockham's indeterminism without the use of branching time. The idea was to introduce a notion of an Ockham model as a 5-tuple,  $(\text{TIME}, <, dur, \Phi, \Psi)$ . Here  $(\text{TIME}, <)$  is a linearly ordered set of temporal instants, and  $dur$  is a function from  $\text{TIME} \times \text{TIME}$  to the non-negative numbers, such that  $dur(t, t')$  represents the duration from  $t$  to  $t'$ . Furthermore,  $\Phi$  is a denumerable set of basic propositional letters  $(p, q, r, \dots)$  over which the propositions of the logical language can range given the usual rules for well-formed formulae in metric tense-logic (with tense operators  $F(n)$  and  $P(n)$  corresponding to future and past and a modal operator,  $L$ , corresponding to necessity, i.e., 'now-unpreventability'). Finally,  $\Psi$  is a set of so-called assignment functions from  $\text{TIME} \times \Phi$  to the truth-values  $\{0, 1\}$ ; that is, each such function in  $\Psi$  gives a truth-value for each instant to each propositional letter. This means that for any pair, such as  $(t, q)$  in  $\text{TIME} \times \Phi$ , of a temporal moment and a propositional letter of the logical language, and for any  $\pi \in \Psi$  a truth-value,  $\pi(t, q)$ , is given as either 0 (false) or 1 (true) (see Jakobsen, Øhrstrøm, & Hasle, 2017 p. 18). There are of course many such basic truth-value functions. In some cases, two of these functions,  $\pi_1$  and  $\pi_2$ , may agree up to some moment in time,  $t_0$ . This can be stated symbolically as  $sim(\pi_1, \pi_2, t_0)$ ; that is, this relation holds if and only if  $\pi_1(t, q) = \pi_2(t, q)$ , for any propositional letter  $q \in \Phi$  and any  $t \leq t_0$ .

For any Ockhamistic model  $(\text{TIME}, <, dur, \Phi, \Psi)$ , the truth-value of a proposition in the formal language may be defined recursively for any  $t \in \text{TIME}$  and any  $\pi \in \Psi$ . The crucial idea here is the semantics of the  $L$ -operator:

$L\alpha$  is true at  $t$  if  $\alpha$  is true with any assignment function  $\pi' \in \Psi$  for which  $sim(\pi', \pi, t)$ ;  
otherwise, it is false.

This means that the evaluation of propositions involving modal operators has to depend on quantification over assignment functions. It was shown in Øhrstrøm and Jakobsen (2018) that a system established in this way can have all the properties we would like an Ockhamistic tense-logic to have, including a notion of true future and the idea that future contingents can be true.

One obvious advantage of the approach presented is that it shows that Prior's somewhat tricky distinction between actual and prima facie assignments can be eliminated. Furthermore, it should be noted that according to this approach, possibility and time are not integrated as they are for branching time. This means that future possibilities are not explained in terms of possible future instants or times. In this approach, time is treated as a linear structure, which makes the idea of

the true future (i.e., what is actually going to happen) conceivable. Strictly speaking, this means that there is only one course of true future events; however, although this allows for a meaningful description of *the true future* as what is actually going to happen, it can still be maintained that a number of alternatives are possible as well. According to this view, there are future possibilities other than those that are going to occur, but contrarily to the branching-time view, these alternatives are not viewed as constituting alternative possible future instants. The alternatives are simply events that could take place during the future course of events.

Another advantage of this formalisation of Ockham's answer is that it solves the problem that would otherwise need to be solved in terms of middle knowledge. This is because the truth conditions of a future tense statement will be well-defined relative to any truth-value function. In other words, there will be a meaningful notion of the true future even for a counterfactual case, that is, regardless of which  $\pi$ -function is used. Thus, it is reasonable to claim that a certain future contingent is true in a particular counterfactual situation that could have occurred if different actions were taken in the past. In this way, the solution is clearly Molinistic.

It should, however, be admitted that this formalisation of Ockham's tense-logic depends strongly on the Priorean assumption mentioned above that 'all truths are made up of simple truths, which are about a particular time'. The reference to assignment functions and even to quantification over such functions makes it important that it is – at least in principle – possible to identify the set  $\Phi$ , that is, the set of basic or simple truths corresponding to the propositional letters in the underlying alphabet. It should also be noted that  $\Psi$  is in principle just a subset of all conceivable assignment functions from  $\text{TIME} \times \Phi$  to  $\{0,1\}$ . This is important in light of the complexity of reasoning. In this way, the variation of truth-values in the system may be limited in a reasonable manner, taking into account that the propositional letters may be seen as representing simple natural language statements. It turns out that many rather simple statements formulated in natural language, like 'he is well-born' or 'he is a father', clearly depend on other statements (see Cresswell, 2007). For conceptual reasons, we may not want arbitrary truth-value variations of such statements.

Furthermore, it should be admitted that although this formalisation of Ockham's logic is based on the idea of linear time combined with a representation of modality in terms assignment functions, it might formally be translated into a branching-time formalism using pairs of times and assignment functions,  $(t, \pi)$ , as moments. However, for metaphysical reasons, we may also want to keep times conceptually apart from assignment functions.

Given the complications and challenges that follow from the strong conceptual dependence on the use of assignment functions, we may want to reconsider the approach. In addition, as observed above, the formal model is formally linear only because it turns out to be equivalent to a branching-time model referring to pairs of times and assignment functions. For this reason, it might be interesting to reconsider the possibilities of a branching-time model based on Ockhamistic and Molinistic ideas. In what follows, we present a model of this kind.

Let us assume a traditional backwards linear and forwards branching-time system based on a partially ordered set of instants (TIME, <), that is, a so-called tree. The linear and complete subsets of TIME are called chronicles. Through every instant in TIME,  $i$ , there is at least one chronicle and perhaps many. If two chronicles,  $c_1$  and  $c_2$ , both are passing  $i$ , then the parts of  $c_1$  and  $c_2$  before  $i$  will be identical.

As mentioned above, Prior's representation of Ockham's tense-logic in his paper *Postulates for Tense-Logic* (1966) incorporated 'a single *designated route* [sic] from left to right, taking one direction only at each fork'. This means that there is a chronicle in the Ockhamistic branching-time system with a very special status. This thin red line represents what was the case, what is the case, and what is going to be the case. At every moment of this actual story or chronicle, there is a unique past and a unique future. However, as we have seen, it would be straightforward to hold that this should also be the case at counterfactual instants. The claim is that if a counterfactual instant had been factual, there would have been a unique past and a unique future at that instant. Taking this Molinistic step, the thin red line should be more than just a single chronicle. We should instead assume a function, TRL, from the set of instants in TIME to the set of chronicles in the branching-time system. This means that there will be a thin red line at every instant in TIME. For arbitrary instants,  $i$  and  $i'$ , the following properties of TRL should hold:

$$i \in \text{TRL}(i) \tag{TRL1}$$

$$(i' \in \text{TRL}(i) \ \& \ i < i') \supset \text{TRL}(i) = \text{TRL}(i') \tag{TRL2}$$

(TRL1) means that the thin red line seen from an instant,  $i$ , will have to be a chronicle through that instant,  $i$ . (TRL2) means that if a later instant,  $i'$ , belongs to the thin red line of an instant,  $i$ , then the two instants will have the same thin red line.

It follows from the assumption that the branching-time system is backwards linear that the past part of any chronicle in the system will include all past instants. Therefore, the following holds for arbitrary instants:

$$i < i' \supset i \in \text{TRL}(i') \tag{TRL3}$$

Given an instant  $j$ , we can introduce an adjusted thin red line function,  $\text{TRL}_j(i)$ , by defining that  $\text{TRL}_j$  and  $\text{TRL}$  differ only for instants that belong to the past of  $j$ , in which case  $\text{TRL}_j$  gives the chronicle  $\text{TRL}(j)$ . In other words,  $\text{TRL}_j(i) = \text{TRL}(j)$  for  $i < j$ , and otherwise  $\text{TRL}_j(i) = \text{TRL}(i)$ . Intuitively, using  $\text{TRL}_j$  means that  $j$  is given temporal priority in the current evaluation in the sense that it at any past instant would belong to the true future. (Alternatively, we may speak of  $j$  as the perspective of the evaluation.)

It is easy to verify that  $\text{TRL}_j$  fulfils the conditions (TRL1–2) if  $\text{TRL}$  does. This means that  $\text{TRL}_j$  formally qualifies as a thin red line function for an arbitrary instant,  $j$ .

Furthermore, we need a notion of duration. Because the branching-time system is backwards linear, we can assume that there is a function, *back*, from  $\text{TIME} \times \mathbb{N}$  to  $\text{TIME}$ , where  $\mathbb{N}$  is the set of positive numbers, such that  $\text{back}(i, n)$  is the unique instant  $n$  time units earlier than  $i$ . Similarly, there is a function, *forward*, from  $\text{TIME} \times \text{TIME} \times \mathbb{N}$  to  $\text{TIME}$ , such that  $\text{forward}(i, j, n)$  is the unique instant,  $i'$ , such that  $\text{back}(i', n) = i$  and  $i' \in \text{TRL}_j(i)$ .

Assuming that there is a basic assignment function giving a truth-value for each propositional letter at each instant, we may then introduce the following recursive definition of the truth-value of a tense-logical proposition at the instant  $i$  giving temporal priority to the instant  $j$ :

$\text{val}(i, j, p) = 1$  iff  $p$  is a propositional letter assigned with the truth-value 1 at the instant  $i$ .

$\text{val}(i, j, P(n)p) = 1$  iff  $\text{val}(\text{back}(i, n), j, p) = 1$ .

$\text{val}(i, j, F(n)p) = 1$  iff  $\text{val}(\text{forward}(i, j, n), j, p) = 1$ .

$\text{val}(i, j, Mp) = 1$  iff  $\exists i' (i < i' \ \& \ \text{val}(i', p) = 1)$

The propositional connectives and negations are treated in the traditional manner. The necessity operator,  $L$ , is defined as  $\sim M\sim$ .

A tense-logical proposition,  $p$ , is said to be valid in general if for any branching-time system with a valuation function,  $\text{val}$ , it holds that  $\text{val}(i, p) = 1$  at any instant  $i$  in the branching-time system.

If we identify  $i$  and  $j$ , it is obvious that we obtain

$$\text{forward}(\text{back}(i, n), i, n) = i \quad (\text{O1})$$

$$\text{back}(\text{forward}(i, i, n), n) = i \quad (\text{O2})$$

This means that

$$\text{val}(i, i, P(n)F(n)p) = 1 \text{ iff } \text{val}(i, i, p) = 1 \quad (\text{O3})$$

$$\text{val}(i, i, F(n)P(n)p) = 1 \text{ iff } \text{val}(i, i, p) = 1 \quad (\text{O4})$$

$$\text{val}(i, i, Mp) = 1 \text{ if } \text{val}(i, i, p) = 1 \quad (\text{O5})$$

Clearly, (O3) and (O4) correspond to (3), (4') and (4''). (O5) implies that  $p \supset Mp$  is valid in general. However, it is also obvious that  $\text{val}(i, i, P(n)F(n + m)p) \supset \text{val}(i, i, LP(n)F(n + m)p)$  is not valid in general, because it is easy to find a structure that would falsify such propositions.

Assuming in Fig. 3.2 that  $\text{TRL}(y)$  is the chronicle including  $x$ ,  $y$  and  $z$ , we find that  $\text{val}(y, y, P(m)F(n + m)p) = 1$ . Since  $\text{val}(y, z, P(m)F(n + m)p) = 1$  and  $\text{val}(y, t, P(m)F(n + m)p) = 0$ , it is evident that  $\text{val}(y, y, LP(m)F(n + m)p) = 0$ . This means that  $P(m)F(n + m)p \supset LP(m)F(n + m)p$  will be invalid according to the semantics suggested above. In this way, this approach leads to the rejection of the crucial principle (5) in Sect. 3.2.

In short, it seems that the semantics sketched above will have all the properties we would want in an Ockhamistic (and Molinistic) semantics.

It turns that it can be very useful to let the evaluation of the truth-value of a proposition depend on two instants instead of just one. Various versions of this technique have also been studied by others, e.g. (MacFarlane, 2003; MacFarlane, 2014; De Florio & Frigerio, 2019a, 2019b, 2020). However, the definition of the evaluation function suggested above differs somewhat from these other studies.)

### 3.5 Conclusion

Prior regarded Ockham as a very good representative of medieval logic and found much inspiration in Ockham's analysis of the Aristotelian argument in Chap. 9 of *De Interpretatione* and in Ockham's tense-logic in general. Prior also accepted Ockham's interpretation according to which the Aristotelian response should be understood in terms of a three-valued logic. Both Ockham and Prior – although for different reasons – found the Aristotelian response too problematic, and they both looked for other and better solutions. Prior made two slightly different formalisations of Ockham's response to the Aristotelian argument. It has been argued that at least Prior's last and most famous Ockhamistic model differs significantly from Ockham's own view, because it does not include the Ockhamistic idea of a true future, which to Ockham was closely related to his acceptance of the doctrine of divine foreknowledge. For philosophical reasons, Prior himself rejected Ockham's assumption of a true future, and he also found his own Ockhamistic models unsatisfactory. However, as we have seen, it is in fact possible to construct a Priorean tense-logical model with all the properties we would want in a semantic model based in Ockham's ideas. This can be done in at least two different ways. In both cases, not only will the models be Ockhamistic, but they will also incorporate the tense-logical ideas that follow from the logic and philosophy of Luis de Molina.

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# Chapter 4

## Ockhamism Without Molinism



Jacek Wawer

**Abstract** According to Ockhamism, some (but not all) future contingents are true. It turns out that a simple-minded representation of Ockhamism within the framework of branching time is highly problematic as it gives no interpretation of the future tense operator in non-actual circumstances. To repair this defect some theorists turned to Molinism—a theory that allows true counterfactual future contingents (e.g., conditionals of freedom). I explain that one can address the formal problems of Ockhamism without resorting to Molinism. Then, I argue that Molinism is indeed a strengthening of Ockhamism and that one could subscribe to the latter without endorsing the former. To this effect, I present a semantic framework which treats the future tense operator and counterfactuals independently and allows a variety of theories regarding actual and counterfactual future contingents, including Ockhamism without Molinism.

Both William of Ockham and Luis de Molina discussed the tension between divine foreknowledge and human freedom. These investigations naturally led them to study the relations between time, modality, and truth. I invoke these two theologians because their names were associated with certain types of theories in temporal logic. The core idea behind Ockhamism is that some future contingents like “The coin will land tails” are true, while according to Molinism not only some future contingents are true, but some counterfactual contingents like “Had I tossed the coin, it would have landed tails” are also true.<sup>1</sup> These two views are often presented as a package deal in temporal logic. It is implied that as soon as one commits to Ockhamism, one is forced to accept a seemingly stronger Molinism. I disagree with this verdict. There are some formal objections that suggest that Ockhamism needs to be extended

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<sup>1</sup> I assume for the sake of the argument that coin tossing is an indeterministic process.

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to Molinism, but I believe that these arguments are misplaced. In what follows I am going to present a sound framework that allows Ockhamism without Molinism.

In the first section, I present the branching time model and outline how it was used by Arthur Prior (1967) to introduce the Ockhamist semantics. Peter Øhrstrøm has insisted for the last four decades (see, e.g. Øhrstrøm, 1981, 2019) that Priorean Ockhamism is not faithful to William of Ockham’s original ideas regarding the semantics of the future tense operator. In Sect. 4.2, I briefly present a simple-minded, “truly Ockhamist” theory and explain how it falls prey to what might be considered a Molinist objection. In response, many Ockhamists convert to Molinism. It is explained in Sect. 4.3 that this is not required. In Sect. 4.4, the Molinist challenge is restated more properly in terms of counterfactuals with contingent consequents. Finally, in Sects. 4.5 and 4.6, various theories of actual and counterfactual future contingents are presented, including non-Molinist Ockhamism.

## 4.1 Branching Time and Prior’s Ockhamism

The branching time model naturally represents how possibilities evolve in time. It elucidates the idea that some initially available options cease to be possible as time goes by. It also captures the intuition that the future, contrary to the past, is open to multiple possible realizations. Additionally, it incorporates the insight that what is possible is very much circumstance-dependent—it depends on what the world is like at a given moment (such situation-dependent necessity was sometimes called “accidental necessity” in the scholastic terminology).

All these intuitions are captured by a pictorial representation of temporal possibilities in the shape of an upward-branching tree. Each point on the tree represents a possible state of the world—these possible states are called “(possible) moments.” Each branch that is growing out of a given moment represents its possible future continuation, while the trunk of the moment represents its unique possible past. Each maximal chain in the tree is a representation of a possible course of events—a “(possible) history.” Figure 4.1 exemplifies a simple branching-time structure.

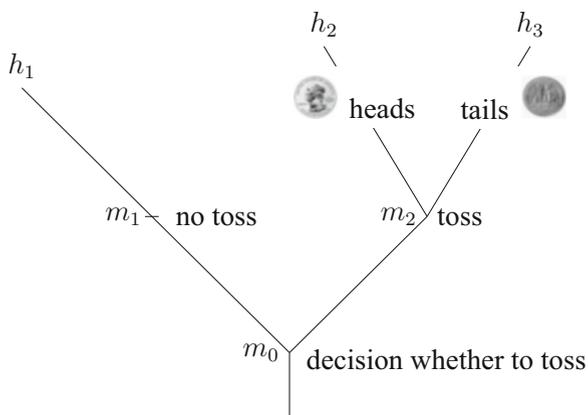
Formally put, a branching time (*BT*) structure is a partially ordered set (i.e. a set ordered by a reflexive, weakly anti-symmetric and transitive relation) that satisfies the extra condition of backwards linearity:

- $\forall m, m_1, m_2 \left( ((m_1 < m) \wedge (m_2 < m)) \rightarrow ((m_1 < m_2) \vee (m_2 < m_1) \vee (m_1 = m_2)) \right)$ .

Elements of the set represent possible moments (and will be called “moments”), and the ordering represents the relation of potential temporal precedence. A “history” is a maximal linearly ordered subset of the set.

Arthur Prior (1967, ch. 7) used this model to encode certain ideas involved in William of Ockham’s solution to the problem of Divine foreknowledge. For this

Fig. 4.1 Model 1



purpose, he used propositional language with temporal operators “It will be the case that” (F) and “It has been the case” (P) and a modal operator of historical possibility ( $\diamond$ ). He dubbed one of the semantic interpretations of these operators “Ockhamism”. In Prior’s Ockhamism we begin with a valuation function,  $V$ , which assigns a set of moments to each propositional variable ( $V : Var \mapsto \mathcal{P}(M)$ ).<sup>2</sup> Intuitively, these are the moments at which the (elementary, present tensed) sentences are true. In Ockhamist semantics, sentences are evaluated at moment-history pairs  $m/h$ , such that  $m \in h$ , according to the following rules:

**Definition 4.1 (A Sentence  $\phi$  is P-Ockhamist True at an Index  $m/h$ )**

- $m/h \models p$  iff  $m \in V(p)$  for  $p \in Var$ ;
- $m/h \models \neg\phi$  iff it is not the case that  $m/h \models \phi$  ( $m/h \not\models \phi$ );
- $m/h \models \phi \& \psi$  iff  $m/h \models \phi$  and  $m/h \models \psi$ ;
- $m/h \models P\phi$  iff  $\exists m' (m' < m \& m'/h \models \phi)$ ;
- $m/h \models F\phi$  iff  $\exists m' (m < m' \& m' \in h \& m'/h \models \phi)$ ;
- $m/h \models \diamond\phi$  iff  $\exists h' (m \in h' \& m/h' \models \phi)$ .

The double relativization of truth—to moment and to history—generates many positive effects; in particular, it ensures smooth interaction between temporal and modal operators, but it also gives rise to a controversy which I discuss below.

## 4.2 “True” Ockhamism and the Molinist Objection

The major conceptual problem with Prior’s Ockhamism (P-Ockhamism for short) lies in its appeal to the history parameter. While it is clear that this is useful for

<sup>2</sup> There are some debates regarding the co-domain of the valuation function—should it be the superset of moments or the superset of moment-history pairs? This detail is irrelevant in the present context (see e.g. Reynolds, 2003, for more information).

the purpose of defining historical modalities, it is equally unclear how to deal with the parameter when we try to apply P-Ockhamism. For example, when we evaluate the truth value of a future-tensed sentence used in a given context, we are required to specify a moment and a history relevant for the purpose of evaluation. How to distinguish the relevant history has been debated since the early days of P-Ockhamism. The natural inclination is to understand it as the actual history or the actual world; however, since at least (Thomason, 1970) it has been argued that the notion of the (contingent) actual future course of events is problematic. For this reason, Thomason stressed that we should merely provisionally posit a history parameter and not attach any metaphysical significance to such a choice (for similar arguments see Belnap et al., 2001; MacFarlane, 2014).

Not everyone has been ready to accept the provisional nature of the semantic parameter. For example, Peter Øhrstrøm and others (see e.g. Øhrstrøm & Hasle, 1995; Øhrstrøm, 2009; Bräuner et al., 2000; Øhrstrøm, 2019) insisted that something more than a provisional parameter is needed to grasp how the future tense operator functions semantically. They stressed that we always need to designate a unique, actual history to assign truth values to future-tensed sentences. They also insisted that the notion of the actual future is required to capture William of Ockham's historical views.

It may be doubted whether Prior's Ockhamistic system is in fact an accurate representation of the temporal logical ideas propagated by William of Ockham. According to Ockham, God knows the contingent future, so it seems that he would accept an idea of absolute truth, also when regarding a statement  $Fq$ . (Bräuner et al., 2000, p. 198)<sup>3</sup>

To incorporate the “truly Ockhamist” spirit into the branching set-up, they insisted that “According to the Ockham-model only one possible future is the true one” (Øhrstrøm & Hasle, 1995, p. 194). A simple-minded semantic application of this general idea proceeds as follows:

**Definition 4.2** The sentence “It will be the case that  $\phi$ ” is true at moment  $m$  iff the sentence “ $\phi$ ” is true at a later moment  $m'$  in the actual history ( $h^@$ );

$$m \models F\phi \text{ iff } \exists_{m'}(m' > m \ \& \ m' \in h^@ \ \& \ m' \models \phi).$$

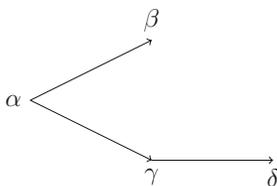
Thus, the truth value of a future-tensed sentence is not relative to a history parameter and is directly decided by the unique actual history distinguished in the branching model. Let us call this crude embodiment of Ockhamism—in fact, it is almost a mockery—M-Ockhamism.

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<sup>3</sup> Arthur Prior would likely agree with this verdict, since he starkly contrasted the provisional “prima facie” Ockhamist assignment relative to a history against the “actual” Ockhamist assignment associated with one “designated” history (Prior, 1966, p. 158). Interestingly, the seventh chapter of Prior (1967) is partly based on the paper from 1966. Nonetheless, Prior leaves out the history-independent assignments altogether, while he continues to use the notion of “prima facie,” history-relative assignments. This omission proved to be unfortunate, as some later authors were left speculating as to why Prior called his Ockhamist assignments “prima facie.” (see e.g. Thomason, 1970; Øhrstrøm, 1984).

M-Ockhamism is intuitive and simple, but it faces what might be called a Molinist objection. Namely, it does not tell us how to evaluate sentences at moments outside of  $h^@$ . This formal problem has already been identified by Thomason (1970), who writes:

Suppose that  $\beta$  is in the real future of  $\alpha$ ; then what of the point  $\gamma$ ? It isn't in real time, and yet in order to evaluate tensed formulas at  $\gamma$  we must provide it a real future. (Thomason, 1970, p. 271)



This means that the future tense operator cannot be reasonably embedded within the scope of modal operators which renders M-Ockhamist semantics highly limited, if not straightforwardly inaccurate. A similar worry was raised by Belnap and Green (1994) and Belnap et al. (2001). The latter expressed it as follows:

We have no trouble with predictions that will be or have been made, but we have no way of understanding predictions that might have been made. We have no way of getting a grip on “Had things gone otherwise, Jack would have asserted the following: ‘It will (eventually) rain.’” (Belnap et al., 2001, p. 162)

This way of putting the problem is particularly “Molinist” in nature. The worry is stated in the form of a counterfactual, while such constructions (so-called conditionals of freedom) were of central interest to “Luis de Molina” when he discussed human freedom and Divine foreknowledge. He argued that such counterfactuals have absolute truth values which are known to God. The problem with M-Ockhamism is that we have no way of evaluating future-tensed sentences outside the actual course of events. Also, it seems that temporal operators are understood differently in actual and non-actual circumstances, which goes against the universal nature of semantic definitions (see Iacona, 2014, for objections along these lines).

The responses of Ockhamists were often Molinist in spirit. The formal idea was first sketched by McKim and Davis (1976), who argued that we should not stop at just one absolutely actual history, but rather distinguish one history at every possible juncture in the tree of possibilities. The distinguished histories might be seen as definite answers to questions like “what would have happened had things gone otherwise?” (the answers to which God supposedly has access). Formally speaking, in semantic Molinism we introduce a function that maps moments to histories  $Mol: M \mapsto Hist$  such that  $\forall_m m \in Mol(m)$ . Intuitively,  $Mol(m)$  distinguishes the history that would have been actual had moment  $m$  been actual. We can now interpret the future tense operator at any moment of the tree:

**Definition 4.3 (Semantic Molinism)** The sentence “It will be the case that  $\phi$ ” is true at moment  $m$  iff the sentence “ $\phi$ ” is true at a later moment  $m'$ , in  $Mol(m)$ ;  
 $m \models^{Mol} F\phi$  iff  $\exists_{m'}(m' > m \ \& \ m' \in Mol(m) \ \& \ m' \models \phi)$ .

Thus, we get rid of the problem of interpreting the future tense operator at non-actual moments, while we do not run into the relativism induced by P-Ockhamism (the  $Mol$  function is as absolute as the actual history itself). However, we are faced with other serious technical challenges (they are described in detail in section 2 of Wawer, 2014). Most alarmingly, the formula  $\phi \rightarrow HF\phi$ , which is often considered one of the most fundamental theorems of temporal logic, is not valid in the Molinist semantics described above.<sup>4</sup> Some logicians have tried to rationalize this failure or improve the semantics, but I do not think these attempts were successful (for detailed argument, see Wawer, 2014, sec. 2).

### 4.3 Ockhamism Defended

I claim that we do not need to submit to the version of semantic Molinism sketched above to address Thomason’s worry. Instead, I intend to preserve the earnest simplicity of M-Ockhamism and its artless, absolutist attitude to actuality, while avoiding its formal trouble.

A rule of thumb for Ockhamists should be to divert from P-Ockhamism—the most appealing formal theory—as little as possible and find another way to get rid of history-relativity (I share this conviction with Andrea Iacona, 2014). To deal with the issue of relativity, I suggest elevating Ockhamism from the semantic to the postsemantic level (the terminology here is MacFarlane’s). To this effect, we need to distinguish between the technical notion of truth-at-index (P-Ockhamist truth in our case) and the more intuitive notion of truth-at-context that is used to assess the contents of assertions. Then, if you share Ockhamist inclinations, you should say that the P-Ockhamist truth at the index is relative but the truth at the context is not. How to dispense with the relativity that is inherent in P-Ockhamism? We need what MacFarlane calls a *postsemantic* theory which links the two notions of truth, dispenses of relativity, and is also true to the spirit of Ockham’s intuition. Such a theory is not particularly extravagant or difficult to find. In fact, it is a theory very much in the spirit of what Lewis (1970) and Kaplan (1989) proposed when they first precisely distinguished index from context in semantic theories. According to such a “flat” postsemantic theory, a sentence is true at a context iff it is true at the context-initialized semantic index. I call this theory flat since its role is highly limited in comparison to more elaborate postsemantic theories such as supervaluationism (Thomason, 1970), subvaluationism (Ciuni & Proietti, 2013), or relativism (MacFarlane, 2003, 2014). Its only role is to provide the unique index that

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<sup>4</sup> The operator  $H$  stands for “It has always been the case that” and it is a dual of  $P$ .

is relevant for semantic evaluation. Technically speaking, postsemantic futurism, as I shall call it, can be defined as follows:

**Definition 4.4 (Futurism)**  $c \Vdash \phi$  iff  $m_c/h_c \models \phi$ , where  $m_c$  is the moment of the context, i.e. the present moment, and  $h_c$  is the history of the context, i.e. the actual history.<sup>5</sup>

According to futurist postsemantics, a sentence is true at a context iff it is true at the unique “designated” semantic index. I call this view “futurism” since in this postsemantics the truth value of a sentence about the future depends on what will happen in the (actual) future. In contrast, in supervaluationism, subvaluationism, Łukasiewicz-like theory, Peirceanism, or assessment relativism, the truth value of a sentence about the future ultimately depends on what is the case at present (i.e., it depends on which possibilities are presently available).

Such a theory has many advantages. Firstly, it is faithful to the spirit of Ockham’s actualistic intuition. Since every context designates just one history as *the* actual history, we arrive at a theory that provides the classical, bivalent treatment of every sentence used at every context, where the truth value of the sentence depends on what did/does/will actually happen. In particular, the sentence “There will be a naval battle tomorrow” is true iff there will in fact be a naval battle on the day following the time of utterance. Secondly, the truth value of a sentence at a context is not relative since the context provides the unique relevant modal parameter (the actual world or the actual history). Thirdly, the theory is free of the traditional technical problems which beset the Molinist semantics presented above. In particular, since futurism is based on P-Ockhamism, it confirms all the (intuitive) validities of P-Ockhamism. In this respect, it is on a par with Supervaluationism or MacFarlane’s Relativism, but it has a formal advantage when we consider the notion of postsemantic consequence (preservation of truth at context). While supervaluationism and relativism diverge from P-Ockhamist consequence (see Malpass & Wawer 2012, sec. 7.3.2 and MacFarlane 2014, sec. 9.8.3), the flat postsemantics proposed above is faithful to the P-Ockhamist notion of semantic consequence. For this reason, it is not threatened by the kind of problems with the consequence relation pointed out by Williamson (1994) or Fara (2010).<sup>6</sup> This is part of what makes this postsemantics “flat.” The futurist consequence relation is so closely linked to P-Ockhamism because futurism

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<sup>5</sup> A version of such a theory was proposed in Wawer (2014) and defended in Wawer and Malpass (2020). Also, a very similar view was put forward by Iacona (2014, see esp. sec. 7). Iacona distinguishes between “plain truth” and “truth in a history,” while I use “truth at context” and “truth at index,” respectively. However, I believe that the difference is mostly terminological and our actual views are very much in line.

<sup>6</sup> For more on these problems in the context of branching time, see Malpass and Wawer (2012), Malpass (2013). By means of a simple example, observe that in supervaluationism  $\Box\phi$  is true at every context at which  $\phi$  is true. This means that  $\Box\phi$  *can* be (post)semantically inferred from  $\phi$ . However,  $\neg\phi$  is not true at every context at which  $\neg\Box\phi$  is. Therefore,  $\neg\phi$  *cannot* be (post)semantically inferred from  $\neg\Box\phi$ . This means, in turn, that the rule of contraposition fails with respect to truth at context. Futurism does not face this problem since it does not conflate truth at context with settled truth (it allows for true future contingents).

does not inflate the notion of truth at context in the way other postsemantic theories do. Thus, we arrive at a formally sound semantic theory which is faithful to the spirit of actualist intuitions with respect to truth about the future (which means that some future contingents are non-relatively true).

It is easy to see that the formal difficulties which threatened M-Ockhamism do not apply to futurism. In particular, even if a modal operator shifts the index of evaluation away from the actual history (the history of the context), we have no difficulties assessing future-tensed sentences. For example, even if you assume that  $m_1/h_1$  is the index designated by the context in Fig. 4.1, it is clear that according to futurism the sentence  $P\Diamond F(\text{toss} \wedge F(\text{heads}))$  is true at this context. It is true, even though the second occurrence of  $F$  is evaluated outside of the history  $h_1$  (for detailed discussion of this issue, see Wawer & Malpass, 2020).

Let us retrace our steps and see what got us here. First, we noticed that Prior's Ockhamism introduces unwelcome relativism to the semantic analysis. Second, to alleviate this problem we turned to simple-minded Ockhamism, where the semantics of the future tense operator is tightly connected to the actual history. Third, in the face of formal difficulties, we moved to semantic Molinism, which also turned out to be formally deficient. Lastly, we suggested that an Ockhamist should stick to P-Ockhamism and get rid of relativism through postsemantic rather than semantic means. This brought us to futurism, which is both faithful to the spirit of Ockhamism and formally unquestionable. In the next step, I want to study how we can get beyond Ockhamism, and introduce counterfactuals into the story.

## 4.4 Counterfactuals

We have seen that semantic considerations alone do not demand a shift towards Molinism. Nonetheless, we may independently raise the issue of conditionals of freedom and ask what is the proper (post)semantic treatment of counterfactuals with contingent consequents, such as “Had I tossed the coin, it would have landed heads” or “Had I met Jane, I would have helped her.” To state this question precisely, however, we need the linguistic resources to study counterfactuals. Thus, we need to extend our language with subjunctive conditionals and stipulate the semantics for the connective. This is not a straightforward task and there are indeed competing theories in this regard (e.g., Thomason & Gupta, 1980; Placek & Müller, 2007; Wawer & Wroński, 2015). Fortunately, we can simplify the issue for our purposes and use a theory in the spirit of Stalnaker (1968), where a counterfactual is true at a point of evaluation iff the consequent is true at the “closest” point of evaluation at which the antecedent is true. Stalnaker used possible worlds as his points of evaluation, while our semantics requires moment-history pairs. I am going to borrow the semantics developed in Wawer and Wroński (2015) as it is flexible enough to accommodate various views with respect to counterfactual future contingents.

The first question that naturally arises with respect to Stalnaker-like semantics is how we should determine “the closest” point of evaluation. To put it slightly more

formally: how to define the selection function which takes the antecedent and the current point of evaluation and delivers the relevant, closest counterfactual point of evaluation? Interestingly, the tempo-modal relations encoded by the branching structure offer a relatively well-founded response to this question. Namely, for a moment-history pair  $m/h$  and counterfactual  $\phi > \psi$ , the closest moment  $m'$  should be simultaneous with  $m$ , and the closest history  $h'$  should branch off as recently as possible to make the antecedent true at  $m'$ . In other words, to check whether counterfactual  $\phi > \psi$  is true at  $m/h$ , we “go back in time” until we hit a history  $h'$  which allows  $\phi$  to be presently true and then check if  $\psi$  is also true in this history.<sup>7</sup>

Thus, the selection function  $s$  takes as its argument a pair consisting of a sentence  $\phi$  and a moment-history pair  $m/h$ , and it selects the moment-history pair  $m'/h'$  such that:

1.  $\phi$  is true at  $m'/h'$  ( $m'/h' \models \phi$ ),
2.  $m \sim m'$ , i.e.  $m$  is co-present with  $m'$ ,<sup>8</sup>
3.  $\forall m''\forall h''((m'' \sim m \wedge (h \cap h' \subset h \cap h'')) \rightarrow m''/h'' \not\models \phi)$ .

It is crucial to note that in many branching models, conditions 1–3 underdetermine the selection function. This is clearly visible in indeterministic contexts. Take the coin toss model above (Fig. 4.1 on page 57): the heads history  $h_2$  branches off history  $h_1$  at the same moment as the tails history  $h_3$ . Therefore, both these histories are equally viable candidates for values of a selection function for the argument  $\langle toss, m_1/h_1 \rangle$ . This is a very important consequence of the previous definition which I happily accept. We shall see that it is useful when we study various accounts of counterfactual future contingents. Now, using the selection function, we can define the truth conditions of a counterfactual connective  $>$  in the Stalnakerian spirit:

**Definition 4.5 (Counterfactual)**  $m/h, s \models \phi > \psi$  iff  $s(\phi, m/h), s \models \psi$ .<sup>9</sup>

Consider now the counterfactual “Had I tossed the coin, it would have landed heads” ( $toss > F(heads)$ ), evaluated at  $m_1/h_1$  of the model depicted on p. 57. As mentioned, the definition above admits two distinct selection functions as parameters of truth, where  $s_1(toss, m_1/h_1) = m_2/h_2$  and  $s_2(toss, m_1/h_1) = m_2/h_3$ . Depending on which function is used, the counterfactual acquires a different truth value: it is true with respect to  $s_1$  and false with respect to  $s_2$ . Each of the

<sup>7</sup> Such a choice of “the closest” index naturally embodies the principle that any degree of similarity (or rather indistinguishability) in the past overrides even a large degree of similarity in the future. Thus, it admits “ $A > BigDifference$ ” counterfactuals (see Bennet, 2003, p. 195ff), while it also naturally creates a desirable “ramp from the actual world to the antecedent” (Bennet, 2003, p. 214).

<sup>8</sup> We can use the concept of instants to determine the class of possible moments co-present with a given moment (see Belnap et al., 2001, sec. 7A.5).

<sup>9</sup> Observe that the truth of a sentence is relative to a selection function, while the definition of the selection function appeals to the notion of truth. To avoid circularity, we need to define  $\models$  and the set of all selection functions in parallel by use of double induction. The curious reader can consult the rigorous definition stated in Wawer and Wroński (2015).

functions provides a unique truth value, but semantics itself does not dictate which of them is *the* selection function. This issue is perfectly parallel to the case of P-Ockhamism which we discussed at the beginning of Sect. 4.2. The semantics demands that we pick a unique selection function, but it is unclear if we can privilege one function over another. At this point, the Molinist clearly has the upper hand as they have an obvious answer: the proper semantic function is *the* function which picks the history that would have been actual had the coin been tossed. There is, according to Molinism, a unique proper answer to the question of which history it would have been (there needs to be one, since God knows this answer). Thus, Molinism is a homogeneous theory with respect to future contingents as it dictates that stand-alone and counterfactual future contingents should be treated analogously: each of them possesses a classical truth value and some, but not all, are true.

This is not the only theoretical option, however. By now,  $F$  and  $>$  are two distinct connectives and they depend on two different semantic parameters (a history and a selection function, respectively). Hence, we are much more flexible than we were in Sect. 4.2 when we first encountered conditionals of freedom.

## 4.5 Homogeneous Theories of Future Contingents

Compare two sentences:

1. “The coin will land heads” (uttered just before an indeterministic coin toss).
2. “If the coin had been tossed, it would have landed heads” (uttered when one decided not to toss the coin at all).

Someone might insist that these two cases are perfectly parallel and deserve homogeneous treatment. Let us explore a few postsemantic theories that are faithful to this principle.

### 4.5.1 *Anti-Molinist Anti-Ockhamism*

According to Prior’s Peirceans, a sentence about the future can be viewed as true only if what it says is inevitable. That is, one can truly say that a sea battle will happen only if it is no longer possible to avoid it. Since the Peirceans subscribe to bivalence, every sentence about the *contingent* future needs to be regarded as false. One way to understand this view is by interpreting the future tense operator as a modally loaded notion. Indeed, as was noted already by Prior (1967), the Peircean “Will” ( $\boxed{F}$ ) is semantically equivalent to the P-Ockhamist “Necessarily will” ( $\boxed{F}\phi : \leftrightarrow \Box F\phi$ ), which means that a sentence predicting that there will be a sea battle is true if and only if there is a sea battle in every possible future course of

events. One way to justify such a strong reading of “will” is by observing that you may reject the prediction of a sea battle by pointing out that it might not happen.

Observe that you can also reject the counterfactual prediction “The Greeks would have won, had there been a sea battle” by saying that they could have lost. This kind of observation might suggest (and did suggest to David Lewis) a similar modally loaded reading of counterfactuals. In this view (at least in its simplified version) the antecedent of a counterfactual designates a set of possible worlds and the counterfactual is true only if the consequent is true in each of the designated worlds. When you transfer this intuition into our setting, you get the result that the counterfactual “Had I tossed the coin, it would have landed heads” is true iff the coin lands heads in *all* the (closest) histories in which it is tossed. Otherwise, it is false. One way to understand this notion of a counterfactual is to identify “would” with “would necessarily” ( $\phi \boxed{\supset} \psi : \leftrightarrow \phi > \Box \psi$ ). This means that a sentence which counterfactually predicts that the Greeks would have won the sea battle is true if and only if the Greeks win a sea battle in every possible course of events that follows (the closest) counterfactual moment where the sea battle is fought. There are close parallels between the Peircean “Will” and the Lewisian “Would.” For example, just as Lewis famously rejected the counterfactual excluded middle,  $\phi \boxed{\supset} \psi \vee \phi \boxed{\supset} \neg \psi$ , the Peircean rejects the future-oriented excluded middle,  $\boxed{F} \psi \vee \boxed{F} \neg \psi$ . Also, they generally accept a modified version of these principles:  $\phi \boxed{\supset} (\psi \vee \neg \psi)$  and  $\boxed{F} (\psi \vee \neg \psi)$ .

The Peirce-Lewis theory stands in stark conflict with the Ockham-Molina theory, which admits true factual and counterfactual future contingents. You can encode the former in the form of anti-Ockhamist and anti-Molinist postsemantics:

**Definition 4.6 (Anti-Molinist Anti-Ockhamism)**  $c \Vdash \phi$  iff  $m_c/h, s \models \phi^\Box$  where  $m_c$  is the moment of the context and  $\phi^\Box$  is the translation of  $\phi$ , where every occurrence of  $F$  and  $>$  is replaced with  $\boxed{F}$  and  $\boxed{\supset}$  respectively.

When you apply this definition to our toy-model and assume that  $m_1$  is the moment of the context  $c_1$  and  $m_2$  is the moment of the context  $c_2$ , you get the expected results:

- $c_2 \Vdash \neg F(\text{heads})$
- $c_2 \Vdash \neg F(\text{tails})$
- $c_2 \Vdash F(\text{heads} \vee \text{tails})$
- $c_1 \Vdash \neg(\text{toss} > F(\text{heads}))$
- $c_1 \Vdash \neg(\text{toss} > F(\text{tails}))$
- $c_1 \Vdash (\text{toss} > F(\text{tails} \vee \text{heads}))$

This means that the claim that the coin will land heads is false at context  $c_2$ ; after all, this result is not necessary. Also, the claim that the coin would have landed heads is false at context  $c_1$ ; after all, this result would not have been necessary. By the same token, it is true that the coin will land (would have landed) either heads or tails, as the disjunction is true in every history passing through  $m_2$  (and for every selection function taking  $m_1/h_1$  as its value).

### 4.5.2 *Non-Molinist Non-Ockhamism*

Another account of future contingents is inspired by (an interpretation of) Aristotle. In this view, which was introduced into the branching setting by Richmond Thomason (1970), such statements lack a truth value. Thus, it is neither true nor false that there will be a sea battle when the outcome of the skirmish is undecided. An attractive feature of this view is that it distinguishes, *pace* Peirceanism, a factual claim predicting a sea battle from a modal claim that the battle is necessary; the latter but not the former is false. Also, the disjunction  $F\phi \vee \neg F\phi$  is true, even though neither of the disjuncts is. To arrive at these results, Thomason used the technique of supervaluations and identified super-truth at a moment (which I interpret as truth at the moment of the context) with P-Ockhamist truth at all histories passing through the moment (super-falsity is identified with super-truth of the negation).

If you share Thomason's intuitions regarding future contingents, you might be inclined to transfer them to counterfactuals. Just as it is neither true nor false that the coin will land heads, it is neither true nor false that the coin would have landed heads had it been tossed. In fact, the intuitive support for supervaluationism is even stronger here since this issue will never be resolved. Also, it seems reasonable to semantically distinguish, *pace* Lewis, the "bare" counterfactual future contingent that states that the coin would have landed heads from a modally loaded counterfactual that states that it would have been inevitable (compare your degree of confidence with respect to these two propositions). Also, if you are happy with the future-oriented law of excluded middle, you might also be inclined to accept the counterfactual excluded middle. All these results are accomplished if you generalize the technique of supervaluations and identify the super-truth of a counterfactual at a moment with its truth at all selection functions (the theory was first described in Wawer & Wroński, 2015).

**Definition 4.7 (Non-Ockhamist Non-Molinism)**  $c \Vdash \phi$  iff  $\forall_h \forall_s (m_c \in h \Rightarrow m_c/h, s \models \phi)$ , where  $m_c$  is the moment of the context.

Let us study several examples in our toy model:

- $c_2 \not\Vdash F(\text{heads})$
- $c_2 \not\Vdash \neg F(\text{heads})$
- $c_2 \Vdash \neg \Box F(\text{heads})$
- $c_2 \Vdash F(\text{heads}) \vee F(\text{tails})$
- $c_1 \not\Vdash (\text{toss} > F(\text{heads}))$
- $c_1 \not\Vdash \neg(\text{toss} > F(\text{heads}))$
- $c_1 \Vdash \neg(\text{toss} > \Box F(\text{heads}))$
- $c_1 \Vdash \text{toss} > F(\text{heads}) \vee \text{toss} > F(\text{tails})$

Thus, all the aforementioned results are confirmed by the formal theory ( $c \not\Vdash \phi$  means that it is not the case that  $c \Vdash \phi$ ). Also, the close parallel between factual and counterfactual future contingents is preserved. There are some intricacies regarding the interaction of necessity with counterfactuals (e.g. consider whether  $\Box(\phi > \psi)$  is equivalent to  $(\phi > \Box\psi)$  in the branching setting). However, these details are not essential to our discussion, so let me move on to an improved version of Molinist Ockhamism.

### 4.5.3 Molinist Ockhamism

We are now in a position to advance the Molinist theory. As I mentioned in Sect. 4.2, the semantic variant proposed by McKim and Davis (1976) and defended by Øhrstrøm (2009) faces considerable formal obstacles (failure of  $\phi \rightarrow HF\phi$  being the most worrisome). In Sect. 4.3, I have also argued that an appeal to Molinism is not in fact required to overcome the semantic problems pointed by Thomason (1970). Nonetheless, one might be inclined to extend Ockhamism and incorporate Molinism for independent reasons. For example, one might require true counterfactual contingents for theological purposes—they need to be true to be a subject of Divine knowledge. Alternatively, the intuitive appeal of the counterfactual excluded middle might push someone towards the Molinist solution.

This view may be readily incorporated into the current set-up by the following postsemantic definition:

**Definition 4.8 (Molinist Ockhamism)**  $c \Vdash \phi$  iff  $m_c/h_c, s_c \models \phi$  where  $m_c$  is the moment of the context,  $h_c$  is the history of the context, and  $s_c$  is the selection function of the context.<sup>10</sup>

The definition presupposes that the context designates not only the moment and the history, but also the unique set of scenarios that would have been actualized had things gone otherwise; also, it allows for true counterfactual future contingents. If  $m_1$  and  $h_1$  are the moment and the history of the context  $c_1$  and  $s_{c_1}(m_{c_1}/h_{c_1}, toss) = m_2/h_2$ , then

- $c_1 \Vdash toss > F(heads)$
- $c_1 \Vdash \neg(toss > F(tails))$

Similarly, if  $m_2/h_2$  are initialized by context  $c_2$ , then

- $c_2 \Vdash F(heads)$
- $c_2 \Vdash \neg F(tails)$

Thus, actual and counterfactual future contingents are strictly analogous. Most importantly, some of them are true. An attractive feature of this expression of Molinism is that it does not meddle with strictly semantic definitions. Therefore, it is protected against the formal attacks mounted against the semantic versions of Molinism. We preserve the intuitive semantics of P-Ockhamism on the “ground level” and incorporate the Molinist insight in postsemantics with the assumption that the context of utterance is resourceful enough to indicate which of the outcomes would have been realized had a coin been tossed. As a result, you have true conditionals of freedom while your logic does not divert from widely accepted P-Ockhamism.

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<sup>10</sup> A version of this theory was considered by John MacFarlane (2014, p. 209).

The obvious objection against this view is provoked by the idea of the selection function of the context. It is already a matter of considerable doubt whether the context can initialize the actual history. The assumption that it can additionally initialize a whole bunch of scenarios that would have been actual had things gone otherwise is doomed to be disputed. One philosopher who expressed such a worry is Michael Dummett:

(C) If a statement is true, there must be something in virtue of which it is true. (...) [T]he principle C may at first strike one as empty. We feel its force only when we consider something which appears a violation of it. (...) For instance, those counterfactuals asserted by one school of theologians to be the objects of God's *scientia media*, relating to the behaviour, had they been created, of beings endowed with free will whom, on the basis of such knowledge, God decided not to create. Most people naturally feel a strong objection to such a conception, precisely on the ground that, in such a case, there would be nothing to *make* the counterfactual true. (Dummett, 1976, pp. 52–53)

If you share these concerns, you have probably given up on the idea of true counterfactual contingents. However, this does not mean that you also need to abandon true future contingents immediately. You may accept a heterogeneous theory and conclude that the actual and the counterfactual case are different in significant respects.<sup>11</sup>

## 4.6 Ockhamism Without Molinism

I am going to argue that you can be an Ockhamist without subsuming to Molinism. I share this view with Robert Adams, who writes that:

The categorical predictions involved in simple foreknowledge may be true by corresponding to future events (...). But in the case of counterfactuals of freedom that are about non-actual creatures or have false consequents, the conditionally predicted actions are not there to be corresponded with because they never actually occur. The truth of counterfactuals is commonly grounded in a logical or causal necessitation of the consequent by the antecedent. (Adams, 1991, p. 345)

Thus, “simple” and “counterfactual” future contingents seem substantially different. A smiliar intuition is promoted by Malpass and Wawer (2012) who motivate it along the following lines:

It is the passage of time that resolves future contingents one way or the other. At the same time, the passage of time, no matter how long-lasting, will never resolve a non-actual future contingent in a similar manner. To the philosophical logician who holds the view, there

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<sup>11</sup> I revisit here the project I undertook with Alex Malpass several years ago (Malpass & Wawer, 2012). We argued that actual and non-actual future contingents should be treated differently, but I am not entirely satisfied with the details of our final theory—the Supervaluational Thin Red Line. The theory I present here is faithful to the spirit of our original paper, but it better expresses (I hope) the intuitions which guided our research. For discussion of some (alleged) problems of our original theory, see Iacona (2014) and Wawer and Malpass (2020).

is therefore a requirement to treat actual future contingents and merely possible future contingents differently. (Malpass and Wawer, 2012)

The authors should have added that there is no “mechanism” in the realm of possibilities, analogous to the passage of time, that would naturally order them in a similar vein. There is no “passage of possibilities” which could help us to grade them as more or less remotely actual. One might point to probability, but it would not help in our case. The central thesis of Molinism is that even if two scenarios are equally likely, one of them is “closer to actuality” since it is the one that would have actually occurred. In fact, the scenario that is very unlikely might be “the closest” to the actuality. It might be (absolutely) true, according to the Molinist, that had I bought a ticket I would have won the lottery. The non-Molinist Ockhamist rejects such inherent “ordering” of actuality, while she accepts the inherent ordering of times. Then, she decides that the metaphysical difference is robust enough to grant a different (post)semantic treatment of actual and counterfactual future contingents.

The guiding idea is that the truth of categorical and hypothetical predictions is differently grounded, thus the difference should be reflected in the postsemantic theory of future contingents. There is more than one way to do this. You can combine Ockhamism with anti-Molinism and get the result that all counterfactual contingents are *false*, while some future contingents are true. This view seems close to what David Lewis might have endorsed. The categorical prediction is either true or false since every world decides the issue one way or the other. On the other hand, since not all the worlds in the closest “tossing-sphere” have the coin landing heads, the counterfactual which states that it would have landed heads is simply false. You can model this result with the following postsemantics:

**Definition 4.9 (Anti-Molinist Ockhamism)**  $c \Vdash \phi$  iff  $m_c/h_c, s \models \phi^\square$  where  $m_c/h_c$  is the moment and the history of the context, while  $\phi^\square$  is the translation of  $\phi$  where every occurrence of  $>$  is replaced with  $\boxminus$ .

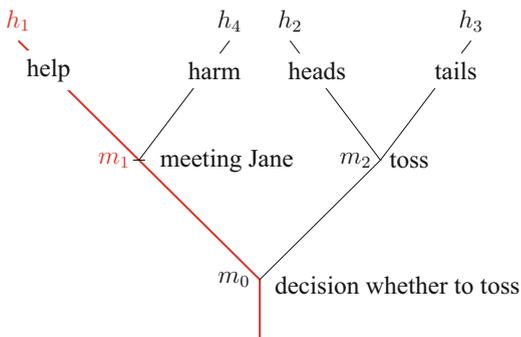
Thus, the context gives you the world that is relevant for the evaluation of future-tensed sentences, while the conditional is modalized, so all counterfactual contingents turn out false.

However, you are free to choose a more moderate path that is akin to what was suggested by Malpass and Wawer (2012). According to this line of thought, if there is no ground (in the actual world) to decide a counterfactual contingent one way or the other, it should be regarded neither true nor false. You can achieve this result by properly mixing some previous theories:

**Definition 4.10 (Non-Molinist Ockhamism)**  $c \Vdash \phi$  iff  $\forall_s m_c/h_c, s \models \phi$ , where  $m_c/h_c$  is the moment and the history of the context.

Thus, we evaluate future contingents with respect to the history of the context (i.e. in the actual world), while we supervaluate over the selection functions. This means that a counterfactual is true (false) only if it is historically necessary (impossible). Otherwise, if it holds for some but not all selection functions, it is neither true nor false. In contrast, every sentence about the future, including a future

Fig. 4.2 Model 2



contingent, acquires one of the classical truth values in every context in which it is uttered. The definition above presupposes that the context *does* initialize the unique moment/history (time/world) of the context, but it *does not* initialize the unique non-actual world relevant for a counterfactual. Both those principles may be disputed, but they consistently embody Ockhamism without Molinism.

Let us take a look at the slightly extended model depicted in Fig. 4.2 and see how non-Molinist Ockhamism works in practice. Assume that context  $c_1$  initializes parameters  $m_1$  and  $h_1$ , and we get the expected results:

- $c_1 \models F(\textit{help})$
- $c_1 \models \neg F(\textit{harm})$
- $c_2 \models F(\textit{help}) \vee F(\textit{harm})$
- $c_1 \not\models (\textit{toss} > F(\textit{heads}))$
- $c_1 \not\models \neg(\textit{toss} > F(\textit{heads}))$
- $c_1 \models (\textit{toss} > (F(\textit{tails}) \vee F(\textit{heads})))$

This means that we end up with a theory which incorporates the previously presented ideas. It is faithful to the principle that future facts have more potential to serve as truth-makers than counterfactual facts. The unique actuality can be used to decide the truth values of future contingents, but it is not robust enough to decide the truth values of counterfactual contingents (the last counterfactual on the list is true, but the consequent is no longer contingent). Thus, future contingents are “bivalent,” while counterfactual contingents are neither true nor false. This concludes the proof of the consistency of Ockhamism without Molinism.

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# Chapter 5

## Future Contingents in a Branching Universe



Mitchell S. Green

*“Prediction is very difficult, especially about the future.”*  
Niels Bohr

**Abstract** Suppose that our world is objectively indeterministic, so that at certain points in time, there is more than one way in which events might carry on. Two main positions address how to think about the future as it unfolds beyond such indeterministic points in time: the Thin Red Line (TRL) approach which holds that among possible future courses of events, exactly one of them is what will happen; and the Open Future (OF) approach which denies this posit of a privileged course of events. OF is often associated with the view that future contingents (statements concerning future events whose truth value is not guaranteed by physical, metaphysical, or logical necessity) are neither true nor false. This “truth-value gap” commitment has in turn been thought to produce unpalatable implications concerning the practice of assertion: (1) Some have denied that it is possible to assert a future contingent when that statement’s propositional content lacks truth value at the time of its utterance; (2) others have denied that one can appropriately assert a future contingent when its propositional content cannot be known to be true at the time of its utterance. In response to (1) I argue that a sentence can have truth conditions, and thus a determinate content, even if it lacks truth value at its time of utterance. Because it is contents (rather than truth-valued contents) that are needed for viable speech acts, I conclude that OF can readily accommodate assertions of future contingents. In response to (2) I argue that even if we accept the “knowledge norm” for assertion that drives this objection, that norm does not mandate a reading on which assertions of future contingents must violate it on OF. The upshot of our response to these two objections to OF is that the contest between it and TRL should be settled, if at all, on other grounds than those pertaining to the pragmatic and epistemological aspects of assertion of future contingents.

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## 5.1 Introduction

Suppose that our world is objectively<sup>1</sup> indeterministic; we are then confronted with a further question how to think of the multiplicity of future courses of events that may ensue upon indeterministic moments. The “Thin Red Line” (TRL) approach contends that from among those future courses of events, exactly one of them is what *will* happen. By contrast, and out of respect for ontological parsimony the Open Future (OF) approach denies this posit, and this denial is usually taken to entail that future-contingent sentences are neither true nor false. Yet critics and even some proponents of OF have argued that this imputation of truth-value gaps results in its inability to make sense of the common and apparently sometimes reasonable practice of issuing predictions when the predicted event is not deterministically settled by current affairs. This challenge takes two forms. One form is sometimes referred to as the *assertion problem* (although it generalizes to other illocutionary acts) and has been pressed by Belnap and Green (1994, 2001), Perloff and Belnap (2011), Stojanovic (2014), and Sweeney (2015). In response I argue that a sentence can have truth conditions, and thus a determinate content, even if it lacks truth value at its moment of utterance. Because it is contents (rather than truth-valued contents) that are needed for viable speech acts, I conclude that the assertion problem does not beset OF.

Another form of challenge to OF (due to Besson and Hattiangadi 2014, 2020) concerns its apparent violation of a norm requiring those who issue assertions to know that the content asserted is true. I argue that even if we accept the “knowledge norm” for assertion that drives this objection, that norm does not mandate a reading on which future-directed illocutions on the OF framework must violate it. The upshot of our response to these two objections to OF is that the contest between it and TRL views should be settled, if at all, on other grounds than those pertaining to the pragmatic and epistemological aspects of assertion of future contingents.

## 5.2 The Branching Approach to Indeterminism

Define a *future contingent* as a token of an indicative sentence uttered in a situation in which its truth value depends on events not deterministically fixed by the context of utterance in which it is used.<sup>2</sup> For instance, imagine (1) below uttered at 4 pm on Tuesday, 10 December, 2019, and in which the coin toss under discussion is an

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<sup>1</sup> The adjective ‘objectively’ is intended to distinguish the hypothesis in question from a kind of indeterminism due to human ignorance.

<sup>2</sup> In what follows, ‘utterance’ is used to refer to locutionary acts. When we need to speak of speech acts proper, or illocutionary acts, we will make that fact clear. For further discussion of the distinction between acts of speech (locutionary acts) and speech acts proper (illocutionary acts), see Green 2020.

indeterministic process so that current conditions do not physically necessitate that the coin will land one way or the other:

(1) The coin lands heads at 5 pm on Tuesday, 10 December 2019.<sup>3</sup>

Then (1), uttered at 4 pm on Tuesday, 10 December, 2019, is a future contingent in our sense, since on one potential course of history, the coin lands heads, while on another potential course of history it lands tails. The sentence's truth value therefore depends on events not deterministically fixed by the context of utterance in which it is used. Other future contingents contain tense operators, such as we find in

(2) The coin will land heads at 5 pm on Tuesday, 10 December, 2019,

uttered in a situation prior to 5 pm on 10 December, 2019. Yet others contain indexical expressions, such as

(3) The coin will land heads at 5 pm tomorrow,

uttered one day prior to 5 pm on Tuesday, 10 December, 2019. Also, we here distinguish between a future contingent and a *future-directed illocution*, here defined as a future contingent put forth with some illocutionary force. All future-directed illocutions are also future contingents, but not vice versa.

Considered as a sentence-type, (1) is plausibly true just in case the coin under discussion lands heads at 5 pm on Tuesday, 10 December 2019. However, one might be puzzled over what to say about the truth value of (1) when it is uttered and thereby tokened at 4 pm that day. Could it be true at the time of utterance? Does it need to be true at that time for its utterance to be intelligible? Similarly, (2)'s truth conditions may be given disquotationally, but we may also harbor doubts about the truth value of the tokening under consideration. Analogous questions may be raised about (3).

In his considerations about the impending sea battle, Aristotle claimed that future contingents are neither true nor false.<sup>4</sup> By contrast, William of Ockham is widely read as contending that a statement about the future can be true at the time of utterance even if it is not the case that its truth is necessitated by current states of affairs. Accordingly, what is now sometimes called Ockhamism, or what Belnap and Green (1994, 2001) term the doctrine of the Thin Red Line (TRL hereafter), holds that among those histories that might branch indeterministically out of the present, there is always exactly one that is the history that is *going* to happen.<sup>5</sup> On this

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<sup>3</sup> A referee for an earlier version of this article contended that (1) is not an acceptable sentence of English unless the coin's landing heads is a scheduled event. Even if that were true, it would not vitiate the use I wish to make of (1). Further, we may readily imagine a dialogic context in which its use would be acceptable even when the event in question is not scheduled: A. What do you say about that coin? B. I say the following: The coin lands heads at 5 pm on Tuesday, 10 December, 2019.

<sup>4</sup> Iacona (n.d.) provides a helpful overview of the history of thinking about future contingents, as do Øhrstrøm and Hasle (2015).

<sup>5</sup> Iacona (2018) argues persuasively that Ockhamism may be defended without commitment to a TRL. For this reason, we may see Belnap and Green (1994, 2001) and many who follow them as offering the TRL doctrine as one elucidation of Ockhamism, but not a mandatory one.

approach it is the trajectory of the red line leading from the present that determines the truth value of future contingents. Likewise, on this approach, sentence (1) above is true at 4 pm on Tuesday, 10 December, 2019, just in case, at 5 pm on Tuesday, 10 December 2019, on the TRL, the coin in question comes up heads. Exactly the same goes for sentences (2) and (3). The TRL thus serves as a truthmaker as well as a falsity-maker for future contingents. For sentences whose truth is not sensitive to indeterministic states of affairs, such as, ‘Gold’s atomic number is 79,’ or ‘The Visigoths sacked Rome in AD 410’, uttered some time posterior to AD 410, no reference to colored lines is needed. The reason is that the first of these sentences is true no matter when uttered (or at least, at any time suitably after the Big Bang), while the second is true no matter when uttered after AD 410.

The privileged character of a particular history is not something determined by the physics of the situation prior to it. Likewise the occurrence of a moment that inhabits the TRL is not an event that supervenes on the physics of the world prior to that moment. Thus while the TRL view provides truth-makers for future contingents, it does so at an ontological cost, and those with naturistic scruples will seek ways to eschew it.<sup>6</sup>

A parsimonious alternative to the TRL doctrine which we shall term the Open Future (OF) view holds that when there is branching in our world, no one of those branches is privileged over any others as being the one that is going to occur. Thus according to OF, not even an omniscient being would know all of what the future holds if there are events in the future not deterministically settled by how things currently stand. If we are tossing a coin, and some aspect of the process is indeterministic, then it could happen that on one history, the coin comes up Heads, while on another history it comes up Tails, but neither history is privileged over the other as being the one that is going to occur. In that case even an omniscient being will not know how the coin will land before it is tossed.

Further, on the best-known elucidation of the OF approach, future contingent sentences such as (1), (2), and (3), will lack truth value at the time they are asserted, namely 4 pm Tuesday, 10 December, 2019.<sup>7</sup> Instead, to assign a truth value to any of these sentences we must wait an hour to see how the coin toss turns out. Indeed, the constraint is not just epistemic: an hour must pass before the 4 pm utterance gets a truth value regardless of what anyone may happen to know. This fact has raised a seeming difficulty that has come to be called the assertion problem. We shall return to it after developing some semantic ideas.

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<sup>6</sup> Borghini and Torrenco (2013, pp. 121–3) acknowledge this limitation, and suggest instead that the TRL is just a brute fact about the world.

<sup>7</sup> Todd 2016 argues that ‘Will:A’ should be analyzed as ‘A is true on the actual future’; but given his denial that there is an actual future, together with his Russellian analysis of descriptions, Todd concludes that all future contingents are false (rather than neither true nor false). Todd may thus coherently maintain an OF view while holding that all future contingents are truth-valued. Schoubye and Rabern 2017 raise a number of objection to Todd, the most serious of which, to my mind, concern his contention that ‘will’ should be analyzed in descriptive terms.

### 5.3 Three Elaborations of the Branching Approach

Let  $S1$  be a quintuple  $\{M, \leq, H, \text{Par}, \text{Val}\}$ , where  $M$  is a set of moments, each member of which is understood as a complete and instantaneous slice of the entire universe;  $\leq$  is a partial ordering relation on members of  $M$ ;  $H$  is a set of maximal linearly ordered sets of moments; and  $\text{Par}$  is a partition of elements of  $M$ , where each resulting element of the partition is an *instant*. (The upshot of  $\text{Par}$  is that for any moment  $m \in M$  we may speak of *the instant of  $m$* , written,  $[m]$ .)  $\text{Val}$  is an evaluation function mapping propositional constants to sets of moments. (We deal with the propositional case only, as quantification brings up issues that are orthogonal to our current concerns.)

As Stojanovic (2014) observes, different approaches to the metaphysics of time are associated with different semantic treatments. For instance, Belnap & Green (1994) held that in order for the semantic evaluation of a future-tensed sentence to proceed in the absence of a TRL, a definition of truth for non-atomic formulae needs not just a moment but also a history. This is because a sentence might be true on one historical continuation of that moment but not another; yet in the absence of a means of breaking the symmetry among various moments, there will be no way of selecting one as opposed to another of these histories as a truthmaker for the sentence in question. For this reason, on these authors' analysis, truth is relativized to both moments and histories, as follows:

'Will:A' is true at  $m/h$  iff for some  $m_1 > m$  and  $m_1 \in h$ , 'A' is true at  $m_1/h$ .

'Was:A' is true at  $m/h$  iff for some  $m_1 < m$ , 'A' is true at  $m_1/h$ .

'Will-always:A' is true at  $m/h$  iff for all  $m_i > m$  and  $m_i \in h$ , 'A' is true at  $m_i/h$ .

'Settled-true:A' is true at  $m/h$  iff for all  $h'$  such that  $m \in h'$  and all  $m_i > m$ , 'A' is true at  $m_i/h'$ .

(To appreciate the difference between 'Will-always:A' and 'Settled-true:A', observe that we may wish to express the thought that it will always be the case that A, without committing ourselves to the further claim that A must occur. One might, for instance, believe of a certain person that they always will in fact act virtuously, even though each time they act they are free to do otherwise.)

By contrast with the Open Future approach, one way in which to implement an Ockamist point of view is with the posit of a TRL, such that every indeterministic moment has a definite and unique future ahead of it. We capture this with a modification of the earlier semantic apparatus to give  $S2 = \{M, \leq, H, \text{Par}, \text{TRL}, \text{Val}\}$ , which is just like  $S1$  except that it also contains  $\text{TRL}$ , a function from moments to histories constrained by the requirement that for every  $m$ ,  $m \in \text{TRL}(m)$ . This allows us to speak of 'the future of moment  $m$ ' for any moment; that will in turn ground a semantic clause that enables us to avoid relativization to histories as follows:

'Will:A' is true at  $m$  iff for some  $m_1 > m$  and  $m_1 \in \text{TRL}(m)$ , 'A' is true at  $m_1$ .

‘Was:A’ is true at  $m$  iff for some  $m_1 < m$ , ‘A’ is true at  $m_1$ .

‘Will-always:A’ is true at  $m$  iff for all  $m_i > m$  and  $m_i \in \text{TRL}(m)$ , ‘A’ is true at  $m_i$ .

‘Settled-true:A’ is true at  $m$  iff for all  $m_i > m$ , ‘A’ is true at  $m_i$ .

Other semantic treatments are available, such as those associated with Peirce, Leibniz, and supervaluationism respectively.<sup>8</sup> But consider again the tenseless (1), understood as tokened at 4 pm. In spite of being tokened at that time, it has a definite set of truth conditions: if at 5 pm the coin comes up heads, then (1) is true; otherwise it is false. Similarly for (2) and (3). Accordingly, a sentence-token’s having truth *conditions* does not require it to have truth *value* at the moment of its tokening. So long as the sentence is certain to be assigned a truth value no matter how history unfolds, and without any post-utterance semantic elaboration on the part of speakers, that will be enough for the sentence to contribute a content to the conversation in which it occurs even before it earns a truth value. In support of this observation I first offer a semantics for tensed and other time-sensitive language that allows for the possibility that a token of a sentence might fail to have a truth value when tokened but come to do so as history unfolds. In so doing I depart from Belnap and Green (1994, 2001) to offer an interpretation of the OF approach that adheres more resolutely to its original motivation.

*Resolutely Open Future (ROF) approach:* On the ROF approach, and in common with that used for the TRL view, sentence truth is relative to moments but not to histories. If the evaluation of tensed expressions requires us to jump forward in (a potentially branching) time, we use instants instead of histories. But we need to bear in mind that if even an omniscient being cannot know what an indeterministic future holds, we should not expect a semanticist to be in any better position. This will mean that a structure we build for semantic evaluation should never tell us theorists what an indeterministic future holds, but should rather require us to wait to see how history unfolds for purpose of semantic evaluation.

To spell out the ROF approach, then, let us return to the tuple  $S1 = \{M, \leq, H, \text{Par}, \text{Val}\}$ , thus abjuring the TRL function. However, we now stipulate that elements of  $M$  are only those moments that have occurred, could occur, or could have occurred in the universe we inhabit. This enables  $S1$  to mirror our universe more closely than do artificially constructed models. The cost of this choice is that sometimes we can only assign truth values to sentences as history unfolds. This is due to the fact that semantic evaluation is *omniscient* but *moment-bound*: it has access to all the facts that obtain up to and including the moment at which that evaluation occurs, but only to facts pertaining to those future events that are settled at that moment of evaluation. The omniscient semanticist cannot peer beyond indeterministic moments any more than a Greatest Conceivable Being can. Rather, all she can know about such moments and their sequelae is what might happen, and she will have to wait if she wishes to know what does in fact occur. For this reason, if our universe contains indeterministic moments, semantic evaluation will have to

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<sup>8</sup> Again see Øhrstrøm and Hasle (2015).

watch events play out before assigning truth values to sentences pertaining to what lies beyond those moments.

The basic ROF clauses are as follows:

‘Will(A)’ is true at  $m$  iff for some  $m_1 > m$ , ‘A’ is true at  $[m_1]$ .

‘Was(A)’ is true at  $m$  iff for some  $m_1 < m$ , ‘A’ is true at  $m_1$ .

‘Will-always:A’ is true at  $m$  iff for all  $m_1 > m$ , ‘A’ is true at  $[m_1]$ .

‘Settled-true(A)’ is true at  $m$  iff for all  $m_1 > m$ , ‘A’ is true at  $m_1$ .

The asymmetry between, for instance, the first two clauses reflects the fundamental asymmetry of time as understood by the Open Future approach. The settledness of the past makes the semantic evaluation of ‘Was(A)’ comparatively easy. By contrast, in evaluating the complement of the future-tense sentence, we consult instants rather than moments. ‘A’ might be true on some moments that make up a particular instant but not on others. But this just means that on the Open Future view, we may not be able to assign a truth value to the complement until such time as the facts settle whether or not ‘A’ holds. That will in turn settle the truth value of ‘Will(A)’. In fact, the truth value of ‘A’ gets settled no matter how history turns out, and so, therefore, will the truth value of ‘Will(A)’.<sup>9</sup>

If ‘Will(A)’ is not a future contingent, but says for instance that it will be the case that gold’s atomic number is 79, then according to ROF semantics, ‘Will(A)’ is true at the time of utterance. (It will be true at a later moment  $m_1$  no matter which history in  $[m_1]$  materializes.) On the other hand, if it is a future contingent, ‘Will(A)’ fails to have a truth value at the time of utterance, but will acquire one at a later time. If that happens, then at that later time we will be careful to say not that the tokening of ‘Will(A)’ *was* true, but that it *is*. Similarly, if someone asserted ‘Will(A)’ at that earlier time, then we will say not that she was right (correct), but that she is.<sup>10</sup>

The notion of a sentence becoming true should not be cause for alarm. You might say, “She is tall,” simply for the sake of complying with the request, “Please use a sentence containing a pronoun and a comparative adjective.” A moment later, you notice a woman of considerable height, and declare, “She sure is!” Here a case can be made that one’s original sentence ‘She is tall’ has come to be true, though it needed an implicit supplementation by the speaker in order to become truth-evaluable. On the Resolutely Open Future approach, ‘Will(A)’ will have definite

<sup>9</sup> A referee for an earlier draft of this article offers what they take to be a counterexample to the claim that every future contingent has its truth value settled eventually. The example they offer is due to Dummett: “A city will never be built here”, and we are to imagine it said of a location on which no city is built over an infinite duration of time. However, our semantic clause for ‘Will-always:A’ predicts, as it should, that the Dummett sentence is true in the imagined scenario.

<sup>10</sup> The truth definitions that we have given for ROF have the welcome feature that they do not validate what Todd and Rabern (2019) call “Retro-closure”: If A, then Was:Will:A. Suppose ‘A’ holds at  $m$ . ‘Was:Will:A’ is true at  $m$  iff ‘Will:A’ is true at some  $m' < m$ . But there need not be any such  $m'$ . After all, back when it was  $m'$  (for any  $m'$  we choose), the future might have been open on the issue of ‘A’. See Todd and Rabern (Ibid) for further reason to be doubtful of Retro-closure.

truth conditions and thus will express a determinate content in the context in which it is uttered even if it has to wait for history to unfold before earning a truth value. Unlike the indexical-involving case, however, it needs no supplementation from the speaker in order to become truth-valued. Instead, all it needs is the passage of time and the concomitant unfolding of events.

Similarly, recall our tenseless sentence:

(1) The coin lands heads at 5 pm on Tuesday, 10 December 2019.

On the ROF approach, and assuming as before that the coin toss is indeterministic, when tokened at 4 pm on Tuesday, 10 December, 2019, (1) lacks a truth value. But if history unfolds in such a way that the coin lands heads at 5 pm, then that token becomes true, and does so without any semantic or pragmatic elaboration on the part of the speaker. As before, this fact will enable us to say, at 5 pm, that the speaker of (1) is right, or correct. It will not follow, nor should we contend, that the speaker of (1) was right (correct) when she tokened this sentence at 4 pm.

## 5.4 Future-Directed Illocutions and the “Assertion Problem”

Assertions are a type of speech act in which a speaker undertakes a commitment to a propositional content. We shall avoid well-known disputes about the nature of propositions if we agree that propositions either are, or determine, a set of truth conditions. (Such an agreement is compatible with their having more fine-grained identity conditions than are given by truth conditions.) Further, one who commits herself by means of an assertion to a set of truth conditions is *right* or *wrong* (alternatively, *correct* or *incorrect*) depending on whether the actual state of affairs turns out to be in that set. Thus one who asserts that there are exactly 196 marbles in an opaque container is right if that container contains 196 marbles; wrong otherwise. In the latter case she will even be wrong if she has extremely good reasons for thinking the jar contains 196 marbles, such as having been told by a reliable source that the jar contains that many marbles. Because an agent might be right about one proposition and wrong about another, where appropriate we will adopt the locution, ‘A is right (wrong) on the issue of p.’ Note that on the way we use terminology here, being right and being wrong (correct, incorrect) are properties either of agents or of their acts rather than of propositions or sentences. (We’ll reserve the adjectives ‘true’ and ‘false’ for propositions and sentences.<sup>11</sup>)

Like other speech acts, the social institution of assertion is a product of cultural evolution, and so we should expect to find that it is designed for a certain job even if no speaker ever consciously set out to formulate a practice of assertion with that

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<sup>11</sup> Failure to attend to the distinction between truth/falsehood of sentences or propositions, on the one hand, and correctness/incorrectness of speakers and their illocutionary acts, can lead to fallacious reasoning. One such fallacy is pointed out in Green 2018 in the course of discussing P. Hanks’ criticism of the force/content distinction.

**Table 5.1** Three dimensions of commitment for four members of the assertive family, and for two non-members (sheer guesses and suppositions) (From Green 2016)

Speech act	liability	frankness	fidelity
Assertion	Y	Y: Belief	Y: Provide strong justification if challenged
Conjecture	Y	Y: Some reason to think content true; perhaps intention to investigate	Y: Provide some justification if challenged; readiness to determine truth value of content
Presumption	Y	Y: Intention to treat content as true	Y: Treat content as true
Educated guess	Y	Y: Some reason to think content true	Y: Provide some justification if challenged
Sheer guess	Y	N	N
Supposition	N	Y: Intention to investigate what follows from content	Y: Reason with content to determine what follows

or any other job in mind. Further, from this evolutionary perspective we should not expect to find that assertion is ideally suited for all purposes to which it might be put. What is more, assertion is a member of what is elsewhere (Green 2016) termed the ‘assertive family’, whose other members include such speech acts as conjectures and educated guesses. All members of the assertive family involve commitment to propositional contents, but do so in different ways. For instance, while it is often appropriate to respond to an assertion of A with the challenge, “How do you know?”, that challenge is inappropriate in reply to a conjecture of A. Instead, an appropriate reply to a conjecture would be a challenge such as, “What reasons do you have in support of that conjecture?” In addition to making assertions about the future, we can also make conjectures and guesses about it. Also, as is the case with those who make assertions, those who make conjectures and guesses will be right or wrong depending on how things turn out.

Table 5.1 sketches the main dimensions of commitment for four members of the assertive family as well as for two non-members. These dimensions are liability (to being right or wrong depending on the truth value of the proposition illocuted), frankness (our term for sincerity), and fidelity (which specifies what a speaker is obliged to do consequent upon asserting, conjecturing, etc., the proposition in question).

People talk not only of asserting propositions; they also speak of asserting sentences. We need not take issue with this way of speaking, but must bear in mind that an indicative sentence can be asserted only if it expresses a propositional content. Thus one who utters ‘She is hungry’ makes an assertion only if ‘she’ has been given a referent in the context of the speaker’s utterance. (Otherwise, she has performed an act of speech but no speech act.) Similar points apply to other well-known indexical terms such as ‘I’, ‘here’, ‘now’, ‘actually’, and ‘today’. We may sum this up by saying that while indicative sentences express characters (functions

from contexts to contents), they only express contents when the context in which they are uttered provides contents for any indexical elements they may contain.<sup>12</sup>

The concern raised by the assertion problem is that if we adopt OF, future contingents will behave like sentences containing free variables, or like sentences containing indexical elements for which the context of utterance fails to provide a content. The difficulty was initially formulated in Belnap and Green 1994. In addition to arguing against the TRL view and in favor of OF, these authors raise a problem for OF to which they then offer a solution. They term this problem the *assertion problem*, although if there is a problem for assertion, there will be a similar problem for other speech acts such as conjectures, bets, and guesses as well—indeed any other speech acts capable of having contents pertaining to an indeterministic future. The problem is as follows. A putative future-directed assertion, such as, “The die will show six,” will on a branching time picture be made at a particular moment *m*—or so we may idealize even though it is clear that any utterance will occur over a time interval rather than at a single moment. But in an indeterministic world, any such moment *m* could have more than one history *h* running through it, on some of which the die shows six, on others it shows four, and so on. The context of utterance provides a time, speaker, location, and the other usual parameters. However, if we adopt the OF approach rather than that of the TRL, the context of utterance will not provide a unique history whose moments would otherwise serve as truth- (falsity-) makers for future contingents. With reference to the throw of a six-sided die, assumed to be an indeterministic process, these facts prompt Belnap and Green to ask:

... how can it possibly make sense to assert e.g. ‘Will:the die shows six’? Surely, it would seem, it must be incoherent to hold both that this sentence is historically open (historical openness thesis<sup>13</sup>) and that it is a proper vehicle for assertion (assertability thesis). On the analogy we have worked out in detail, it should (it would seem) make no more sense to assert ‘Will:the die shows six’ than to assert ‘*x* is brindle’ (nonassertability thesis). This is the Assertion problem. (1994, p. 378)

This reasoning would suggest that defenders of OF will have difficulty making sense of people’s tendency to assert (conjecture, bet on, etc.) future contingents. Granted, some such assertions (conjectures, etc.) are of questionable reasonableness. However, not all are: just change the die-throwing example, and the coin-toss example we have used in (1)–(3), to one in which a speaker predicts, on the basis of multiple reliable weather forecasts all of which call for 90% chance of rain tomorrow, that it will rain on that day.

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<sup>12</sup> For further discussion see Green 2021b.

<sup>13</sup> These authors understand the historical openness thesis as stating that the sentence ‘Will:the die shows heads’ does not have a truth value that is determined by either the context of utterance or other parameters of semantic evaluation.

## 5.5 The Assertion Problem Defused<sup>14</sup>

Let us, however, reflect upon the above-quoted argument's analogy between future contingents and sentences containing a free variable. It is true that 'x is brindle' fails to express a content until we specify what will fill in for the variable; so too, the indexical-containing 'she is brindle' fails to express a content until we specify to whom the pronoun refers. As a result of failing to express contents, both sentences (or sentence-frame for the free-variable case) will fail to have a truth value and will fail to have truth conditions. As such they will both be unsuited for use in locutionary acts, to say nothing of illocutionary acts. This much should not be controversial. Nor should the observation that according to OF, at the time of utterance, 'The die will show six' might be neither true nor false if the die-roll is an indeterministic process. But unlike the open sentence case, and unlike the indexical case, the future contingent will be either borne out or falsified no matter what comes to pass: on every history passing through the moment of utterance, the die in question either shows six, or it does not. This becomes particularly clear on our ROF semantics: no matter what, when the instant in question comes to pass, either the coin lands heads or it lands tails; that will in turn determine whether the earlier prediction has or has not been borne out. As a result 'The die will show six' has a determinate set of truth conditions, and accordingly a determinate content that may be locuted or, if one so wishes, asserted, conjectured, bet upon, queried, etc., depending on the intentions of the speaker.

In an expanded version of their 1994, Belnap and Green (2001) formulate the assertion problem as follows:

Our semantic account of history-open sentences seems *severely in tension* with our assertability claims almost to the point of apparent contradiction: Like assignment-open sentences, history-open sentences "have *no* truth value" (given only model and context). But if they have no truth value, it would seem that they would be no more assertable than assignment-open sentences. After all—if we may be permitted language known to be untrustworthy—it is certain that to assert A is to assert that A is *true*. (2001, p. 158; italics in original.)

(In these authors' terminology, an assignment-open sentence is a sentence that has a free variable, such as 'x is brindle', tokened in a situation in which no value has been assigned to 'x'.) As with our response to the 1994 formulation of the problem, we may observe that a sentence's lacking truth value is compatible with its having truth conditions; further, that unlike assignment-open sentences, a future contingent does have truth conditions and thus is apt material for use in both locutionary and illocutionary acts.

What is new in the 2001 formulation of Belnap and Green's argument is in the final sentence of the quoted passage, that is, the claim that to assert that A is to assert that A is true. This point, however, does not add to the urgency of the assertion

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<sup>14</sup> The argument of this section develops a suggestion made but not pursued in detail in Green 2013.

problem. It is only if we take ‘is true’ as meaning ‘is true now’ that any concern should arise. That construal, however, is not mandatory. Consider again sentence (1). Imagine asking a speaker who asserts it at 4 pm on Tuesday, 10 December 2019, whether she means that what she says is true. She will likely aver that she does. Now imagine asking her whether she means that what she says is true *now*. It would be reasonable for her to stare back at her interrogator in puzzlement, and remark that all she needs to say in response is that she is claiming that the coin will land heads at 5 pm.<sup>15</sup>

A more recent discussion of the assertion problem merits a similar reply. Sweeney 2015 argues on grounds similar to that of Belnap and Green that the OF view implies that it is not possible to assert future contingents. Her reasoning is as follows. On the OF approach, at an indeterministic point in time, the context of utterance will not provide a unique history to serve as a truthmaker (or falsity-maker) for a future contingent such as ‘It will be sunny in Barcelona tomorrow.’ Sweeney infers that on the OF approach, future contingents are not assertable, writing:

In brief, the assertion problem is to be understood as follows. Future contingents appear to be assertable. The history parameter – required in order to assess the truth of the historical modalities – must be initialised by the context of utterance, yet the context of utterance – having no unique history – is incapable of initialising the history parameter. As such, future contingents are not truth-evaluable, therefore they are unassertable. (2015, pp. 412-413)

Consider the final sentence of the quoted text. We have seen that on OF, future contingents do not have truth values at the time at which they are uttered. It does not follow that they are not truth evaluable. After all, in all cases, time will tell whether the future-contingent is borne out or not. ‘The die will show six’ has determinate truth conditions—or at least, *modulo* phenomena such as vagueness—truth conditions as determinate as may be expected of ordinary-language sentences rather than those from an advanced science. If, subsequent to the utterance, the die shows six, then the speaker is right on the issue of the die in question; otherwise she is incorrect on that issue. As was the case with Belnap and Green’s discussions, Sweeney identifies no bar to the assertability of future contingents on the OF view.<sup>16</sup>

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<sup>15</sup> Note also that because ‘A asserts p’ is an intensional context, we may reasonably doubt that to assert p is to assert that p is true, just as we may reasonably doubt that to assert that Hesperus is shining is to assert that Phosphorus is shining even if Hesperus is one and the same entity as Phosphorus. Granted, it does appear undeniable that to assert p is among other things to represent p as being true. However, that does not entail that one who asserts p represents p as being true now, rather than as being true at the appropriate time and in the appropriate way.

<sup>16</sup> Stojanovic also raises the assertion problem, and does so in the following terms: “The Assertion problem, as it arises for the Open Future account, is to explain how, on a semantic level, a future tensed sentence behaves like a sentence that contains a free pronoun, while behaving very differently at the level of assertion: asserting a future tensed sentence is typically felicitous even in the absence of a unique future (supplied as a value for the history parameter), while asserting a sentence with a pronoun appears to require that there be something for the pronoun to refer to.” (2014, p. 40). It should by now be clear that the appropriate reply to the problem thus formulated is that future-tensed sentences are importantly different from those containing what Stojanovic calls

One may attempt to minimize the contrast we are here highlighting between future contingents and indexical-containing sentences. (We leave aside sentences containing free variables for simplicity.) Granted, typically the only way to get an indexical-containing sentence to express a content is by means of an action such as uttering ‘I’, or ‘here’ at a certain location, and thus giving those words content as directed by their characters. By contrast, no such further act is required for sentences such as (1), (2), or (3) to “kick in” and do their m/h-pair sorting work. We may however imagine a set-up that is independent of the speaker of an indexical-containing sentence, and so rigged that no matter what happens, the indexical becomes saturated with a content, thereby enabling the entire sentence to express a content and thereby become truth-evaluable. Imagine that we drop from an airplane a sandbag on which is written the words, ‘It’s sunny here’. The sandbag has attached to it an electronic tracking device so that we can locate it after it has landed. Then after our flight is over we locate the sandbag, making sure to check whether it is sunny at that location. Assume that the process of the bag’s falling from plane to ground is not deterministic.

It would seem that in the scenario just envisioned, no matter where the sandbag lands, the inscribed sentence is either true or false. This case of what we might call an *aleatory illocution* shows that being guaranteed to end up having definite truth conditions, without any further action on the part of the speaker, is not a sufficient condition for an indicative sentence to express a proposition. Observe however that we would not say that whoever wrote the words, ‘It’s sunny here,’ on the sandbag made a claim with a definite content before the object was released from the airplane. (Or if she did, then her tokening of ‘here’ refers to the location of the plane, and so would have determinate truth conditions.) Instead, what she said depends on where the sandbag lands. By contrast, in the future contingent cases such as (1)–(3), nothing at all is needed subsequent to the utterance, either from the speaker or from the environment, for its content to become fixed. The content and thus the truth conditions of the sandbag inscription on the other hand depend on a contribution from the environment.<sup>17</sup>

Future contingents, then, have a content, or set of truth conditions, when they are uttered, and this is in spite of the fact that on the OF approach, they do not (yet) have truth values. The point is easy to miss because future contingents are often expressed with indexical words such as ‘tomorrow’. However, that is an inessential feature of such cases, as we have seen in example (1). Even in cases such as (2), which involves the temporal connective ‘will’, it is doubtful that we find indexicality. We

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free pronouns. This difference emerges clearly once we notice that the former but not the latter have determinate truth conditions.

<sup>17</sup> This point may be obscured by the fact that we can imagine people in the airplane placing a bet on whether the sandbag lands somewhere sunny. However, that does not show that the sentence inscribed on the sandbag, and before the bag has landed on the ground, expresses a determinate content. Instead, the bettors are wagering on the following quite determinate content, namely that wherever the sandbag lands, that place will be a sunny one (for at least a relatively brief period after the bag’s landing).

may observe this point by noting that if two speakers utter tokens of (2), one on Sunday, 8 December, 2019, and the other on Monday, 9 December, 2019, we have no hesitation in describing them as having said the same thing. That is in stark contrast to what we would say of two speakers who each assert (3) on different days. Although they have uttered tokens of the same sentence-type, in an important sense, they have said different things, as witnessed by the differing truth conditions of the two utterances.<sup>18</sup>

On the Open Future approach, then, future contingents have truth conditions, and thus determinate content, on the strength of the fact that they are certain to turn out true or false in the fullness of time. However, Belnap and Green argue that attempting to dissolve the assertion problem by exploiting this fact as we have done in the previous section is facile. Their reason is that if the strategy were viable, then we should equally well argue that sentence-frames such as ‘x is tall’ have semantic contents and are therefore also apt vehicles of assertion and other illocutions. Belnap and Green 1994 put the objection as follows:

It would be inadequate to attempt to be quick with the assertion problem by pointing out that even Will:A has a semantic value, represented e.g. by a set of m/h pairs, which can be a “content” available for such relations as asserting. The problem is that even ‘x is brindle’ has a semantic value, represented e.g. by a set of assignments. It would be arbitrary for us to insist without discussion that a set of assignments cannot serve as the content of an assertion, whereas a set of m/h pairs can. (1994, p. 382)

These authors appear to have been placing undue weight on the formal analogy between assignments of values to variables and sets of truth conditions. This formal analogy needs to be balanced against a strong pragmatic disanalogy, namely that sentence-frames like ‘x is brindle’ require an act of assignment of values to variables on the part of the speaker, or (as with the aleatoric case) an artifice by means of which the world will do so, in order to express an intelligible content. On the other hand, ‘Will:A’ needs no such supplementary act or plan so long as ‘A’ itself expresses a content. This fact becomes even clearer with sentences such as (1), which contains no temporal operators. Only someone overly impressed by a formal analogy could be in doubt that this sentence has a semantic content if uttered at a time prior to 5 pm on Tuesday, 10 December 2019.

As further support for the viewpoint defended here, we may also observe that future contingents’ lack of truth values at the time of utterance also does not disqualify them for use in conversation. For what we assert (conjecture, guess, etc.) are contents (or if you prefer, sentences expressing such contents), which when accepted by our interlocutors become added to conversational common ground (CG), itself defined as that set of propositions that a group of interlocutors not only all accept, but are also mutually aware of the fact that they all accept. The

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<sup>18</sup> Even the indexical-containing (3) may be understood as having definite truth conditions in the absence of the posit of an actual future. One may see this by noting that on a natural extension of the ROF approach that explicitly incorporates indexicality, ‘tomorrow’ takes us to the instant associated with one day in advance of the time of utterance rather than to a moment on a particular history. It then submits to semantic evaluation in much the way that (2) does.

propositions comprising CG must be accepted but need not be true: that is why Flat Earthers can perfectly well carry on conversations on the CG approach. Also, CG may get supplemented not only by dint of assertions being made and accepted by others, but also by virtue of the occurrence of so-called manifest events, that is, events that are publicly perceptible where it is also mutually known that that they are publicly perceptible. For instance, if two people are having a conversation in a coffee shop and a rock crashes through a window near them, it will likely be CG that a rock has just crashed through a nearby window even though no illocution has been performed. Evidence for this is found in the fact that one conversationalist might remark, “Well, that was scary,” without having to use a gesture or other elucidation of ‘that’, and with confidence that her addressees will know what she was referring to.<sup>19</sup>

Whether amended by illocutions or manifest events, CG now carves out a narrower set of possibilities than it did earlier. This in turn will help interlocutors to answer a question of fact that is guiding their discussion, or to form a plan of action. Either way, the content of a future contingent may do its conversational work without there yet being a fact of the matter settling its truth. For another example, imagine S asserts that it will be sunny tomorrow in Madrid, and her interlocutors accept that claim, letting it become part of CG. They may now all act accordingly, for instance by planning for a game of bocce in El Retiro Park for the day under discussion. They may do all this without yet knowing whether S’s prediction will turn out to be correct, and may do all this even if there is currently no fact of the matter about tomorrow’s weather in Madrid. Likewise, A might bet B a sum of €100 that it will be sunny tomorrow in Madrid. Assume that A and B have agreed-upon standards for determining the level of radiation needed for a day to count as sunny. Then the bet may be proffered, accepted, and settled tomorrow in good order with the winner getting paid €100, all the while undeterred by the fact that ‘It will be sunny tomorrow . . .’ lacks a truth value at the time at which the bet is offered and accepted.

The above observations should lead us to conclude that the assertion problem is specious: future contingents have determinate truth conditions at the time of their utterance even if they lack truth values at that time. This is confirmed by the fact that even without truth values, future contingents are apt material for conversational contributions. Indeed, even future contingents that contain indexicals may be ascribed truth conditions if we adopt one semantic articulation of the Open Future approach. The Open Future approach to time and indeterminism is at no disadvantage relative to the TRL view on the issue of the assertability of future contingents; similarly for other illocutionary acts that have future contingents as their contents.

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<sup>19</sup> See Stalnaker (2014) and Green (2017, 2021a) for further discussion of conversational dynamics in which CG plays a central role.

## 5.6 Future-Directed Illocutions and Creditworthiness

We have seen that the assertion problem is not one that the Open Future approach needs to solve. Instead, according to that approach, future contingents should be seen as sentences that lack truth value at the time at which they are uttered, but that will acquire values come what may and at the appropriate times. As a result of their determinate truth conditions, these sentences invariably express “illocutable” contents, and are thus apt for moving conversations forward while making their producers liable to having their predictions borne out or not depending on how things go.

This observation also enables us to set aside as superfluous the ‘credit/discredit’ account that Belnap and Green (1994, 2001) had offered as a characterization of the norms governing assertion. According to that approach, a speaker *S* asserts *A* if and only if she undertakes a commitment having the following schematic structure:

*S* asserts that *A* just in case, if *A* is true, then *a* deserves credit, and if *A* is false then *a* deserves discredit.

The analysis is not sufficient to capture the content of the analysandum, since the former would apply equally well to someone who has properly undertaken to see to it that *A* be the case rather asserting it. Be that as it may, Belnap and Green go on to elaborate this basic idea with reference to the way in which an assertion contributes to conversational common ground, and they elaborate the analysis further in their 2001. We need not pause over these further developments. For if *A* is a future contingent, then the credit/discredit approach, no matter how embellished, will aid us in understanding how *A* may be asserted only if we have already presupposed that we know what it is for that future contingent to be either true or false. That is, the credit/discredit approach takes for granted that future contingents have a determinate semantic content; otherwise we would have no guidance as to when a speaker deserves credit or discredit by virtue of illocuting one. But then it would appear that on their own terms Belnap and Green should have no need to view the assertion problem as a difficulty in need of a solution.<sup>20</sup>

It helps to observe that our criticism of Belnap and Green’s attempt to resolve the assertion problem by appeal to pragmatic features of that speech act, is distinct from a different criticism of that strategy made by Malpass and Wawer. Commenting on the credit/discredit strategy for resolving the assertion problem, these authors write:

To us, this move to pragmatics seems to be no help. We are concerned with the way that truth-values are given to predictions of future contingents in Priorian-Ockhamism. The basic problem is that utterances occupy single moments but many histories. Since we have to have both to ascribe a truth-value to a prediction (according to Priorian-Ockhamism), there are many non-trivial ways in which we can evaluate a given prediction. It can be true and false, at the same time, that there will be a sea battle tomorrow. Appealing to pragmatics is just to change the subject, in our opinion. It is as if Belnap et al. would have us consider the

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<sup>20</sup> Analogous considerations also show that the elaborate account of assertion offered in Perloff and Belnap (2011) is not necessary to solve the problem at which it is aimed.

pragmatics of assertion involved in “*a*-asserts-‘The coin will land heads’” while what we should actually be concerned with is the semantics of “The coin will land heads.” (Malpass and Wauer 2012, p.124)

In light of what we have explained thus far, Malpass and Wauer are correct to point out that the assertion problem is, in spite of its name, a semantic rather than a pragmatic problem. However, rather than changing the subject as these authors contend, Belnap and Green offered a strategy that presupposed a semantic solution and so in an oblique way adhered to the subject matter. Once we lay bare that presupposed semantic solution and explain, as I have done above, how it may be used to address the assertion problem, there should be no remaining challenge to the Open Future approach on the issue of either locuting or illocuting future contingents.

Properly understood, then, on the Open Future approach, a future contingent has a well-defined set of truth conditions even though it lacks truth value at the time of its utterance. In this way, future contingents are crucially distinct from indexical-containing sentences such as ‘She is tall’ and open sentences such as ‘x is tall’, neither of which has truth conditions unless supplemented in some way by speakers or their context of utterance. For this reason, a proponent of OF may see future-contingents as apt vehicles of assertion, as well as of guesses, conjectures, bets, hopes and fears. Further, once history unfolds in such a way as to settle the truth (falsity) of the earlier prediction (bet, etc.), we may say of the speaker that her prediction—the prediction she made at the earlier time—is correct (incorrect). (To say that it *was* correct is, as we have seen, to slip into ways of talking that threaten to beg questions against the Open Future approach.)

## 5.7 Future-Directed Illocutions and Assertoric Norms

Another challenge to the Open Future approach comes from Besson & Hattiangadi (2014, 2020). These authors do not argue that assertions of future contingents are impossible or in some respect absurd on OF.<sup>21</sup> Instead, they argue that if OF were true, then assertion of future contingents would run afoul of the norm that one should only assert what is true. In aid of this critique, these authors offer the

*Truth Norm:* You ought to assert that P only if P is true. (2020, p. 482)

As we have seen, on the OF view future contingents have no truth values at the time at which they are uttered even though they will be settled either true or false no matter what comes to pass. Besson and Hattiangadi infer, from the premise that future contingents have no truth values at the time at which they are uttered, that OF implies that those who assert future contingents are in violation of the Truth Norm.

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<sup>21</sup> These authors’ term for OF is ‘OF-incompatibilism’, which they characterize as the view that an ontically open future is incompatible with bivalence.

This inference depends on a reading of the Truth Norm as requiring that what one asserts be true at the time of one's utterance. However, such a reading is not mandatory. One could just as well advocate another norm such as the

*Truth Norm\**: You ought to assert that P only if either P is true at the moment of utterance, or turns out to be true at a time and in a manner appropriate for the assessment of your remark.

A defender of the Truth Norm\* might suggest that it is an appropriate elucidation of the Truth Norm while also being suitable for an OF framework. After all, if one asserts (1), and it comes to pass that the coin in question does come up heads, we will surely be in a position to conclude that what the speaker has said has turned out to be true.

Although they do not consider the Truth Norm\*, Besson and Hattiangadi would likely challenge it. This is because they argue that everyday conversational practice can only be explained by invocation of the Truth Norm, construed as being restricted to utterances true at the time of utterance. More exactly, Besson and Hattiangadi contend that

The pragmatic data suggests that we sometimes judge assertions of future contingents to be correct, even though we judge the future to be open in relevant respects. (2014, p. 270)

To support this *prima facie* surprising claim, these authors ask us to imagine an expert TV meteorologist Barbara with an excellent record of predicting the weather one day in advance. After carefully reviewing her information about weather patterns she announces on air

(4) It will be sunny in Madrid tomorrow.

Barbara makes this prediction in spite of knowing (let's suppose) that weather is not a deterministic process, and that it's compatible with the current state of the world that tomorrow's weather in Madrid will be wet and gloomy. Nonetheless, Besson and Hattiangadi remark of this case,

Under the circumstances just described, it seems natural to regard the assertions of ... (4) as correct. Yet, ... though we judge (4) to be correct, we do not think that the future is closed with respect to the weather in Madrid—everyone knows how sensitive weather systems are to change. Even if it is now true that it will be sunny in Madrid tomorrow, it is certainly possible that it will not be sunny, and however much evidence Barbara may have for the truth of what she says, it is neither fixed nor certain that it will be sunny in Madrid on the day after the day of her utterance. Yet, we regard Barbara's assertion as correct. (2014, p. 260; numbering of example changed to fit the text)

I take Besson and Hattiangadi here to be telling us that common sense judges that what Barbara asserts, namely (4) (or its content) is true, and further that common sense would pass such a judgment at the time of utterance rather than waiting until tomorrow and seeing what the weather is like in Madrid. Further, I take Besson and Hattiangadi to mean not merely that Barbara's viewers are willing to accept her televised weather prediction and plan accordingly. (If this is all that Besson and Hattiangadi mean, then we may point to sect. IV above to explain how such an interpretation in no way mandates ascription of truth to the accepted prediction.)

Besson and Hattiangadi's claim about common sense is, however, dubious. For it is one thing to agree that Barbara's claim is justified, and quite another to agree that she is correct, at the moment of her utterance, in saying what she does. Being correct is, as we have seen, a matter of being right, which is in turn a property had by agents and propositions. Thus where *S* is an agent and *p* is a proposition,

*S* is right that *p* if and only if *S* judges that *p* or performs an illocutionary act from the assertive family whose content is *p*, and *p* is true.

Rightness, like correctness, is not a property had by propositions or agents alone, but only by pairs of agents and propositions, or of illocutionary acts and their contents. Accordingly, if we judge, at the time she speaks, that Barbara is correct or right in uttering (4), we must already have made up our minds about tomorrow's weather in Madrid. That would be an unusual thing to do prior to checking tomorrow's weather by watching a forecast on the news. Suppose, that is, that George is not a meteorologist and has no proprietary information about tomorrow's weather in Spain. He switches on the news for the purpose of finding out tomorrow's weather in that location, and sees Barbara utter (4), to which he replies:

(5) Yep, she's right; it will be sunny in Madrid tomorrow.

This would be a surprising reply, suggesting as it does that George is privy to information unavailable to others that he is addressing. Instead, knowing Barbara's credentials, George might conclude that she must be justified in making the prediction that she does. So too, he and his interlocutors might accept into their conversational common ground that it will be sunny in Madrid tomorrow, and plan their actions accordingly. But in both cases saying Barbara is right is out of place; so too for describing her utterance as correct.

Accordingly we should be suspicious of Besson and Hattiangadi's claim that the Barbara example provides pragmatic evidence that we sometimes judge future contingents to be correct at the time that they are made, and in full awareness of the fact that they are contingent in the relevant sense. Instead, the most that pragmatic data shows is that we sometime judge assertions of future contingents to be justified, and that we sometimes accept such assertions. Neither of these admissions should force us to favor a Truth Norm over a Truth Norm\*, or a TRL-style theory over that of the Open Future.

Reminding ourselves that assertion is but one member of a larger family of illocutionary types all of which have propositional contents and word-to-world direction of fit, brings to light that assertion is one among many products of cultural evolution designed to support reliable sharing of information both inter- and intra-personally. Each such product has its own standards and potential for abuse. We have codified some of these features with the Liability-Frankness-Fidelity (LFF) approach to explaining the nature of commitment associated with members of the assertive family. In that light, I hope to have made clear that on the issue of either locuting or illocuting future contingents in indeterministic situations, the Open Future approach is at no disadvantage compared to the Ockhamist approach. If,

therefore, the debate between the Ockhamist and the Open Future approach is to be resolved, it will have to be on other grounds.<sup>22</sup>

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# Chapter 6

## A Too Thin True Future: The Problem of Grounding Within Presentist TRL Semantics



Ciro De Florio and Aldo Frigerio

**Abstract** In this paper, we discuss the coherence and the stability of three rather plausible philosophical intuitions: the idea that all that exists is present (Presentism); the idea that there exists a true future, although it is just a contingent future (Thin Red Line); and the idea that a proposition depends on (or is grounded in) a truthmaker (Truthmaking). We will not show that assuming these three ideas together is logically incoherent; however, their combination seems to be very difficult to hold and, ultimately, it should be discarded. As a consequence, some of these assumptions must be rejected. We will analyze in detail one of the most promising strategies that can be pursued to reconcile Truthmaking and Presentism: adopting a liberalized version of Truthmaking, for which not only what exists but also what will exist and what existed can ground the truth of a proposition. However, as for the future, this strategy works only if the future is historically closed. If there are future contingents, this line of defense is flawed.

### 6.1 Introduction

In this paper, we discuss the coherence and the stability of three rather plausible philosophical intuitions: the idea that all that exists is present (Presentism); the idea that there exists a true future, although it is just a contingent future (Thin Red Line); and the idea that a proposition depends on (or is grounded in) a truthmaker (Truthmaking).<sup>1</sup>

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<sup>1</sup> We would like to thank all the participants in the Workshop on Ockhamism held at the University of L'Aquila; in particular, many thanks to Alessio Santelli and Giorgio Lando for inviting us to write this essay. We thank also two anonymous referees for constructive comments and recommendations, which definitely help to improve the quality of the paper.

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We will not show that assuming these three ideas together is logically incoherent; however, their combination seems to be very difficult to hold and, ultimately, it should be discarded. As a consequence, some of these assumptions must be rejected. However, Presentism, Thin Red Line (TRL) and Truthmaking are deeply rooted theses, and their revision is not an easy matter.

In a nutshell, our argument proceeds as follows. In light of TRL semantics, there are true contingent future tensed propositions. By Truthmaking, some facts that make these propositions true must exist. But, by Presentism, all that exists is present, and thus there are no future facts that can make these propositions true. One might abandon the principle of truthmaking, affirming that truth does not depend on how things are; or, alternatively, one might argue that the present – i.e. all that exists – is sufficiently rich to warrant the truth of future tensed propositions. We will show, however, that these strategies are very costly.

There is another route, which seems more promising: to liberalize the principle of truthmaking, assuming a *tensional* version of it. To guarantee the ground of *past* tensed propositions, the truthmaking principle must be expressed in a tensed way. Aside from the merits of this solution (or better, of this family of solutions), it is interesting to notice that symmetric arguments concerning the future are almost missing in literature. The presentist strategy of liberalization is mostly focused on the past. As we will see below, there are obvious reasons for this.

In this paper, we will show that the liberalized version of the truthmaking principle is insufficient to ground future tensed propositions under the assumption of a TRL semantics: we cannot make sense of the idea of a privileged branch (the Thin Red Line) if the future is open and does not exist yet.

The structure of this paper is as follows. In the next section, we will briefly illustrate the theory of truthmaking. Section 6.3 is devoted to the attempts to conciliate Presentism and truthmaking and to the presentist strategies to ground past tensed propositions. Section 6.4 examines two semantics of future tensed propositions that assume that the future is open: Aristotelian and TRL semantics. Section 6.5 contains our main argument: while Aristotelian semantics is compatible with the liberalized truthmaking principle and with Presentism, the TRL semantics is not. Section 6.6 concludes the paper.

## 6.2 The Grounding Problem

### 6.2.1 Correspondence

Philosophy is not a place for opinion polls. However, the *PhilPapers Survey* (see Bourget & Chalmers, 2014) provides the following results regarding the nature of truth: correspondence 50.8%, deflationary 24.8%, others 17.5%, epistemic 6.9%. So, the theory of correspondence retains a scant absolute majority. This poll reflects a common sense intuition: the truth of a proposition (or at least of *some* propositions)

depends on how things are “out there”. It is not an epistemic question (which has to do with the degree of justification of the proposition under consideration), nor a linguistic question, nor a question connected to extra-theoretical factors such as the authority of the utterer of the sentence expressing the proposition. The truth of the proposition “it rains” depends on how the weather is today.

This intuition, although vague and imprecise, has a *realist* vein. It is an intricate historical question to investigate the origins of this conception of truth: the *locus classicus* is Aristotle’s *Metaphysics* 1011b25, which is very often quoted but is not very clear. However, there are previous reference in Plato (for instance, *Cratylus* 385b2 and *Sophist* 263b). In these passages, and then in a more explicit form in the Medieval philosophical reflection, the vague realist intuition has taken the shape of the *theory of truth as correspondence*. It is not our aim here to sketch out the conceptual map of the various versions of this theory; however, we will consider some points, which will be useful in the following discussion.

The correspondence theory is meant to provide a characterization of truth that, to a first approximation, can be:

(Correspondence)  $x$  is true iff there exists a  $y$  such that  $x$  corresponds to  $y$ .

where  $x$  refers to a truth bearer, i.e. to a member of the class of entities that can be true or false, and  $y$  refers to some worldly entity in line with the realist intuition that characterizes the correspondence theory.

Among the most discussed candidates for the role of truth bearers, we can list propositions, sentence types, sentence tokens and beliefs. In the following, for convenience, we will assume that propositions are primary truth bearers.<sup>2</sup> The “worldly pole” is even more debated: which entities make propositions true? We can distinguish *object-based* and *fact-based* answers to this question. According to the former, a truth bearer has a subject-predicate structure that must be reflected in the reality: a proposition is true if and only if its predicate can be truly applied to its object. Notice that in this case two different relations are needed: (i) a relation of reference between the subject of the proposition and the object the proposition is about; (ii) a correspondence relation between the predicate of the proposition and the property of the object in question. On the contrary, fact-based views do not make specific assumptions about the internal structure of the facts that make propositions true. These views are the most widespread today.

The difference between these two kinds of views can be interpreted in light of an explanatory trade-off concerning the correspondence theory. One of the most common criticisms advanced against the correspondence theory regards the opacity of the relation of correspondence: how can a linguistic or representational entity

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<sup>2</sup> A primary truth bearer is an entity that can be true or false in an absolute and non-derivative way. Other entities can be truth bearers in a derivative way, in which case they are not primary truth bearers. For example, it can be supposed that the sentence “snow is white” is true (and thus it is a truth bearer) because it expresses the proposition that snow is white. The proposition is the primary truth bearer, whereas the sentence is true or false depending on the truth value of the proposition it expresses.

such as a truth bearer *correspond* to a worldly entity? The trade-off arises precisely when one tries to clarify the relation of correspondence. The more one is committed to a thick and informative notion of correspondence, the more one must conceive the relation of correspondence as (a kind of) isomorphism: the linguistic and epistemic structures of our judgements must be reflected in the ontological structure of reality. In this way, the correspondence theory becomes metaphysically loaded. On the other hand, the more one does not make any assumption about the structure of reality, the more the notion of correspondence becomes obscure.

Another problem for the correspondence theory lies in the *symmetry* of the relation of correspondence. If proposition  $x$  corresponds to  $y$ , the opposite must also be true:  $y$  (a piece of the world) must correspond to  $x$ . However, our strong intuition is that reality determines the truth values of propositions and not vice versa. Aristotle was already aware of this twofold aspect – symmetric and asymmetric:

The fact of the being of a man carries with it the truth of the proposition that he is, and the implication is reciprocal: for if a man is, the proposition wherein we allege that he is true, and conversely, if the proposition wherein we allege that he is true, then he is. The true proposition, however, is in no way the cause of the being of the man, but the fact of the man's being does seem somehow to be the cause of the truth of the proposition, for the truth or falsity of the proposition depends on the fact of the man's being or not being. (Cat. 12b11)

The asymmetry between what makes true and what is made true is the basis of truthmaking theories, which can be interpreted as the most recent versions of the correspondence view on truth.<sup>3</sup>

## 6.2.2 Truthmaking

The concept of truthmaking is not entirely new in the history of philosophy – and this vindicates its continuity with the correspondence theory.<sup>4</sup> The basic idea is an elaboration of the Aristotelian passage quoted at the end of the previous section: the fact that snow is white makes the proposition that snow is white true. Generalizing, propositions are true or false in virtue of how things are:

(TM)  $x$  is true if and only if there is some  $y$  that makes  $x$  true.

Two preliminary considerations. Firstly, similarly to what we said about the correspondence theory, an important question for the advocates of the truthmaking theory is to establish the nature of the entities that make propositions true.

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<sup>3</sup> Some scholars do not agree with this affiliation, and there are reasons that militate against it. A precise judgement on this matter presupposes a taxonomy of theories and positions which is quite intricate and which is too far afield from the topic of this paper.

<sup>4</sup> Actually, things are more complex. Some scholars argue that the truthmaking is compatible with other theories of truth; for instance, with deflationism. See McGrath (2003), Vision (2005), and Thomas (2011).

Interesting candidates are facts, states of affairs, moments, individuals, and so on. Secondly, contrary to the correspondence theory, (TM) can hardly be considered as a definition of truth: the relation “*y* makes *x* true” at the right of the double implication is clearly circular with respect to the predicate “*x* is true”. Many authors (see, for example, Mulligan et al., 1984) consider the concept of truthmaking as primitive and explicative with respect to the intuitive notion of truth, typical of ordinary language. Being primitive, the concept of truthmaking cannot be explicitly defined. This fostered axiomatic characterizations of truthmaking (see, for example, Mulligan et al. (1984) and Armstrong (1997)).

In the following, we will assume that truth bearers are propositions (as we have done in the case of the correspondence theory) and that truthmakers are *facts*. So the version of (TM) adopted here is:

(TM) A proposition *p* is true if and only if there exists a fact *F*, such that *F* makes *p* true.

There are several issues about the truthmaking theory. In addition to those already mentioned regarding the ontology of truthmakers (for instance, some might be skeptical about the category of facts), several issues concern the logical profile of the theory.

Other questions regard the attempts to provide an explanation of the nature of the relationship of truthmaking. According to some authors, it is a relation of necessitation; according to others, it is connected to the notion of essence. However, our concern here is to analyze the issues about the class of propositions that can be made true by truthmakers. In fact, a “naive” truthmaking theory tends to inflate the domain of facts. Take for instance mathematical truths.<sup>5</sup> If a naive truthmaking theory is accepted, we must postulate a domain of mathematical facts, whose ontological status is notoriously very complex.<sup>6</sup> Things are even worse if we take into consideration the class of ethical, aesthetical or normative truths. Our universe of facts becomes more and more inflated.

There are some recovery strategies that the advocate of the truthmaking theory can exploit. She can (i) bite the bullet and allow for a robust domain of facts, which includes – for instance – abstract mathematical facts. Alternatively, (ii) she can embrace a form of the *error theory*: mathematics, ethics and aesthetics must be considered *at face value* but they are literally false.<sup>7</sup> Otherwise, (iii) the truthmaking

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<sup>5</sup> We are not committed to a specific theory of mathematical truths here. By mathematical truths we simply mean the most relevant statements of mathematical theories or the statements on which mathematicians agree.

<sup>6</sup> How can we have an epistemic access to facts that are conceivably constituted by abstract objects and properties? See Benacerraf (1973) for one of the best-known starting points of the debate; Cameron (2008) for a discussion of the problem of ontology of mathematics in the framework of truthmaking; and De Florio (2018) for the connection between truthmaking and grounding in the philosophy of mathematics.

<sup>7</sup> John Mackie is an error theorist in ethics; a similar view in the philosophy of mathematics is proposed by Hartry Field.

theorist can try to trace some classes of truths back to other classes of truths, whose truthmakers are less problematic. Finally, (iv) it is possible to affirm that ethical and aesthetic propositions are not apt to be true or false (and, thus, are not actually truth bearers) but express a positive or negative attitude towards some acts or objects. The latter strategy is difficult to apply to mathematical truths in light of its noncognitive character.

Another connected issue concerns the extension of the true propositions that are made true by truthmakers. In this regard, a very natural – but, as we will see shortly, problematic – position is Maximalism:

(Maximalism) For every truth, there must be something in the world that makes it true.

Maximalism is an extreme position: every truth has a truthmaker. Obviously, the same truth can have more than one truthmaker and one truthmaker can make true more than one proposition. However, there is no true proposition without a fact that makes it true. Maximalism is a natural position because it fulfils a clear explanatory requirement: if Maximalism were not true, we should accept that we have no explanation of the truth of some propositions.

However, the defense of Maximalism must deal with some classes of propositions whose truth is difficult to accommodate within the truthmaking theory: negative propositions (“Emma is not brunette”), universal propositions (“Italians love football”), modal propositions (“it is necessary that water is H<sub>2</sub>O”). In literature, there are many attempts to accommodate these truths. An important line of thought is to decide to abandon (TM) without abandoning the intuition that reality makes propositions true. John Bigelow argues that (TM) in its maximalist version is a too strong principle. What we actually need to account for the asymmetry between being and truth is a sort of conceptual intuition: if things were different from the way they are, the domain of truth would be different. This is expressed by the Truth Supervenes on Being principle:

(TSB) Truth supervenes on things and the properties and relations that they instantiate (cf. Keller, 2004; Markosian, 2004; Torrenco, 2013)

Let us consider the negative proposition “there are no dragons”. This proposition is true not because there is some fact that makes it true (it should be an odd negative fact), but because it has no counterexamples. In the world, there is no fact that makes the proposition “there are dragons” true. As David Lewis expresses it with his usual elegance, it is true since it lacks false-makers (Lewis, 1992, p. 216).

We have analyzed the first claim, i.e. the truth of a proposition depends on something that makes it true. In the next section, we will see how this plausible principle is in tension with a certain metaphysics of time.

### 6.3 Grounding and Presentism

As is well known, there are many different opinions about which parts of the temporal series exist. The position closest to common sense is Presentism. According to Presentism, all that is present exists and all that exists is present.<sup>8</sup> Since the present changes, Presentism is committed to a dynamic theory of time. What exists continuously changes. The opposite view is Eternalism: past, present and future exist in the same way according to this metaphysics of time.<sup>9</sup> It is quite natural to connect this ontological stance with a static theory of time, according to which the passage of time is illusory.<sup>10</sup> The debate between the advocates of Presentism and Eternalism is very vast and we will not attempt even to sketch it out here. Rather, we are interested in a particular aspect of this debate, i.e. in a problem that Presentism must face and that is connected to truthmaking. Consider the following sentences:

1. Napoleon was defeated at Waterloo 18th June 1815
2. Obama is taller than Napoleon

These sentences seem to express true propositions. If we take TSB on board, a world that makes these propositions false must be different in some aspects from the actual world. If we call the actual world  $w_0$ , a world  $w_1$ , which makes (1) and (2) false, cannot be identical to  $w_0$ . The eternalist has no problem here: since the past exists as the present, a world that makes these two propositions false will have a different past from  $w_0$ . For example,  $w_1$  might be a world in which the battle of Waterloo takes a completely different turn and in which Napoleon is very tall. By contrast, Presentism does not seem to respect TSB. In this view, the truthmakers of propositions can only be part of the present state of the world. But, it is possible to conceive two worlds,  $w_0$  and  $w_1$ , which are identical as to present facts but which have different pasts. As an extreme situation, one can imagine that  $w_1$  is a Russell's world, that is, a world that came into existence just 3 min ago and is totally indistinguishable, by hypothesis, from the actual world at the present moment. In Russell's world, the past has never existed, and all the traces of the past (memories, photographs, historical documents, and so on) are fake. But then, there is nothing in the present that can make true in  $w_0$  and false in  $w_1$  that Napoleon was defeated at Waterloo or that Obama is not taller than Napoleon, since  $w_0$  and  $w_1$  are indistinguishable according

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<sup>8</sup> There is a debate about the very formulation of the presentist thesis. See Meyer (2005) and Mozerky (2011). However, we will disregard these issues here because they are not directly connected to the aims of this essay.

<sup>9</sup> There are intermediate positions between these two, such as the growing block theory, according to which the present and the past, but not the future, exist, and the shrinking block view, according to which the present and the future, but not the past, exist. However, to simplify matters, in this paper we will consider just the two opposite views.

<sup>10</sup> Here, we consider Eternalism as the view according to which the whole temporal reality is a four-dimensional block and time is a B-series. Although natural, this connection is not necessary: there are dynamic eternalist positions, such as the moving spotlight theory. Since our focus is on truthmakers, we disregard dynamic eternalist views here.

to the presentist. Since the past does not exist, the presentist seems not to be able to provide truthmakers to past tensed propositions, which remain groundless.

The lack of grounding for past tensed propositions such as (1) and (2) is one of the main arguments put forward against Presentism by eternalists. Presentists have different strategies to overcome this criticism. For example, they can affirm that past tensed propositions such (1) and (2) are not true or reject the idea that they must be grounded by some real facts. However, these are too drastic solutions, which did not succeed even among presentists.<sup>11</sup> Few are prepared to renounce the truth of (1) and (2) or to affirm that their truth does not depend on how things are in the world. The presentist has two further possibilities, less drastic than the previous ones:

- (a) to keep TSB and enrich the present with entities that provide the truthmakers of propositions such as (1) and (2)
- (b) to keep a not enriched present and liberalize TSB providing a *tensed* version of this principle

The first strategy has many versions, but the basic idea is the same: the world  $w_1$ , in which (1) and (2) are false, has a different present from the actual world  $w_0$ , in which these two propositions are true. Some presentists who follow this strategy have embraced the so-called *Lucretianism*, i.e. the idea that the world acquires complex properties such as “being such that Napoleon was defeated at Waterloo”. The universe presently instantiates these properties, which ground the truth of propositions such as (1) and (2).<sup>12</sup> Others have turned to abstract entities of various kinds. For instance, Keller (2004, pp. 96–99) hypothesizes that, if it is true that Napoleon does not exist now, nevertheless his *haecceitas* exists. This is a property that can be truly predicated only of Napoleon. This haecceitas has several relationships with other haecceitas and properties, for instance with the haecceitas of Waterloo and with the property of being defeated. Alternatively, it can be maintained that there exist abstract times, which represent how things are at a certain time (*Ersatz Presentism*). Abstract times form a B-series, which accounts for the truth of past and future propositions (Bourne, 2006; Crisp, 2007).

It has been noticed that these strategies have at least two problems (see Caplan & Sanson, 2011; Tallant & Ingram, 2015):

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<sup>11</sup> For a presentist rejection of past truths such as (1) and (2), cf., for example, Markosian (1995, 2013), but he is a rather isolated case. More frequent is the rejection of past truths among those sympathetic with verificationism (cf., for instance, Dummett (1968, 2004)). However, this rejection is based on reasons wholly different from Presentism, and it is certainly possible to be a verificationist (and reject past truths) without being a presentist.

<sup>12</sup> For such an idea, see Bigelow (1996). This idea, in turn, has many variants. Keller (2004, pp. 99–101) suggests that past entities are constituted by more fundamental entities (atoms, strings, etc.), which still exist and which possess tensional properties sufficient to account for propositions such (1) and (2). Cameron (2011) believes that present entities instantiate temporal distributional properties such as being red at  $t_0$  and being white at  $t_1$  as well as an age, a property which says how far an object is in its life. The combination of these two properties allows the grounding of the proposition that  $x$  was red if  $x$ 's present age is  $t_1$ .

- (a) They are expensive from an ontological point of view. Presentism is a theory that counts ontological sobriety among its theoretical virtues: it admits much fewer entities than Eternalism. However, the introduction of tensed properties and haecceitas seems to vanish this advantage. Moreover, the introduced entities often have an exotic nature and this is, clearly, a further cost.
- (b) One could cast doubts that these entities are really explanatory of the truths that they are supposed to ground; rather, they seem to be parasitic on what existed in the past. Let us call  $p$  the proposition that Emma is blonde and, therefore,  $\mathbf{P}p$  the proposition that Emma was blonde. Let us take into account the two following explanations of the truth of  $\mathbf{P}p$ :
- (i) The proposition that Emma was blonde is true *because* Emma has *now* the property of having been blonde
  - (ii) The proposition that Emma was blonde is true *because* the state of affairs of Emma's being blonde existed in the past

It is not hard to appreciate the difference between (i) and (ii). In the former, the tensed feature is discharged on the property at issue and it cannot be otherwise, since according to TSB what is true supervenes on what is present, that is, on the present instantiation of a past property. One can be dubious about the existence of past properties (such as having been blonde, having been defeated and so on) but the relevant point is another. The point is that (i) does not properly explain why  $\mathbf{P}p$  is true; or better, its explanatory account is dependent on (ii). It is because Emma had, in the past, a certain property that we can say, in a derivative manner, that Emma has, now, a certain past tensed property. One can better observe the explanatory asymmetry by inverting the verse of the explanation. Suppose that one tries to argue that Emma was blonde because she has (now) the property of having been blonde. This is absurd: it is because things were in a certain way in the past that the present has now traces (if any) of the past. This explanatory asymmetry can be applied to all the strategies of enrichment of the present: the entities that enrich the present and that serve as truthmakers of past tensed propositions borrow their explanatory power from what happened in the past.

Presentists have another strategy for grounding past truths such as (1) and (2), which is more promising in our opinion. Rather than enriching the present, they can liberalize the truthmaking principle, advancing a tensed version of it. Not only what is present can provide truthmakers for these truths, but also what was and what will be present.<sup>13</sup> Emma is presently brunette and present facts cannot ground the truth of the proposition that she was blonde. However, to ground this truth, the fact that Emma is blonde need not exist *now*; it is sufficient that this fact *existed* in the past. To ground past truths, the fact that things *were* in a certain way is sufficient.

The comparison with modal entities is illuminating. Consider the proposition "Emma could be blonde" and suppose that this is true. Paralleling the eternalist, the

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<sup>13</sup> For this strategy, see Tallant (2009), Sanson and Caplan (2010), Baia (2012), and Tallant and Ingram (2015).

modal realist might insist on the basis of principles such as (TM) that there must exist a fact that makes this proposition true, for example a possible world in which Emma is blonde. Then, one of the outcomes of the strong version of truthmaking theory is Lewis' modal realism. However, the actualist, like the presentist, might reply that the existence of real facts is not required for grounding the truth of modal propositions. Rather, if the world can be in a certain way, that is sufficient to ground the truth of "Emma could be blonde". In other words, this is sufficient to ground the modal truths concerning that particular arrangement of the world.<sup>14</sup>

Presentists following this strategy can state a principle that is alternative to TSB, which will be called TSTB (Truth Supervenes on Tensional Being):

(TSTB) For any worlds  $w_1$  and  $w_2$ , let  $p$  be the proposition that something exists in one world but not the other, or else some object instantiates a property or a relation in one world but not the other. For any proposition  $q$ , if  $q$  is true in  $w_1$  but not  $w_2$ , then  $p$  or  $\mathbf{P}p$  or  $\mathbf{F}p$  (cfr. Baia, 2012, p. 349).

Eternalists have objected to TSTB in many ways. A first criticism is that presentists who accept this principle do not take the idea of grounding seriously enough. This criticism has taken different formulations. Sider (2001, pp. 36, 40–41) and Heathwood (2007, p. 141) claim that the presentist is cheating. The intuition at the basis of grounding is that truth must be grounded by reality, but, since the past does not exist in the presentist's eyes, the truth of past tensed propositions is grounded by nothing real. Asay & Baron (2014) and Baron (2015) argue that TSTB risks inflating the truthmaking principle, making it ineffective. The latter principle must be substantial:

If truthmaker theory is deflated then all of the substantive issues in truthmaker theory seem either completely mysterious or else trivial to solve. It is, for instance, hard to see how we could have a substantive debate about the metaphysics of truthmakers—about what truthmakers really are—once the dependence of truth on ontology has been stripped of metaphysical import. Similarly, debates about the nature of the truthmaker relation—how exactly it is that we should understand the dependence at issue—appear just as pointless if truthmaking is metaphysically light-weight. (Baron, 2015, p. 930)

TSTB leads to an "explosion: a situation where one's restriction on truthmaking motivates truthmaking restrictions on all propositions, thereby undercutting truthmaker theory entirely. This would be problematic: as already discussed, no one should give up truthmaker theory *tout court*" (Asay & Baron, 2014, p. 322).

These concerns are certainly justified: the truthmaking principle cannot be reduced to a disquotational principle for which every proposition  $p$  is true if the fact  $p$  exists in the world. However, it is also clear that these concerns cannot lead to a truthmaking Maximalism in which for every proposition  $p$  there is a fact in the

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<sup>14</sup> As a referee suggests, actualists might ground modal truths on what actually exists by stating that there are real facts in virtue of which there is a possible world in which Emma is blonde. These might be facts about Emma's essence, for example. Of course, this is correct. However, this is not the only way of characterizing the actualist position: the actualist might say that the concept of possibility and necessity are primitive and not reducible to essences or other existing facts.

world that makes  $p$  true because, as we have suggested, Maximalism is problematic from many points of view. There are cases in which the truthmaking Maximalism should be relaxed, as, for instance, in the case of negative and modal propositions. If the grounding principle leads to the postulation of negative facts or of possible worlds existing in the same way as the actual world, i.e. of odd entities, it is a bad principle, which must be modified.

Eternalists who reject TSTB have a hard path to go down: they must show that the modification of the truthmaking principle is healthy in the case of negative or modal truths, but not in the case of tensed truths. However, it is very difficult to show that we must inflate the truthmaking principle in dealing with negative and modal truths but not in the case of tensed truths. It is hard to see how one could justify this difference.

A different kind of criticism of TSTB is put forward by Torrenco (2013). He believes that the presentist who accepts TSTB has a theory that is no different from that of the eternalist. In Eternalism, a proposition  $\mathbf{P}p$  is true with respect to a time  $t$  iff there exists a time previous to  $t$  at which  $p$  is true. However, TSTB says something very similar:  $\mathbf{P}p$  is true if at a time previous to the present there was a fact that made  $p$  true. The difference between Presentism and Eternalism would be cancelled.

However, this criticism has at least two problems. Firstly, there is a tenseless formulation of the truth conditions of  $\mathbf{P}p$  that is open to the eternalist but not to the presentist: the eternalist can say that  $\mathbf{P}p$  is true at  $t$  iff at a time previous to  $t$  the fact that  $p$  tenselessly holds. This formulation is obviously closed to the presentist. Secondly, the difference between Presentism and Eternalism need not be centered on the truth conditions of tensed propositions. According to the eternalist, all times are actual and exist in the same way. By contrast, according to the presentist, only the present exists. This is a real difference between the two ontological positions that is independent from the theory of truthmaking. It is possible to maintain that the two theories have similar formulations of the truth conditions of tensed propositions and that nevertheless they differ for the privilege that the present has in one but not in the other.

Although we are sympathetic with TSTB, a full defense of this principle against the criticisms of eternalists is beyond the aims of this essay. Rather, we want to verify whether this principle can be exploited to defend a particular semantics of future tensed propositions, i.e. the Thin Red Line. We devote the next section to this semantics and to its difference from other views.

## 6.4 Toward the Future(s)

The discussion concerning Truthmaking between presentists and eternalists is focused on past propositions. This is understandable: few are prepared to renounce the truth of propositions such as (1) and (2). Concerning future tensed propositions, opinions are more varied. One possibility is the *determinist* conception, according to which the future is determined by the past. In this case, propositions concerning

the future are true or false, as are those concerning the past, because what will happen tomorrow is already determined today. Suppose, however, that the world is indeterministic, and that the future, unlike the past, is open. This means that many future histories are historically possible, and that the past does not determine, at least in its entirety, what will happen. The past, on the contrary, is not open: there is just one possible past. This means that the past was in a certain way and it is historically necessary that it was in that way.<sup>15</sup> Which truth value should we then assign to contingent propositions concerning the future in an indeterminist framework? There are at least two possible positions; either propositions concerning the future are untrue (the Aristotelian solution)<sup>16</sup> or they can be true (the Thin Red Line solution).

The Aristotelian position<sup>17</sup> is grounded in the intuition that no future history is privileged over any other because the past does not establish which will ensue. If a proposition is true in some possible future and false in others, it seems we cannot say what will happen in the future *tout court*. Thus, an indeterminist and open conception of the future seems to imply that contingent propositions concerning the future cannot be true. However, many scholars have claimed that the truth of contingent propositions about the future is not incompatible with indeterminism and libertarian freedom.<sup>18</sup> A common motto among these scholars is that the future is “determinate but not determined.” The basic idea is as follows. Suppose that Ann is a libertarian<sup>19</sup> agent, and that the actual situation in the world does not determine whether or not Ann will drink a beer tomorrow. Tomorrow, however, Ann will have to choose whether to drink a beer, and her choice will eliminate the other alternative. Suppose that the truth of the proposition “Ann will drink a beer tomorrow”, when evaluated at the present time, *depends* on the choice Ann makes tomorrow. If Ann chooses to drink a beer tomorrow, the proposition is true at the present time; if Ann chooses otherwise, the proposition is false. Obviously, Ann’s choice is epistemologically inaccessible today, but this does not preclude that

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<sup>15</sup> Of course, this does not imply that the past could have been different from the way in which it was. The histories that pass through an instant  $t$  do not differ for the facts preceding  $t$ , but an instant  $t'$  previous to  $t$  can belong to many histories that differs for the facts following  $t'$  (the future facts of  $t'$ ). This asymmetry between past and future is grounded on the intuition that, while the past is stable and settled, the future can be, to a certain extent, determined by what will do.

<sup>16</sup> Under the label “Aristotelism” we collect the positions according to which propositions regarding future contingents cannot be true. By “untrue” we mean that these propositions can be considered either false (Peircean semantics, see Prior, 1967, pp. 128–9 and, more recently, Todd, 2016) or neither true nor false (supervaluationism, cf. Thomason, 1970, 1984). For present purposes, these two alternatives can be treated on a par because both suppose that there is no true future history that is privileged over the others.

<sup>17</sup> We will use the term “Aristotelian” without adopting any stance about the historical question of Aristotle’s actual theory (on this issue, see Crivelli, 2004, pp. 198–226)

<sup>18</sup> This thesis has been proposed by many different scholars in different contexts; see, for instance, Barnes and Cameron (2009), Merricks (2009), Øhrstrøm (2009), Malpass and Wawer (2012), Rosenkranz (2012), Borghini and Torrenzo (2013), and Wawer (2014).

<sup>19</sup> A libertarian agent is an agent that can perform (at least) a free action in the following sense: the agent determines the action and the agent could do otherwise.

Ann will choose in a certain way tomorrow. If the truth of the proposition at the present time depends on Ann's future choice, then the proposition "Ann will drink a beer tomorrow" has a truth value, even though we do not know which one. We can preserve bivalence even in a libertarian and indeterminist framework, in which the present does not determine which among the possible future histories will become true.

If a future history is to become true, it is privileged, on the basis that this history will become true while the others will be pruned. In other words, the future history that occurs is the actual future history; the others are just possible futures that will not become real. The existence of a true future history is not at odds with indeterminism because it is precisely the fact that the agent will freely choose in a certain way that privileges that history over the others. This privileged history is usually called the Thin Red Line (TRL)<sup>20</sup> to distinguish it metaphorically from other histories.

From here, we will ignore the determinist model, according to which there is only one future history. We will instead compare the two indeterminist models outlined above: the Aristotelian model, according to which there are several possible future histories, none of which is privileged over the others; and the TRL model, according to which there is a true future history that is privileged over the others.

To begin, some basic notions of temporal logic will be introduced to characterize the two positions in question.<sup>21</sup> A branching time structure (BT) is a couple  $B = \langle T, < \rangle$ , where  $T$  is a non-empty set of instants and  $<$  is a relation defined on  $T$ . Intuitively, the instants are possible instantaneous states of the world and  $<$  is the relation of temporal precedence. This relation is therefore asymmetric and transitive and satisfies (at least) the conditions of *Backward Linearity* (BL) and *Historical Connectedness* (HC):

$$(BL) \forall t, t_1, t_2 ((t_1 < t \ \& \ t_2 < t) \rightarrow (t_1 = t_2 \vee t_1 < t_2 \vee t_1 > t_2))$$

In words, two instants of the past of  $t$  are either identical or ordered by  $<$ ; this implies that, for every instant  $t$ , there is one and only one past history.

$$(HC) \forall t_1 \forall t_2 \exists t (t \leq t_1 \ \& \ t \leq t_2)$$

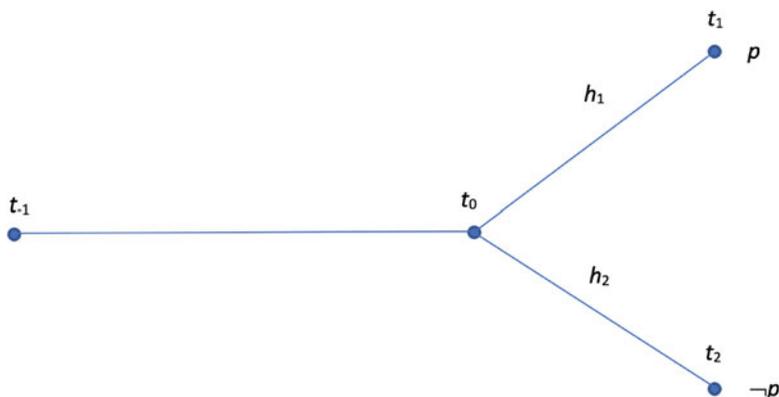
HC asserts that, in the past, all the instants are connected; the maximal subsets of instants linearly ordered in  $T$  are referred to as *histories* – the possible courses of events in the world.

Ours is a propositional language that includes a possibly infinite set of propositional variables (Var) and two temporal operators **P** and **F**. We can define an evaluation function  $V: \text{Var} \rightarrow \mathbb{P}(T)$  that maps every propositional letter  $p$  onto a set of instants at which  $p$  is true. A branching time model is, then, a couple  $\langle B,$

<sup>20</sup> The expression "Thin Red Line" was introduced by Belnap and Green (1994).

<sup>21</sup> See, for instance, Burgess (1979), Thomason (1984), Øhrstrøm (1981, 2009), Belnap et al. (2001), and Hasle and Øhrstrøm (1995).

V). According to the indeterminist intuition, there is only one past history but many possible future histories. We can represent this situation as follows:



Let us suppose that we evaluate the propositions in the schema with respect to the instant  $t_0$ . While the two future histories  $h_1$  and  $h_2$  differ only from  $t_0$  onward, they share all the states of affairs at instants prior to  $t_0$ . In  $h_1$  at moment  $t_1$ , the proposition  $p$  is true; in  $h_2$  at moment  $t_2$ , the proposition  $\neg p$  is true. The problem is how to evaluate the proposition  $\mathbf{F}p$  – that is, in the future,  $p$  – with respect to  $t_0$ . Indeed, while there is a state of affairs in  $h_1$  that makes  $p$  true, there is no such state of affairs in  $h_2$ .

So, when  $p$  is true in some future histories and false in other histories, which is the truth value of the proposition  $\mathbf{F}p$  with respect to the moment  $t_0$ ? As noted above, there are two possible alternatives. The first of these is that this proposition is untrue<sup>22</sup>; in this framework, the clause of the future is

$$M, t \models \mathbf{F}p \iff \forall h \exists t' (t' > t \ \& \ t' \in h \ \& \ M, t'/h \models p)$$

If  $p$  is not true in all histories radiating from  $t_0$ , then at least two options are possible. In the first option,  $\mathbf{F}p$  is false (Peircean model). In this case, all propositions concerning future contingents are false. In the second option,  $\mathbf{F}p$  is false if, in all histories radiating from  $t_0$ ,  $p$  is false and  $\mathbf{F}p$  is neither true nor false if

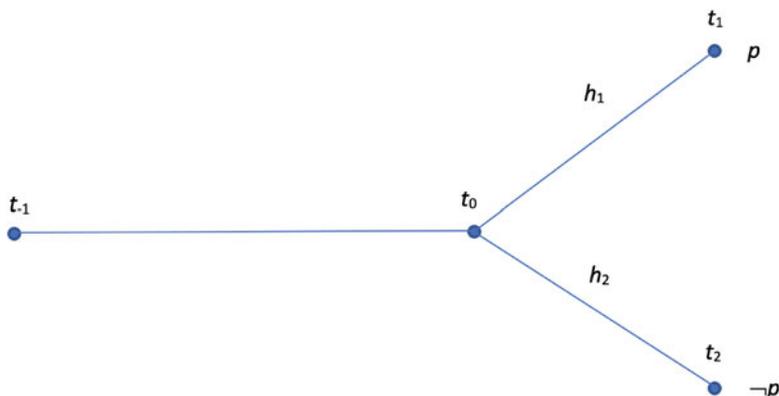
<sup>22</sup> Recall that by “untrue” we mean either false or neither true nor false. As Todd (2016) points out, there are some analogies between the positions according to which the propositions concerning the future lack a truth value or are false and the respective positions of Strawson and Russell regarding which truth value, if any, to assign to a proposition such as “The actual king of France is bald”, expressed at a time when France is a republic. However, Schoubye and Rabern (2017) show that the standard arguments for Russell’s treatment of definite descriptions fail to apply the treatment of the future operator.

there is at least one history in which  $p$  is true and at least one history in which  $\neg p$  is true.<sup>23</sup>

The TRL model is different; it assumes that the future is branching, as in the Aristotelian model, but presupposes that one of these histories has a privileged status with respect to the others. In other words, it is the history of the world that will come true. A TRL structure is a couple  $T = \langle B, \text{TRL} \rangle$ , where  $B$  is a branching structure and  $\text{TRL}$  is a privileged history:

$$\begin{array}{lll}
 M, t \models^{\text{TRL}} p & \iff & t \in V(p) \\
 M, t \models^{\text{TRL}} \neg \varphi & \iff & M, t \uparrow^{\text{TRL}} \varphi \\
 M, t \models^{\text{TRL}} \varphi \ \& \ \psi & \iff & M, t \not\models^{\text{TRL}} \varphi \ \text{and} \ M, t \models^{\text{TRL}} \psi \\
 M, t \models^{\text{TRL}} \mathbf{P}\varphi & \iff & \exists t' (t' < t \ \& \ M, t' \models^{\text{TRL}} \varphi) \\
 M, t \models^{\text{TRL}} \mathbf{F}\varphi & \iff & \exists t' (t' > t \ \& \ t' \in \text{TRL} \ \& \ M, t' \models^{\text{TRL}} \varphi)
 \end{array}$$

The relevant clause is the one concerning the future:  $\mathbf{F}\varphi$  is true if there is a time in the privileged future history at which  $\varphi$  is true. Notice that the Thin Red Line is a constituent of the structure and not of the valuation; it is the world that has a unique privileged history.



In this schema, history  $h_1$  is marked because it is the history that the agent will make actual by choosing  $p$ . Of course, the agent could have chosen otherwise, but she will not.

We will not discuss which of these two models best accounts for the idea of an open future. One of the objections leveled against the TRL model is that it does not take the openness of the future sufficiently seriously and that it is a disguised form of determinism (see Belnap & Green, 1994; MacFarlane, 2003). If what an agent will do is already determinate, she cannot really do otherwise; possible futures that differ

<sup>23</sup> This is the intuition underlying the supervaluationism. According to this semantic framework, sentences can be either *supertrue*, or *superfalse* or neither.

from the TRL would not really be open to the agent. Advocates of the TRL reply that choosing one alternative does not mean that the agent could not have chosen another. If it is only contingently true that the agent will choose an alternative over the others, there is no necessity, and the openness of the future is preserved (see Øhrstrøm, 2009; Rosenkranz, 2012). The theoretical evaluation of this debate is outside the goals of this paper; rather, we would like to investigate whether the TRL semantics can be combined with all metaphysics of time (and it is, for that, *neutral* with respect to them) or, on the contrary, whether TRL semantics requires a particular metaphysical framework, that is, Eternalism. The next section explores this point.

## 6.5 A Too Thin True Future

We are now at the heart of the question: can an advocate of TRL semantics be a presentist, maintaining – at the same time – a conception of truth based on truthmaking? The actual theoretical commitments of such a view are the following.

[Truthmaking] As we have seen in Sect. 6.2, the TRL presentist must assume a theory of truth according to which truth is grounded on being; that is, truth depends on something which exists (or which existed or which will exist).

[True Future] This is the distinguishing mark of TRL theorist; there exists – now – a true future. In the previous section, we have seen how to characterize this intuition by exploiting a model of temporal semantics: the TRL is the true history of the world, the one that has happened and that will happen. The truth clause for future tensed propositions, as said above, makes explicit reference to TRL: being true means – so to speak – belonging to the true future.

[Openness] However, the TRL is not the only possible history. We have emphasized how the TRL is a radically indeterminist view since it considers the future as open: there exist instants from which many historically possible courses of events stem. One can plausibly argue that the openness of the future is a necessary condition (even though not sufficient) for a libertarian conception of free will. An agent is free in the libertarian sense if she is the cause of her action and if she could do otherwise; for the latter condition, she must have a (more or less wide) range of alternatives in front of her. Let us see now the argument.

### 6.5.1 *The Argument Against TRL Presentism*

What grounds the truth of a proposition such as “Emma will drink a beer”? In light of [Truthmaking], there are two possibilities: either there is something that makes this proposition true or there will be something in the future that will make the proposition “Emma is drinking a beer” true. The first option is accepted by the

eternalist:  $\mathbf{F}p$  is true because there is a *future* fact  $A$ . In this case, the future exists in a tenseless way. Contrary to what may appear at first sight, the existence of a future fact that makes  $\mathbf{F}p$  true is not in contrast with [Openness].<sup>24</sup> To satisfy this principle, it is sufficient that the state of the world at  $t$  and the natural laws do not completely determine the states of the world subsequent to  $t$ . In this way, more than one possibility is left open at  $t$ . If you are eternalist, you can say that one of these possibilities is actual because it is that that (tenselessly) obtains. However, this is a contingent fact: the state of the world at  $t$  allows for other possibilities. If we take into consideration free agents, then the fact that a particular history obtains is a consequence of a free choice of an agent at a moment subsequent to  $t$ . This agent, however, could have chosen differently from what she actually chooses at that moment.

To better see why Eternalism and [Openness] are compatible, consider the past decisions of a free agent. If yesterday Emma freely chose to drink a beer, she could have chosen differently from the way she actually chose; for example, she could have drunk a Coke.  $\mathbf{P}p$  is true because Emma chose in a certain way, but this is not in contrast with her freedom because she could have made another proposition true. So,  $\mathbf{P}p$  is only contingently true. Now, in Eternalism, there is no privileged time, and the future is treated as the past. The fact that Emma will choose in some way in the future is not in contrast with the fact that she could have chosen differently from how she will actually choose. According to the eternalist, there exists an actual history of the world, consisting of actual facts, and, nevertheless, there are also many possible histories, which stem in correspondence to the points of indetermination of the actual history: these are the histories that could have obtained but that are not actual because contingently they do not happen. These possible histories are sufficient to rescue [Openness].

The eternalist can hold the three principles above together. She can assert that the truth of formulas such as  $\mathbf{F}p$  is grounded in future facts which exist tenselessly, thereby satisfying [Truthmaking]; she can also assert that a formula such as  $\mathbf{F}p$  is true iff there is a future fact  $A$  that makes  $p$  true at a time subsequent to the time of evaluation, thereby satisfying [True Future]. Finally, if she is indeterminist and asserts that the present state of the universe does not completely determine the future states, she can also satisfy [Openness].

Presentists who wish to hold all three of these principles cannot appeal to future (or past) entities to ground the truth of future (or past) tensed propositions. However, as we have seen, presentists can assume TSTB rather than TSB. So, they might say that, even if *now* there is not a future fact that makes  $\mathbf{F}p$  true, this fact *will* exist. This means that in the future,  $p$  will be true. This strategy can be successful when past tensed propositions are at stake, but for future tensed propositions things become more complex. Indeed, if [Openness] is assumed, it is indeterminate at the moment whether a fact that will make  $p$  true will exist. The presentist can say that, even though there is no fact that makes  $\mathbf{P}p$  true now, such a fact *existed* and that

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<sup>24</sup> This has been underlined by some eternalists, for instance Oaklander (1998).

this is sufficient to ground the truth of  $\mathbf{P}p$ . If there were a unique future history, a symmetrical reasoning might be applied to the future: even though there is no fact that makes  $\mathbf{F}p$  true, such a fact *will* exist and this is sufficient to ground the truth of  $\mathbf{F}p$ .

However, the TRL theory requires [Openness], that is, the existence of many future histories such that the present state of the world does not determine which one of them is the actual future history. In other words, since the presentist admits – as existing – only the present state of the world, and since that state does not determine the evolution of the world, it follows that all future histories are *on a par*. Let us suppose that in a possible future history the fact  $A$  holds and that it grounds  $\mathbf{F}p$ ; moreover, let us suppose that in another possible history  $A$  does not hold. So, there exists at least one history in which  $A$  holds and at least one history in which  $A$  does not hold; therefore, it is indeterminate whether  $A$  will exist and, as a consequence, it is indeterminate whether  $\mathbf{F}p$  is grounded or not. If the future is ontologically indeterminate and if the truth of a proposition depends on how things are in the world, also the truth value of a contingent proposition should be indeterminate.

The past case is different: just one past history existed, and in that history the fact  $A$ , which grounds  $\mathbf{P}p$ , either existed or did not exist. Thus, assuming TSTB, the truth of  $\mathbf{P}p$  is grounded since it is now determinate whether  $A$  existed or not. Summing up, if the future is really open (there is no privileged history), the presentist's argument concerning the past is not transferable to the future case.

We can illustrate our point in a slightly more formal setting, introducing a truth predicate  $T$ , which applies to propositions; thus,  $Tp$  means that  $p$  is true. Consequently, according to the truth-making theory, if  $Tp$  then  $\exists A, A \models p$ , that is, there exists a fact ( $A$ ) that makes  $p$  true. Let us consider, again, the future tensed proposition “Emma will drink a beer”; for what was said before, we have:

- (i) “Emma will drink a beer” is true  $\iff T(\mathbf{F}p) \iff \exists A, A \models \mathbf{F}p$   
(ii) “Emma will drink a beer” is true  $\iff \mathbf{F}(Tp) \iff \mathbf{F}(\exists A, A \models p)$

From this analysis, the difference between the different options clearly appears: while (i) is committed to the (tenseless) existence of a future fact in order to make the proposition  $p$  true, (ii) is only committed to the future existence of a fact that makes  $p$  true. It is because Emma, in the future, drinks a beer that, now, it is true that Emma will drink a beer. So far, so good.

Things become complicated when we take into account the openness of the future. Let us assume that  $\mathbf{F}p$  is a contingent future at  $t_0$ . We therefore have at least two possible histories which radiate from  $t_0$ :  $h_1$  and  $h_2$ . Let us imagine that within  $h_1$  we have the fact  $A$ , which makes  $p$  true, and within  $h_2$  the fact  $B$ , which makes  $p$  false. Thus, we have following situation:

- (iii)  $\mathbf{F}(\exists A, A \models p)$   
(iv)  $\mathbf{F}(\exists B, B \not\models p)$

Both (iii) and (iv) describe a part of the semantic structure to which the TRL presentist is committed. The problem is that if (iii) and (iv) are acceptable descriptions, we have troubles with the truth value of  $\mathbf{F}p$ . If the ground of the truth of

$\mathbf{F}p$  is the future existence of a truthmaker of  $p$ , here we have both the future existence of a truthmaker and the future existence of a falsemaker. But  $\mathbf{F}p$  cannot be both true and false. The conclusion is that *if* (iii) and (iv) describe something of the branching structure of the world, *then* it follows that  $\mathbf{F}p$  is semantically indeterminate. That is,  $\mathbf{F}p$  is neither true nor false *because* there is no determinate truthmaker able to make  $\mathbf{F}p$  true.

The presentist cannot assume all three principles together. If she does not want to abandon her theory of truth, she must either give up [Openness] and say that the future is, actually, closed or give up [True Future] and say that  $\mathbf{F}p$  does not have a determinate truth value.

### 6.5.2 A Possible Presentist Answer

The TRL presentist could answer the previous argument by reproducing at the ontological level the intuition she has at the semantic level. It is plain that the present state of the world does not determine whether the fact  $A$  will exist or not. However, it is also true that in the future either there will be such a fact or not (even though we cannot determine which alternative will happen): if  $A$  will hold, then  $\mathbf{F}p$  is true now; if  $A$  will not hold, then  $\neg\mathbf{F}p$  is true now. Either way, one of the two alternatives will obtain and, whatever it is, this alternative is the contingently privileged time branch, that is, the TRL. In order to establish whether  $\mathbf{F}p$  is true, one must wait and see what will happen in the TRL. Despite the openness of the future, the TRL presentist can insist that TSTB is sufficient to ground propositions such as  $\mathbf{F}p$ , assuming that the world will take one definite direction and that this direction, whatever it is, does determine the truth value of future tensed propositions.

This presentist's answer has some appeal, but we believe that it is incorrect. The TRL presentist is confusing two different things: the fact that  $p$  will have a truth value at an instant subsequent to the present and the fact that  $\mathbf{F}p$  is true (or false) at the present. It is clear that Emma will choose to drink a beer or not tomorrow. At the very instant at which Emma will make her choice, the world will "take a certain direction" and will become more determinate. That means that  $p$ , the proposition that Emma drinks a beer, will acquire a truth value. But this is what *will* happen tomorrow. *Today* the world is still indeterminate because Emma has not chosen yet. Whereas for the eternalist the dynamics of the world is illusory and all times are on par, for the presentist the dynamics is a serious matter: the world changes and becomes progressively more determinate. What is indeterminate today will not be so tomorrow. And this becoming of the world is not an illusion but a real fact. Presently, the state of the world does not determine whether  $A$  will occur or not. Of course, tomorrow things will be different because there will exist something that will make  $p$  true or false. But this is indeed what will happen tomorrow, not how things are today. From the fact that tomorrow the world will become more determinate, we cannot infer that the world is *already* determinate. The presentist must take seriously the

fact that the world changes and that propositions progressively acquire truth values that they previously lacked.

In order to better characterize this intuition, let us introduce the notion of determinateness (D) which applies to propositions. The idea is the following: a proposition is determinate if and only if it is true or false (obviously, the case in which a proposition is both true and false is excluded). From what was said before, the determinateness of a proposition (its truth or falsity) is grounded in a feature of the world which makes it true or false. If the world does not decide (so to speak) the truth or falsity of the proposition at issue, we have that it is indeterminate.<sup>25</sup>

The TRL presentist is confusing the two following principles:

(v)  $\mathbf{F}(\mathbf{D}(p))$

(vi)  $\mathbf{D}(\mathbf{F}(p))$

(v) holds: in the future the proposition  $p$  will acquire a truth value. But we think that from (v) the TRL presentist is not allowed to deduce (vi), that is, the determinateness of  $\mathbf{F}(p)$ . There is nothing in the present state of the world that is able to guarantee the determinateness of this proposition, and according to presentists the present state of the world is all that exists. Here, assuming TSTB is not helping since it is now genuinely indeterminate whether the facts grounding  $p$  will obtain in the future. Therefore, it seems that there is nothing able to justify the passage from (v) to (vi). In other words, (v) does not require the existence of a truthmaker of  $p$  but only its future existence. On the contrary, (vi) requires that the world is arranged in such a way that  $\mathbf{F}p$  is true or false. But since  $p$  is contingent, the present state of the world is not sufficient to ground its truth or falsity, unless one gives up the branching structure.

## 6.6 Conclusion

In this paper, we have compared TRL semantics with two metaphysics of time: Eternalism and Presentism. TRL semantics states that future tensed formulas have a truth value, even though the future is assumed open. The basic idea is that a future tensed formula is true if it is true in the actual history of the world. However, the question is how an actual history of the world can exist *now* given that the present state of the world does not determine what it is. In our opinion, this question has a reasonable answer within an eternalist metaphysics, in which the actual history of

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<sup>25</sup> If we assume a supervaluationist semantics, predicate D could be defined as the following:

$$M, t \models \mathbf{D}(p) \iff \forall h \in t \ M, t/h \models p \vee \forall h \in t \ M, t/h \not\models p$$

That is,  $p$  is determinate at  $t$  (in model  $M$ ) if (and only if) in all histories  $h$  which pass through  $t$ ,  $p$  is true or in all histories which pass through  $t$ ,  $p$  is false. It is indeterminate if in some histories  $p$  is true and in other histories it is false.

the world, distinct from the other possible but not actual histories, exists tenselessly. Such a metaphysics can ground future tensed propositions because there are future facts that determine their truth value.

However, if Presentism is accepted, things become much more complex. Presentists have problems even with past tensed propositions because there are not past facts that can ground these propositions. Presentists can overcome this difficulty by relaxing TSB and by postulating that tensed propositions can be grounded not only by existing facts but also by facts that existed and that will exist. If the future is closed, TSTB is sufficient to ground future tensed propositions. However, according to TRL semantics, the future is open and, hence, it is indeterminate whether there will be a fact that can make a future tensed proposition true. The present state of the world does not determine whether such a fact will exist or not. TSTB is not sufficient to ground such propositions either.

Presentists have two possibilities. They can drop [Openness] and assume that the future is closed, for instance embracing determinism. Although the future does not exist, it is already determined that a fact *A* will exist. In this case, TSTB is sufficient to ground future tensed propositions because the future is as determinate as the past. Alternatively, presentists can reject [True Future]: this means abandoning the idea that there is a privileged history of the world and embracing an Aristotelian semantics, for which future contingents are untrue.<sup>26</sup>

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<sup>26</sup> A further possibility is to reject [Truthmaking], i.e. the idea that propositions are made true by how things are in the world. However, as we have seen, renouncing the idea of a link between the truth of propositions and the world has high costs and forces deep revisions of very basic philosophical assumptions.

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# Chapter 7

## Presentism, Ockhamism, and Truth-Grounding



Fabrice Correia and Sven Rosenkranz

**Abstract** Permanentists have no trouble explaining how truths about the past or future can be grounded in reality. If  $n$  time-units ago, there was something that made  $\alpha$  true, then, whatever it was, according to permanentism, it still exists so as to make ' $n$  time-units ago,  $\alpha$ ' presently true. Presentists, by contrast, cannot infer, from the fact that  $n$  time-units ago, there was something that made  $\alpha$  true, that, whatever it was, it still exists. Their ontology doesn't include merely past entities. For this reason, presentists face the challenge to explain how contingent truths about the past – whose existence it is hard to deny – can be grounded in reality. This paper expounds and defends a relatively recent line of response to this grounding challenge that likewise extends to contingent truths about the future. As such, it is also open to those Ockhamists who posit true future contingents but deny that the future is already fully determined by what presently exists and how it presently is.

A notorious objection against presentism contends that, for want of a sufficiently rich ontology, presentism cannot heed the requirement that truths not 'float free' but be grounded. While presentists are as well-positioned as proponents of other ontological views in order to account for truths about the present, for them heeding this requirement becomes *prima facie* more difficult, as soon as we turn to truths about the past, of which there are plausibly many examples, including some that concern things in time no longer in attendance. Below we review different lines of response that are open to presentists and identify a hitherto somewhat neglected strategy that exploits truth-value links and taps into the ontological resources available at non-present times. The latter strategy is arguably less problematic than others on the menu: it seeks to steer a middle course between a signally uninformative deflationism and an ontologically profligate inflationism.

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On one sensible reconstruction of their view, Ockhamists hold that, except for issues to do with vagueness or semantic deficiency, sentences about the future are either true or false, where the truth-value of many of them is not in any way predetermined by how things presently are.<sup>1</sup> In other words, Ockhamism combines the principle of bivalence for sentences about the future with a conception of the future as nonetheless open. It is accordingly clear that Ockhamists cannot heed the requirement that truths about the future be grounded by appeal to the thought that such truths are nomologically necessitated by how things presently are. Unlike presentism, however, Ockhamism is *prima facie* consistent with a rich ontology that includes merely future things not presently in attendance; and all the grounds needed for truths about the future may well be found amongst the latter. Yet, it is unclear whether Ockhamism is naturally combined with such a rich ontology. For, the openness of the future that Ockhamists subscribe to is arguably more radical than such a rich ontology might allow. Either way, it turns out that the very same strategy that we recommend to presentists is open to Ockhamists – or so we shall argue. Adoption of this strategy still leaves Ockhamists with the choice between an ontology enriched by merely future things and a more radical form of indeterminism at odds with such an ontology.

We conclude by devising a formulation of the grounding requirement that is hospitable to presentism and Ockhamism of either variety and in fact should be acceptable to all parties to the debate about time, truth and existence.

## 7.1 The Grounding Problem for Presentism

On one straightforward characterisation of it, presentism is the view that, always, everything in time is located at what then is the present time (Correia & Rosenkranz, 2015, 2020).<sup>2</sup> The notion of temporal location is here broadly conceived so that continuants, events, states, tropes and even facts about temporal reality can all be said to be located at times.<sup>3</sup>

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<sup>1</sup> See Rosenkranz (2012). Historically more faithful interpretations focus on divine foreknowledge, and its compatibility with our freedom, rather than the truth of future contingents and its compatibility with an open future; some of these interpretations are moreover primarily concerned with past divinations and our freedom to presently act as we do, rather than present divinations and our freedom to act in the future as we will (see, e.g., the papers in Part II of Fischer & Todd, 2015). Clearly, however, these issues are intimately related. See Prior (2003: 44) for an argument why divine foreknowledge, past or present, presupposes the truth, past or present, of future contingents.

<sup>2</sup> The behaviour of ‘the present time’ can be elucidated by appeal to the distinction between the *time of utterance* and the *time of index* familiar from contemporary philosophy of language: ‘the present time’ – like ‘the referent of ‘now’’, but unlike the indexical ‘now’ – is a temporally non-rigid designator for the time of index, where temporal operators like ‘Always’ or ‘2068 years ago’ may shift the time of index away from the time of utterance.

<sup>3</sup> Without implying that any type of thing is reducible, or irreducible, to any other, it seems extensionally correct to say the following. Events are located at the times contained in their

Presentism, as characterised, accordingly implies the present truth of

Everything in time is located at  $u$

where  $u$  is the present time.

Most would concede that there are, presently, truths about the past – including truths to the effect that, sometimes in the past, certain things in time existed, and were thus-and-so, that are not located at  $u$ . For instance, most would agree that the following is a truth about the past:

2068 years ago, Caesar crossed the Rubicon

where no subject identical to Caesar – and no event or trope of Caesar’s crossing the Rubicon, for that matter – is located at  $u$ .

In the light of this concession, presentists face a challenge: they must answer to the constraint that truths about the past, like any other types of truth, do not ‘float free’ but require grounding. Their sparse ontology would *prima facie* seem to debar presentists from doing so. They are committed to denying that Caesar, or any event or trope of his crossing the Rubicon, presently exists. But to the extent that, plausibly, constituents exist whenever those things exist whose constituents they are, presentists must also deny that there are, presently, any facts, or states of affairs, of which Caesar, or any such event or trope, would be a constituent.

How, then, can presentists heed the requirement that all truths about the past be grounded? This is, roughly put, the so-called *grounding problem for presentism* (Sider, 2001; Keller, 2004).

## 7.2 The Nuclear Option

What we might call ‘the nuclear option’ implies acceptance of a thoroughgoing determinism according to which every world-state nomologically necessitates every other world-state, where world-states correspond to ways the world is at a given time (Hofer, 2016). Here, a way the world is at a given time  $t$  is best conceived in terms of the things in time located at  $t$  and the natural properties and relations they instantiate at  $t$  – where properties and relations are natural only if they are not ‘mere-Cambridge’ or in any other way gerrymandered (Shoemaker, 1980; Correia & Rosenkranz, 2018: 112–15). If such a global determinism is correct, the present

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temporal extension. Continuants are located at the times included in the temporal extension of the events that are their histories. States of things are located at the times at which those things are in those states. Tropes are particularised property-instantiations that are located at the times at which the relevant property is instantiated. Tensed facts are located at the times at which they obtain. Tenseless facts are located at the time that is their *topic* (for the latter notion, see Fine, 2005: 296). For convenience, we may also stipulate that, on the relevant notion of temporal location at work in the suggested characterisation of presentism, individual time instants are located at themselves and only at themselves.

world-state nomologically necessitates that, 2068 years ago, the Roman governor of Gaul crossed the Rubicon, and hence that ‘2068 years ago, the Roman governor of Gaul crossed the Rubicon’ is presently true.

Nomological necessitation is not yet grounding, however, because grounding requires metaphysical necessitation, and nomological necessitation is a weaker relation. But under the envisaged circumstances, we can still say that the present world-state, the natural laws, and the fact that the latter are all the natural laws that there are, conspire to metaphysically necessitate any past or future world-state (Rosenkranz, 2013). According to the nuclear option, metaphysical necessitation is not only necessary but also sufficient for grounding, and the truth of sentences about the past is grounded in the present world-state, the natural laws and the fact that the latter are all the natural laws that there are (cf. Sider, 2001: 37–39).

One obvious first objection against this view is that it is hostage to the form of global determinism described above, and that this form of determinism is highly controversial. A second, independent objection proceeds from the assumption that ‘grounding’ denotes something much more robust than mere metaphysical necessitation: grounding is explanatory – the grounds *explain* what they ground – and subject to the condition that the grounds be *wholly relevant* to what they ground (see Fine, 2012a, b for clear formulations of both these features). Metaphysical necessitation notoriously fails to exhibit either feature (*ibid.*). To illustrate, granted that mathematical truths are metaphysically necessary, they are metaphysically necessitated by any other truths, in particular by truths that have no explanatory bearing on matters mathematical; and if it is at all correct to say that the truth of ‘2068 years ago, the Roman governor of Gaul crossed the Rubicon’ is metaphysically necessitated by the obtaining of the present world-state, the natural laws and the fact that the latter are all the natural laws that there are, what is said to necessitate its truth contains a lot that is entirely irrelevant to its truth. The second objection then is that the nuclear option conflates grounding with metaphysical necessitation and ultimately does not meet the grounding requirement.

The first objection contends that, in the light of its commitment to global determinism, the nuclear option is highly controversial. Since global determinism *is* undoubtedly highly controversial, the objection is therefore hard to resist. The second objection, by contrast, purports to establish that the nuclear option is not merely controversial but inadequate. Yet it is unclear to us what force the objection really has. The requirement that truths not ‘float free’ is underspecified; and it may well be that, if accurate, the finding that truths about the past are metaphysically necessitated in the way suggested is sufficient to discharge it. Any remaining misgivings about the nuclear option would then have to profess doubt about the accuracy of this finding – which is to say, about global determinism.<sup>4</sup>

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<sup>4</sup> Another worry one might have is that even if the actual world is deterministic, other possible worlds are not: determinism, if true, is only contingently true. For all that has here been said, presentism itself may at best be only contingently true; and friends of the nuclear option might insist that it is. Even if this was so, however, there is no reason to expect that no indeterministic world is presentist. Friends of the nuclear option might then still insist that no presentist world

Be that as it may, it is worth our while to investigate whether there are alternative lines of response open to presentists – lines of response immune to the objections just discussed.

### 7.3 Nefarious vs Upstanding Presentism

The grounding problem for presentism was supposed to result from the combination of two claims: that truths do not ‘float free’ but require grounding, and that there are truths about the past, including truths of the form ‘2068 years ago,  $Fa$ ’, where ‘ $a$ ’ used to refer to a thing in time but does not refer to anything located at the present time. But, on reflection, the tension with presentism’s sparse ontology only arises if the first of these claims – the grounding requirement – is given a particular reading, *viz.* one on which it implies that, always, every truth requires there to exist some entity or entities whose existence or features, in some suitable sense of ‘guarantee’, guarantee its truth. This reading of the requirement is indeed rather natural. It is equally natural to think that anything in existence whose existence or features guarantee the present truth of ‘2068 years ago,  $Fa$ ’ has either the thing referred to by ‘ $a$ ’ as a constituent or at least some past event or state that belonged to that thing’s history. According to presentism, there exist no such things.

However natural the aforementioned interpretation of the grounding requirement may be, it can be resisted. Consider the following, ontologically neutral version of a grounding requirement on truths of a given kind  $K$ :

(GR) For any truth  $\varphi$  of kind  $K$ , there is a  $p$  such that its being the case that  $p$  grounds its being the case that  $\varphi$  is true,

where ‘ $\varphi$ ’ is a standard nominal variable, ‘ $p$ ’ a sentential variable and ‘Its being the case that ... grounds its being the case that —’ is a binary sentential operator, which will henceforth be abbreviated to ‘...  $<$  —’.<sup>5</sup> We intentionally leave the interpretation of the operator underspecified, thereby allowing (GR) to be made to square with weaker and with stronger conceptions of grounding. Thus, in particular, ‘ $p < q$ ’ may be understood as being true already when its being the case that  $p$  metaphysically necessitates its being the case that  $q$ . Alternatively, it may be understood as being true only if its being the case that  $p$  explains, and is wholly relevant to, its being the case that  $q$ . There may be yet other viable interpretations not considered here.

We regard (GR) as ontologically neutral because ‘ $p$ ’ is a sentential variable, and, as we presume, quantification into sentential position is not ontologically

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both is indeterministic and allows for truths about the past. But with every step, this line of defence becomes less convincing, casting doubt on the idea that the nuclear option can deliver more than a contingently true explanation.

<sup>5</sup> It is natural to understand grounding as being many-one rather than one-one, i.e. to hold that the general form of grounding statements should be taken to be ‘ $p, q, \dots < r$ ’ where ‘ $p, q, \dots$ ’ is a list of one or more sentences, but for the sake of simplicity we will ignore this.

committing (see Prior, 1971; Rayo & Yablo, 2001). Once the requirement is accepted, it is an important further question what logical form *ground-clauses* must have, i.e. those sentences that, for a given choice of ‘*K*’, might serve as replacements for ‘*p*’ in ‘ $p < \varphi$  is true’, where  $\varphi$  is a truth of the relevant kind.

For some choices of ‘*K*’, ground-clauses may uncontroversially be said to have the form ‘*X* exist(s)’, with ‘*X*’ being a term for one or more things, as for example in ‘Bernie Sanders exists < ‘Bernie Sanders is human’ is true’. But it may be denied that ground-clauses for truths invariably have that form, irrespective of which kinds of truths are in question. We are here chiefly interested in truths about the past; and the question accordingly is why we should have to suppose that ground-clauses for truths about the past have the form ‘*X* exist(s)’.

Echoing Aristotle, it might for instance be suggested that the grounding statements of interest to us here are homophonic, e.g. that

2068 years ago, *Fa* < ‘2068 years ago, *Fa*’ is true

(Tallant, 2009, 2010; Tallant & Ingram, 2015), or almost homophonic, e.g. that

2068 years ago, *a* instantiated the property of *F*-ness < ‘2068 years ago, *Fa*’ is true

(Gallois, 2004; Sanson & Caplan, 2010).

Presentists who endorse (GR) for truths about the past and take the relevant grounding statements to be homophonic or quasi-homophonic – Tallant and Ingram (2015) call them ‘nefarious’ – do not face any grounding problem, because the corresponding ground-clauses – e.g. ‘2068 years ago, *Fa*’, ‘Sometimes in the past, *Fa*’, and other supposedly problematic sentences of similar types – are governed by a past-tense operator which, according to presentists at least, cancels any ontological commitment to any object referred to by ‘*a*’ (or any event or state belonging to such an object’s history, for that matter) (Correia & Rosenkranz, 2018: 70–71).

While we harbour sympathies for nefarious presentism, we are aware that many find the view wanting in explanatory strength.<sup>6</sup> An alternative to nefarious presentism that fares *prima facie* better on this score is what Tallant and Ingram (2015) call ‘upstanding presentism’. Upstanding presentists agree with their nefarious colleagues that truths about the past must conform to (GR). But unlike the latter, they insist that the relevant ground-clauses have to be about the present. The nuclear option is most naturally understood as a form of upstanding presentism in this sense. On that view indeed, its being the case that ‘2068 years ago, the Roman governor of Gaul crossed the Rubicon’ is true is grounded in its being the case that *S* & *L*, where ‘*L*’ is the conjunction of all the laws of nature and a statement to the effect that they are all the laws that there are and ‘*S*’ expresses that the world is presently in such

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<sup>6</sup> One reason why one might hold that nefarious views have insufficient explanatory power is implicit endorsement of the view that pointing to a ground whose topic is the present is somehow more explanatory than pointing to a ground whose topic is the past or future (for the notion of topic, see again Fine, 2005: 296). It is, however, unclear what might warrant this view. In any case, all the other proposals under discussion – including our own – cohere with it.

and such a state. Given a suitable conception of laws of nature, ‘*S & L*’ is wholly about the present.<sup>7</sup>

Another view in the same camp is *Lucretianism*. On that view, its being the case that ‘2068 years ago, the Roman governor of Gaul crossed the Rubicon’ is true is grounded in its being the case that the universe instantiates the property of *having once been such that the Roman governor of Gaul crossed the Rubicon*, where instantiation of this irreducibly past-tense property at a given time does not entail the existence of anything not located at that time (Bigelow, 1996). Others have suggested, somewhat less plausibly, that the relevant ground-clauses make reference to an abstract thing with a certain content or shape, e.g. *the past* (Kierland & Monton, 2007) or some ersatzist object like an abstract time (Crisp, 2007).

All these upstanding options are problematic, for one reason or another. We have already discussed the nuclear option and its problematic features above. The obvious objection against Lucretianism is that its ontology is inflated: it posits properties of highly non-natural sorts, including irreducibly past-tense properties. Therefore the solution it purports to offer comes at a considerable price that many presentists will not be willing to pay.

It might be replied that this is only an objection to Bigelow’s own version of the view, and that it is possible to ‘deflate’ the view, by adopting the following recipe: replace ‘the world has the property of being such that 2068 years ago, *p*’ by ‘the world is such that 2068 years ago, *p*’, and likewise for all other ground-clauses for truths about the past whose articulation involves the use of past-tense sentential operators. However, the last sentence type is quite close to ‘2068 years ago, *p*’, and therefore it is not at all clear whether the deflated version of Lucretianism significantly differs from nefarious views in explanatory strength. Similar kinds of complaints can be issued against views that invoke abstract things of the sort previously mentioned and corresponding attempts at their deflation.<sup>8</sup>

## 7.4 The Revolutionary Strategy

The aforementioned options – nefarious and upstanding – are not the only ones open to presentists. A third line of response is to deny that the grounding requirement on truths about the past must take the form embodied by (GR). According to the proposal we have in mind, grounding explanations of truths about the past exploit truth-value links between the present truth of a sentence about the past and the past truth of a corresponding sentence about what then was the present – in such a way that the past grounds for the past truth of the latter sentence suffice to explain the present truth of the former. For want of a better name, call proponents of this view ‘revolutionary’.

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<sup>7</sup> The nuclear option is discussed in Sider (2001: 37–39).

<sup>8</sup> It could also be argued that some if not all of these upstanding views fail to heed the demand that the grounds for a given truth be wholly relevant to that truth. But as we stressed in the previous section, we do not want to make too much of that demand.

Perry (2004), Westphal (2006) and Baia (2012) can all be regarded as belonging to this third camp (see also Rosenkranz, 2012). However, Perry (2004) and Westphal (2006) provide too little detail about the exact shape they expect such alternative grounding explanations to take; and Baia (2012) employs non-metric tense operators that are too blunt a tool to deliver all that we may wish for.<sup>9</sup> We can improve upon the current state of revolutionary thinking as follows (see Correia & Rosenkranz, 2018: 106–12).

As a background, we assume a minimal metric tense logic that governs metric tense operators of the forms ‘ $F_n$ ’ (for ‘ $n$  time-units in the future’) and ‘ $P_n$ ’ (for ‘ $n$  time-units in the past’), where the subscripts accordingly denote positive numbers measuring temporal distances (Prior, 2003: 162). We likewise assume as given a regimented tensed language in which to formulate the formulas of that logic. Some of these formulas will be sentences about the present, and we shall use ‘ $\alpha$ ’ as a (nominal) variable for such sentences.

The particular view we have in mind adopts the following general principle:

P1 Always, if  $\alpha$  is true, then  $\exists X(X \text{ exist} < \alpha \text{ is true})$

where ‘Always, ...’ is defined as ‘ $(\forall_n P_n \dots) \& \dots \& (\forall_n F_n \dots)$ ’ and ‘ $<$ ’ is used in the same way as before. Although on our preferred interpretation, ‘ $<$ ’ expresses a robust notion of grounding, we leave the exact meaning of ‘ $<$ ’ underspecified. Plausibly, we also have

P2 Always, if  $\alpha$  is true, then  $\alpha \text{ is true} < F_n(‘P_n \alpha’ \text{ is true})$

In combination with P1, this yields

P3 Always, if  $\alpha$  is true, then  $\exists X(X \text{ exist} < F_n(‘P_n \alpha’ \text{ is true}))$

Assume then that some sentence about the past is now true, e.g. let  $s$  be a particular sentence about the present and assume

(1) ‘ $P_n s$ ’ is true

Given the truth-value links, (1) implies

(2)  $P_n(s \text{ is true})$

From (2) and P3, we get

(3)  $P_n \exists X(X \text{ exist} < F_n(‘P_n s’ \text{ is true}))$

If we translate this back into English (and for convenience use a shorthand formulation in predicative terms rather than operator terms), (3) says that  $n$  time-units ago, there were things whose existence grounded the fact that  $n$  time-units later, ‘ $P_n s$ ’ would be true. Now is the time at which those sentences are true that  $n$

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<sup>9</sup> A further shortcoming of Baia’s proposal is that it ultimately does not furnish us with explanations of why presently true sentences about the past are presently true, but merely with explanations of why the corresponding sentences about the present were true in the past.

time-units ago were going to be true  $n$  time-units later. Consequently, (3) says, in effect, that  $n$  time-units ago, there were things whose existence grounded the fact that ‘ $P_n s$ ’ is now true.

Thus, (3) delivers a grounding explanation of the present truth of the sentence ‘ $P_n s$ ’, which is a sentence about the past, by tapping into the ontological resources available  $n$  time-units ago. This, we submit, is explanation enough. Consequently, if she adopts this revolutionary strategy, the presentist is home and dry. For, (3) does not ontologically commit her to the existence of any past entity, be it an object, an event or whatever else. At the same time, (3) is more explanatory than the bland homophonic grounding explanations that are the nefarious presentists’ stock in trade.

## 7.5 Ockhamism

Ockhamism is the combination of two tenets: first, that – barring issues to do with vagueness or semantic deficiency – any truth-apt sentence about the future is presently either true or false, and secondly, that the future is nonetheless not presently settled in all respects and is to this extent open (Rosenkranz, 2012).<sup>10</sup> Ockhamists accordingly draw a distinction between *determinacy* of truth-value and *settledness* of truth-value (for an early articulation of the distinction, see Broad, 1937). The right to this distinction must be earned – if only because a significant number of authors deny that bivalence holds for all truth-apt (non-vague, semantically non-deficient) sentences about the future, precisely because their truth-value is not presently settled (Łukasiewicz, 1970; Thomason, 1970; Belnap et al., 2001; MacFarlane, 2003).

On one natural reading, ‘settled’ means the same as ‘nomologically necessitated by the present world-state’ – where, as before, the present world-state is understood in terms of the things located at the present time and all the natural properties and relations they presently instantiate. On the corresponding interpretation of Ockhamism’s second tenet, it implies rejection of global determinism, as that position was characterised above.

Like everyone else who posits truths of a given kind, Ockhamists are under the obligation to heed the grounding requirement for truths about the future. It is clear that they cannot discharge this obligation opting for the nuclear option. But neither would they seem to be committed to an austere ontology – like that of presentism, for example – which would debar them from any appeal to purely future things in time as grounds for such truths.

Let us follow Williamson (2013: 4) and call ‘permanentism’ the ontological thesis that always everything always exists. Presentists of any stripe and proponents of the so-called *Growing Block Theory* (GBT) reject this thesis. By contrast,

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<sup>10</sup> See footnote 1.

Ockhamism, as characterised, is neutral on this issue. To exist at the present time, and to be located at the present time, are distinct notions (Correia & Rosenkranz, 2020), and the present world-state of global determinism was characterised in terms of the latter. Therefore, Ockhamism, as characterised, not only is perfectly compatible with permanentism, its proponents can in principle offer grounding statements for truths about the future that assume the following form:

$X$  exist < ‘ $F_n\alpha$ ’ true

where ‘ $X$ ’ picks out things in time that, while they presently exist, are first ever located at the time  $n$  time-units later than now.

As indicated earlier, on a common conception of grounds, grounds fully account for what they ground. Assuming this conception, in order for the existence of suitable such  $X$  to ground the truth of, say,

In five years’ time, a new-born child will make his father happy

it will not be enough that their existence accounts for the existence of something that, in five years’ time, will be a new-born child that will make his father happy. The  $X$  must likewise account for that thing’s going to be, in five years’ time, a new-born child and making his father happy. This severely restricts the choice of  $X$ : they must be either facts or sufficiently fact-like such as tropes or events – *matters of fact*, for short. Permanentism alone does not guarantee that there are suitable such matters of fact for each truth about the future.

It is at this stage that it becomes somewhat doubtful whether we have characterised Ockhamism in the most faithful way. For, if, for each truth about the future, there are indeed presently existing matters of fact that ground it, then does *this* really cohere with the tenet of the open future *as it was intended*?

Consider the following variation of what we called ‘global determinism’. As before, the view is that every world-state nomologically necessitates every other world-state, but world-states are now conceived in terms of things in time *existing* at  $t$  and the natural properties and relations they instantiate at  $t$  (cf. Correia & Rosenkranz, 2018: 115–16). Call this variation of global determinism ‘determinism\*’, call the world-states as here characterised ‘world-states\*’, and correspondingly, use ‘settled\*’ for ‘nomologically necessitated by the present world-state\*’. Given presentism, determinism\* is equivalent to determinism, as on that view things in time exist at  $t$  iff they are located at  $t$ . But, as highlighted above, Ockhamism does not entail presentism.

If for any true sentence about the future, there exist at present some  $X$  such that the existence of  $X$  grounds the sentence’s truth, then to the extent that grounding implies necessitation, the truth of any such sentence is presently settled\*. Is this something Ockhamists can be happy to endorse?

It is underdetermined what the correct answer to this question is. There is certainly nothing in the formulation of the view, given at the beginning of this section, that would dictate that ‘settled’ be understood as ‘nomologically necessitated by the present world-state\*’ rather than ‘nomologically necessitated by the present world-state’. If the answer to the question is negative, Ockhamism’s second tenet should be

interpreted as implying rejection of both determinism and determinism\*; and then its proponents – indeterminist\* Ockhamists – will be committed to a more radical thesis of the open future than they would otherwise be (cf. Correia & Rosenkranz, 2018: 116).

## 7.6 Ockhamists on the Revolutionary Road

No Ockhamist can avail herself of the nuclear option, in order to heed the grounding requirement. As just argued, those Ockhamists who find indeterminism\* an attractive and congenial position cannot avail themselves of permanentist accounts of truth-grounding either. The same will apply to upstanding accounts that posit abstract items whose present existence is meant to already guarantee which truth-values sentences about the future have. Indeterminist\* Ockhamists might therefore be tempted to postulate irreducibly future-tense properties that, like the irreducibly past-tense properties contemplated before, are attributable to the universe as a whole and whose postulation is the hallmark of Bigelow's Lucretianism. However, as indicated, an ontology of such properties is arguably too costly. Nefarious positions, though ontologically non-committal, are arguably too deflationary to be informative; and the same applies to deflated versions of Lucretianism.

It therefore comes as good news that Ockhamists, be they indeterminists or indeterminists\*, can opt for the revolutionary strategy which delivers more informative grounding statements than the nefarious strategy permits but, unlike other lines of response, does so at no additional ontological cost. Just as P2 is plausible, so is

P4 Always, if  $\alpha$  is true, then  $\alpha$  is true  $< P_n$ ('F $_n\alpha$ ' is true)

This, together with P1, implies

P5 Always, if  $\alpha$  is true, then  $\exists X(X \text{ exist} < P_n$ ('F $_n\alpha$ ' is true))

Assume then that some sentence about the future is now true, e.g. let  $s$  be a particular sentence about the present and assume

(4) 'F $_n s$ ' is true

Given the truth-value links, (4) implies

(5) F $_n(s \text{ is true})$

From (5) and P4, we get

(6) F $_n \exists X(X \text{ exist} < P_n$ ('F $_n s$ ' is true))

If we translate this back into English (and for convenience use a shorthand formulation in predicative terms rather than operator terms), (6) says that  $n$  time-units hence, there will be things whose existence will ground the fact that  $n$  time-units earlier, 'F $_n s$ ' was true. Now is the time at which those sentences are

true that  $n$  time-units hence will have been true  $n$  time-units earlier. Consequently, (6) says, in effect, that  $n$  time-units hence, there will be things whose existence will ground its being the case that ‘ $F_n s$ ’ is true *now*.

In other words, (6) delivers an account of the grounds for the present truth of the sentence ‘ $F_n s$ ’, which is a sentence about the future. To the extent that the truth of (6) is neither settled nor settled\*, the same holds of ‘ $F_n s$ ’; and there is no suggestion whatsoever that the truth of (6) must be either settled or settled\*. Of course, (6) can serve as a statement of the grounds for the present truth of ‘ $F_n s$ ’, only if it is true. But it is certainly legitimate for the Ockhamist to suppose so. One cannot fault a theory’s attempt to meet a challenge by denying it the very means that the theory says are available, *viz.* truths about the future of the kind (6) exemplifies. Consequently, if she adopts this revolutionary strategy, the Ockhamist is home and dry.

At the same time, (6) is more explanatory than the homophonic grounding explanation

$F_n s < \text{‘}F_n s\text{’ is true}$

and less ontologically committal than a grounding statement of the form

$X \text{ exist} < \text{‘}F_n s\text{’ is true}$

Even so, the Ockhamist might after all endorse permanentism, and then her acceptance of (6) will commit her to

(7)  $\exists X F_n (X \text{ exist} < P_n (\text{‘}F_n s\text{’ is true}))$

If we translate this back into English (and for convenience use a shorthand formulation in predicative terms rather than operator terms), (7) says, in effect, that there are now things such that,  $n$  time-units hence, their existence will ground the fact that ‘ $F_n s$ ’ is now true. Plausibly, to the extent that always everything always exists, the existence of such things will  $n$  time-units hence ground the fact that ‘ $F_n s$ ’ is now true, only if their existence presently grounds the fact that ‘ $F_n s$ ’ is now true. If so, (7) will in turn yield a grounding statement of the form

$X \text{ exist} < \text{‘}F_n s\text{’ is true}$

But importantly, if Ockhamists forego commitment to permanentism and opt for presentism or GBT instead, so as to allow for commitment to indeterminism\*, her acceptance of (6) will not commit her to (7). For, according to either presentism or GBT, the inference from ‘ $F_n \exists X \varphi$ ’ to ‘ $\exists X F_n \varphi$ ’ is not valid (Correia & Rosenkranz, 2018: 50, 71).

## 7.7 Conclusion

The revolutionary road leads us to a formulation of the grounding requirement for truths that is hospitable to both presentism and GBT – and hence also to the variety of Ockhamism according to which some sentences about the future have an unsettled\* truth-value:

(TGR) For any truth  $\varphi$  of kind  $K$ , sometimes,  $\exists X(X \text{ exist} < (\text{Now}, \varphi \text{ is true}))$

where ‘ $K$ ’ subsumes all ‘temporal truths’, i.e. truths about what was, is or will be the case, ‘Sometimes, ...’ is defined as ‘ $(\exists_n P_n \dots) \vee \dots \vee (\exists_n F_n \dots)$ ’ and ‘Now’ is a temporal operator that always shifts the time of index back to the time of utterance.<sup>11</sup>

Those intent on challenging presentists who believe in truths about the past concerning things no longer in attendance, and Ockhamists who believe in truths about the future whose truth is presently unsettled\*, may consider (TGR) too weak and contend that there is a legitimate formulation of the grounding requirement that results from (TGR) by deleting the occurrence of ‘sometimes’. But once it is conceded that ‘ $\varphi$ ’ also ranges over sentences that are about the past or the future, this contention seems as yet entirely unmotivated. For, failing antecedent endorsement of permanentism, such sentences do not even pretend to be about presently existing matters of fact (cf. Westphal, 2006).

Admittedly, the ordinary notion of what a given sentence *is about* admits of theoretical reconstruction; and even truths that are not, in any ordinary sense, about a given type of thing, may nonetheless be said, upon theoretical reflection, to be made true by things of that type. But this is then a discussion we must have *before* we can conclude that none of the challenged parties can heed the requirement that truths not ‘float free’. To simply assume a theory that construes sentences, *prima facie* about what was the case or did exist, as really being about presently existing matters of fact, is to beg the question against the presentist; and to simply assume a theory that construes sentences, *prima facie* about what will be the case or exist, as really being about presently existing matters of fact, is to beg the question against the indeterminist\* Ockhamist.

We conclude that, pending further argument about matters of this nature, both presentists and Ockhamists with indeterminist\* leanings can sleep tight. The constraint that truths not ‘float free’ should be no cause for any nightmares.

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<sup>11</sup> See footnote 1.

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# Chapter 8

## The Metaphysics of Ockhamism



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**Abstract** This paper investigates Ockhamism from a metaphysical point of view. Its main point is that the claim that future contingents are true or false is less demanding than usually expected, as it does not require particularly contentious assumptions about the future. First it will be argued that Ockhamism is consistent with a wide range of metaphysical views. Then it will be shown that each of these views leaves room for the claim that the future is open, at least on some plausible interpretations of that claim.

### 8.1 Preliminary Clarifications

Ockhamism is the theory according to which future contingents are true or false, although they are neither determinately true nor determinately false. Its core idea is that truth and falsity depend on what happens in the actual future, while determinate truth and determinate falsity depend on what happens in all possible futures. Consider the following sentence:

(1) There will be a sea battle tomorrow

According to Ockhamism, (1) as uttered today is true or false, for either the actual future is such that there will be a sea battle tomorrow or it is such that there will not be a sea battle tomorrow. This, however, does not mean that (1) as uttered today is determinately true or determinately false, because today is not settled whether there will a sea battle tomorrow.<sup>1</sup>

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<sup>1</sup> Ockhamism goes back to Ockham (1978, pp. 515–517), Øhrstrøm (2009) provides a detailed presentation of Ockham's view.

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From the logical point of view, Ockhamism is disarmingly simple. Most theories of future contingents reject bivalence, so they imply some sort of logical asymmetry between sentences about the future and sentences about the past. Ockhamism, instead, preserves bivalence and thereby logical symmetry between sentences about the future and sentences about the past. Consider (2) and (3):

- (2) There is a sea battle
- (3) There was a sea battle yesterday

According to Ockhamism, (1) is true as uttered today if and only if (2) is true as uttered tomorrow, and (2) is true as uttered tomorrow if and only if (3) is true as uttered the day after tomorrow, so (1) and (3) are related to (2) exactly in the same way. This specularity holds because (1) as uttered today, (2) as uttered tomorrow, and (3) as uttered the day after tomorrow describe one and the same fact, the way things will be tomorrow.

The aspect of Ockhamism that may easily be perceived as problematic, and is often perceived as problematic, is its reliance on the notion of the actual future. In the current debate on future contingents, Ockhamism is usually associated with *the thin red line*, the view according to which there are many possible continuations of the present—many branches that depart from the same trunk—and one of them is the actual future. This view has been widely discussed, especially for its implications on formal semantics, and the main problem that has been raised in connection with it is that it seems at odds with the claim that the future is open.<sup>2</sup>

Although the interest in Ockhamism has grown considerably in the last few years, and some arguments against the thin red line have been convincingly countered, it is still an open question whether the notion of the actual future is viable from a metaphysical point of view. The present work is intended to shed light on this question by dispelling some recurrent doubts about Ockhamism and pointing out some sources of confusion and misunderstanding.<sup>3</sup>

The first part of the paper suggests that there is no necessary connection between Ockhamism and the thin red line. As will be explained, Ockhamism is consistent with four distinct ontologies of time, and is neutral with respect to the divide between branching and divergence. The second part of the paper shows that each of the views considered in the first part is compatible with the claim that the future is open, at least on some plausible interpretations of that claim.

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<sup>2</sup> The expression ‘thin red line’ goes back to Belnap and Green (1994). The objection is expressed in various forms in McArthur (1974, pp. 284–285), Belnap and Green (1994, p. 381), Perloff et al. (2001, p. 162), MacFarlane (2003, pp. 325–326).

<sup>3</sup> Recently, Ockhamism has been elaborated and defended in Øhrstrøm (2009), Rosenkranz (2012), Iacona (2013), Iacona (2014), Wawer (2014), Malpass and Wawer (2020).

## 8.2 Presentism and the Growing Block Theory

As is well known, there are four main views that one may hold about the existence of past, present, and future entities: presentism, the growing block theory, the shrinking block theory, and eternalism. This section is intended to show that Ockhamism is consistent with the first two views, while the next section will deal with the other two.

Presentism is the view according to which only present entities exist: past entities and future entities do not exist. Imagine an incredibly big and incredibly thin slice of salami. The slice is the present, and we are in it. Behind us there is nothing, because the past does not exist, and ahead of us there is nothing, because the future does not exist. Figure 8.1 illustrates the situation just described:

The growing block theory is the view according to which past and present entities exist but future entities do not exist. This view describes reality as a totality that increases as time goes by. Imagine, as before, that we are in a slice of salami. Behind us lies the past, the portion of salami that precedes the slice, while ahead of us there is nothing, as in Fig. 8.2.

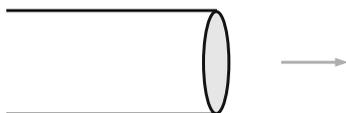
The first impression one might have is that presentism and the growing block theory plainly contradict Ockhamism. If there is nothing ahead of us, how can future contingents be true or false in virtue of what happens in the actual future? It is no accident that some eminent advocates of presentism and the growing block theory have denied bivalence. However, this impression does not resist scrutiny. As will be suggested, it is conceivable that future contingents are true or false even if the future does not exist.

Let us focus on the growing block theory. According to Broad, who provided the first clear formulation of this theory, (1) is neither true nor false: since tomorrow has not yet come, there is presently no fact that could render (1) true or false. However, Broad's denial of bivalence is disputable. As Correia and Rosenkranz have argued, it should not be assumed that, in order for (1) to be true, there has to be some present fact that makes it true. To think so is to rely upon an unjustified assumption about grounding, the assumption that in order for a sentence about the future to be presently true, its truth must *presently* be grounded in what there is and how it is. According to Correia and Rosenkranz, the grounding requirement on truth should

Fig. 8.1 Presentism



Fig. 8.2 The growing block



rather be phrased as follows: in order for a sentence about the future to be presently true, its truth must be grounded *in the future* by something being certain ways.<sup>4</sup>

Of course, truthmaking is a hard problem, and we cannot take for granted that Correia and Rosenkranz are right on this point. But at least we can say that is not obvious that the growing block theory rules out bivalence. Whether it does depends on what makes sentences about the future true or false.

Note that, if the grounding requirement is phrased in the way suggested by Correia and Rosenkranz, it warrants the truth value link between (1) and (2) stated in Sect. 8.1. Let us assume that (1) as uttered today is true just in case its truth is grounded in the way things will be tomorrow. Then (1) as uttered today and (2) as uttered tomorrow are grounded in the same fact. Therefore, it makes perfect sense to say that (1) is true as uttered today if and only if (2) is true as uttered tomorrow. Similar considerations hold for the truth value link between (2) and (3), if it is assumed that sentences about the past are presently true when they are grounded in the past.

Note also that, if the truth of a sentence about the future is grounded in the future, rather than in the present or in the past, its being grounded is clearly compatible with its being contingent. For example, if (1) is true as uttered today in virtue of something that will happen tomorrow, its truth is not rendered inevitable by how things located in the present or in the past now are or were. So, grounding does not entail necessitation.<sup>5</sup>

Similar considerations hold for presentism. Insofar as grounding is understood in the way suggested by Correia and Rosenkranz, presentism leaves room for the thought that the truth or falsity of (1) as uttered today depends on what will happen tomorrow. More generally, the presentist can say that sentences about the future are presently true when they are grounded in the future, and that sentences about the past are presently true when they are grounded in the past.

As long as it is granted that presentism and the growing block theory do not rule out bivalence, it can be shown that Ockhamism is consistent with these two theories. To do so, it suffices to appeal to abstract entities that the presentist and the growing block theorist may easily accept, and that represent the nomically possible extensions of the world at the present time. Let an *ersatz future* be defined as follows:

**Definition 8.1** An ersatz future is a consistent and negation-complete set of sentences about the future.

This is not a rigorous definition, of course, because it makes no reference to a specific language and does not provide a precise characterization of the relevant set of sentences. But at least it is reasonable to expect that it can be converted into a rigorous definition, once the due technicalities are properly handled.<sup>6</sup> To say that a set of sentences  $S$  is consistent is to say that there is no  $p$  such that  $S$  includes

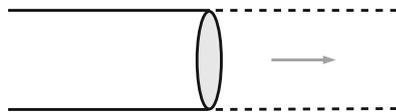
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<sup>4</sup> Broad (1923, p. 73), Correia and Rosenkranz (2018, pp. 110–116).

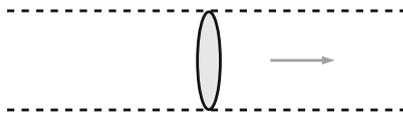
<sup>5</sup> Correia and Rosenkranz (2018, pp. 116–121).

<sup>6</sup> See for example Briggs and Forbes (2012).

**Fig. 8.3** Past, present, and ersatz future



**Fig. 8.4** Ersatz past, present, and ersatz future



both  $p$  and  $\sim p$ . To say that  $S$  is negation-complete is to say that, for every  $p$ ,  $S$  includes either  $p$  or  $\sim p$ . In other words, for every sentence that describes a future state of affairs as obtaining,  $S$  includes either the sentence itself or another sentence that describes that state of affairs as not obtaining.<sup>7</sup>

Now let us assume that bivalence holds. Given Definition 8.1, actuality can be defined in terms of truth:

**Definition 8.2** An ersatz future is actual if and only if it contains only true sentences.

If bivalence holds, the set of sentences about the future can be divided into two mutually exclusive and jointly exhaustive subsets, the true ones and the false ones. The set of the true ones is an actual ersatz future. As a matter of fact it is the only actual ersatz future, for if  $S$  and  $S'$  are both actual, it turns out that, for every  $p$ ,  $S$  includes  $p$  if and only if  $S'$  includes  $p$ , which means that  $S = S'$ .

The fact that there is a unique actual ersatz future suggests that, even if it is granted that the future does not exist, it may still be claimed that time is linear in some sense. Figure 8.3 illustrates this sense in the case of the growing block theory. The dashed lines indicate the actual ersatz future. They show that there is some sort of continuity between past, present, and future, although there is no continuity at the ontological level.

The same sort of linearity holds in the case of presentism, on the assumption that there is a unique actual ersatz past defined in the way considered. In Fig. 8.4, the dashed lines on the right indicate the actual ersatz future, while those on the left indicate the actual ersatz past.

It is easy to see that the Ockhamist definitions of truth and falsity hold in the framework just sketched. Let  $p$  be a sentence about the future. Then  $p$  is true if and only if it is true in the actual ersatz future, and  $p$  is false if and only if it is false in the actual ersatz future. So it turns out that future contingents are true or false.

Two final remarks. The first is that the ersatz story can hardly provide an explanation or a justification of Ockhamism. Ockhamism defines truth *simpliciter* in terms of truth in the actual future. Since in the ersatz story the actual future is nothing

<sup>7</sup> This is one way to define an ersatz future, but there are other ways. An alternative definition could be given in terms of a set of propositions, or in terms of recombination of existing entities. Nothing essential will depend on this choice.

but the set of true sentences about the future, it turns out that truth in the actual future is defined in terms of truth *simpliciter*. So there is no explanatory or justificatory gain. However, note that our aim here is not that of offering an explanation or a justification of Ockhamism. The limited purpose of the reasoning just outlined is to show that Ockhamism is consistent with presentism and with the growing block theory, and for this purpose it suffices to show that the Ockhamist definitions of truth and falsity can be phrased in the way suggested.

The second remark is that, independently of Ockhamism, the theoretical costs of endorsing the ersatz story might be too high for the advocates of presentism or the growing block theory. “Ostrich” approaches along the lines suggested by Correia and Rosenkranz have been widely debated in the last few years, mainly in connection with the so-called grounding problem for presentism, and there is no general agreement on their tenability. For example, Torrenco questions such proposals, arguing that they posit an unreasonably high amount of brute facts, among other things. But again, it is not among the purposes of this paper to assess the pros and cons of each of the options considered.<sup>8</sup>

### 8.3 The Shrinking Block Theory and Eternalism

Since Ockhamism is consistent with presentism and the growing block theory, which entail that the future does not exist, *a fortiori* it is consistent with the shrinking block theory and eternalism, which entail that the future does exist. The shrinking block theory is the view according to which present and future entities exist but past entities do not exist. In Fig. 8.5, the slice of salami that represents the present is attached to the portion of salami that follows it, the future. Eternalism is the view according to which past, present, and future entities exist. In Fig. 8.6 the slice of salami that represents the present is part of a whole salami, a *history*, which may be conceived as a linearly ordered sequence of moments.<sup>9</sup>

Ockhamism is consistent with the shrinking block theory and with eternalism because both views imply that there is a unique actual future, so they both accord

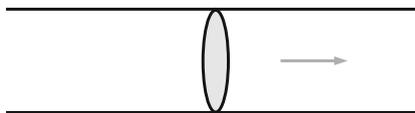
**Fig. 8.5** The shrinking block



<sup>8</sup> Torrenco (2014).

<sup>9</sup> While presentism, the growing block theory, and the shrinking block theory are essentially “dynamic”, in that they imply that the passage of time is metaphysically real, eternalism may be understood either dynamically, assuming that the present really moves along the line of time, or “statically”, assuming that the experience of the passage of time is merely illusory. However, the difference between these two interpretations do not matter for our purposes.

Fig. 8.6 Eternalism



with the idea that future contingents are true or false in virtue of the actual future. In Figs. 8.5 and 8.6, the portion of salami that follows the present may be conceived as the unique actual future. Therefore, it may be claimed that the truth or falsity of sentences about the future depends on what happens in that portion.

Note that the shrinking block theory leaves room for the existence of a unique actual ersatz past. So it is somehow analogous to the growing block theory: there is some sort of continuity between past, present, and future, although there is no continuity at the ontological level. Moreover, both the shrinking block theory and eternalism trivially include a unique actual ersatz future, in addition to the real actual future.

## 8.4 Branching and Divergence

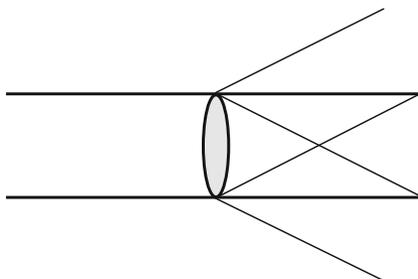
So far it has been argued that the claim that future contingents are true or false is compatible with each of the four views outlined. However, this claim does not exhaust Ockhamism. The other claim to be considered is that future contingents are neither determinately true nor determinately false. Since determinate truth and determinate falsity depend on what happens in all possible futures, something has to be said about the possible futures that are not actual.

Possible futures may be conceived in different ways. In the case of presentism and the growing block theory, a natural way to go is to identify possible futures with ersatz futures, in accordance with Definition 8.1. As we have seen, Figs. 8.3 and 8.4 show the unique actual ersatz future. What they do not show, however, is that the actual ersatz future is not the only ersatz future. Suppose that (1) is true as uttered today. Then (1) is part of the actual ersatz future. However, there are ersatz futures that do not include (1) but its negation. This fact can be described in terms of *truth in an ersatz future*, defined as follows:

**Definition 8.3** A sentence about the future is true in an ersatz future if and only if it belongs to that future.

Although (1) is true in the actual ersatz future, there are ersatz futures in which it is false. Note that truth in an ersatz future is not the same thing as truth *simpliciter*. Although truth *simpliciter* entails truth in the actual ersatz future, truth in an ersatz future does not entail truth *simpliciter*.

In the case of the shrinking block theory and eternalism, possible futures may be conceived as real entities that exist in the same sense in which the actual future exists, although it is not necessary to do so. The relation between the actual future

**Fig. 8.7** The thin red line

and the other possible futures may be understood either in terms of *branching* or in terms of *divergence*. Here we will restrict consideration to eternalism in order to spell out these two options.

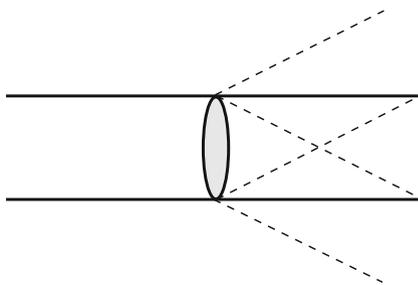
As we have seen, the view that is mostly associated with Ockhamism is the thin red line. According to this view, time branches into a plurality of possible futures. Each of these futures, together with the past and the present, forms a history. One of the possible futures is the actual future, and the history that includes it is the actual history. Figure 8.7 illustrates the thin red line. As in the previous figures, the slice is the present, the moment in which we are now, and the portion of salami behind us is the past. In front of us there are three portions of salami. The portion in the middle is the actual future. This future exists exactly in the same way in which the past and the present exist.

What about the other possible futures? Do they exist in the same way? This is less clear. According to the received version of the thin red line, the answer is affirmative: the only difference between the actual future and the other possible futures is that the actual future is actual. But the received version of the thin red line should not be taken as gospel, given that it has been framed by the worst enemies of Ockhamism, namely, *branching purists*. Branching purists endorse a realist conception of branching according to which there is a plurality of overlapping worlds that are equal in all respects, so they tend to define the thin red line as an unwelcome variant of that conception.<sup>10</sup>

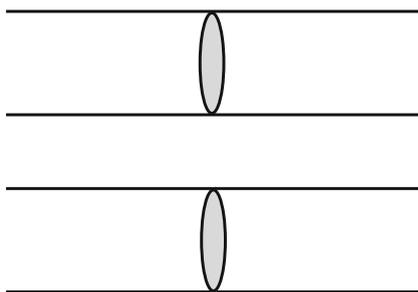
An alternative way to phrase the thin red line is to treat non-actual futures as less real than the actual future, as in Fig. 8.8. Non-actual futures can be conceived as ersatz futures rather than as concrete entities that exist in the same way as the actual future. Of course, in this case there is no real branching, assuming that ersatz branching does not count as “real”, and linearity holds at the ontological level. But this is not necessarily a problem. Whether it is a problem depends on how important is real branching, and it is not obvious that the Ockhamist should agree with branching purists on the importance of branching.

<sup>10</sup>This is the version that we find in Belnap and Green (1994), Perloff et al. (2001), and in MacFarlane (2003).

**Fig. 8.8** The thin red line with ersatz branching



**Fig. 8.9** Divergence

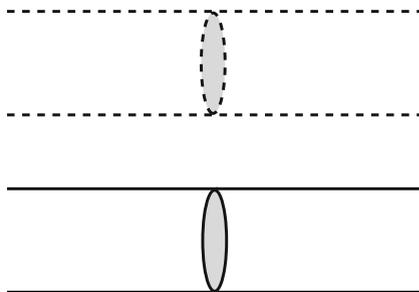


Independently of how non-actual futures are understood, determinate truth and determinate falsity can be defined in accordance with Ockhamism. Let  $p$  be a sentence about the future. Then  $p$  is determinately true if and only if it is true in all possible futures, and  $p$  is determinately false if and only if it is false in all possible futures. So it turns out that future contingents are neither determinately true nor determinately false.

Now let us consider divergence. According to this view, we belong to a single history, the actual history, although there are other histories that are qualitatively identical up to now but have a different future. The key difference between divergence and the thin red line—assuming the received version of the latter—concerns the possibility of overlap. To endorse the thin red line is to think that two histories can overlap, that is, that they can have some part in common. To endorse divergence, instead, is to conceive histories as entirely disconnected totalities.

Figure 8.9 illustrates divergence. Imagine that the salami below is the actual history, and that the left portion of the salami above—the portion that precedes the slice—is qualitatively identical to the left portion of the salami below, but that the right portion of the salami above—the portion that follows the slice—differs from the right portion of the salami below. The two salami are divergent histories. As in the case of the thin red line, time is linear in the sense that the actual history, just as any history, is a linearly ordered set of moments.

Divergence has been spelled out and defended by Lewis within his conception of possible worlds. According to that conception, possible worlds are as real as the actual world, and actuality is indexical, that is, the actual world is nothing but our world. Therefore, to say that the salami below is the actual history is to say

**Fig. 8.10** Ersatz divergence

that we are in that salami. In the other salami there are other individuals who are counterparts of us. Just as we have a future, the right portion of the salami below, our counterparts have their own future, the right portion of the salami above.<sup>11</sup>

It is important to note, however, that in order to endorse divergence it is not necessary to buy the whole of Lewis's conception. Nothing prevents an Ockhamist from thinking that actuality is not indexical and that non-actual histories are less real than the actual history. In Fig. 8.10, the salami above is represented as an ersatz history. As in the case of the thin red line, the ersatz version of divergence entails linearity at the ontological level. As a matter of fact, it is not even clear whether there is any substantive difference between ersatz divergence and ersatz branching.<sup>12</sup>

Independently of how non-actual histories are understood, determinate truth and determinate falsity can be defined in accordance with Ockhamism. If one assumes divergence, one can say that a sentence is determinately true if and only if it is true in all possible futures, and determinately false if and only if it is false in all possible futures. So it turns out that future contingents are neither determinately true nor determinately false.

Let us close this first part of the paper with two general remarks. One is about the irrelevance of ontology. What has been said so far suggests that the tenability of Ockhamism does not essentially depend on the question whether the future exists, at least if 'exists' is read in some substantive sense which does not apply to ersatz entities. On the one hand, as the case of presentism and the growing block theory shows, the existence of the future is not necessary for Ockhamism. On the other hand, even if a unique actual future exists, it is not in virtue of its mere existence that Ockhamism holds, because other possible futures can exist as well. What Ockhamism requires is that the future is *determinate*, in the sense that every question about the future that one may ask has a definite answer. Existence and determinateness are not the same thing.<sup>13</sup>

<sup>11</sup> Lewis (1986, p. 206).

<sup>12</sup> At least as far as the future is concerned. In the case of the past, it might be argued that ersatz divergence, unlike ersatz branching, implies that no individual can inhabit two distinct past portions of histories.

<sup>13</sup> This is essentially the distinction drawn in Torre (2011, pp. 361–363).

The other remark concerns ersatz futures. As is well known, ersatzism is widely discussed in modal metaphysics, and some philosophers regard it as unsatisfactory. The main problem that has been raised in connection with ersatzism is that its explanatory power is constrained by the expressive resources of the language in terms of which it is defined. This gives rise, among other things, to obvious issues of cardinality, because there seem to be more possible states of affairs than those describable in any language. However, it is important to understand that the explanatory limits of ersatzism do not affect its suitability for our purpose. Since Ockhamism is a theory about the semantic properties of certain sentences, future contingents, all that is needed from an ersatz future is that it makes true or false those sentences. So no problem can arise if the ersatz future itself is defined in terms of the same language to which those sentence belong.

### 8.5 Three Ways to Understand the Openness of the Future

The claim that the future is open occurs quite often in the debate on future contingents. Many philosophers tend to think that, at least on some plausible interpretation, this claim is an intuitive hypothesis that yields substantive consequences. Here ‘intuitive’ means ‘pretheoretically plausible’: an intuitive claim about the future is a claim that seems true to those who are not familiar with the subtleties of the disquisitions on future contingents and do not endorse a definite view of future contingents. Instead, ‘yields substantive consequences’ means ‘makes a difference to the issue of future contingents’: a claim about the future has substantive consequences if it supports a definite view or a definite set of views of future contingents, while it rules out other views. The remaining part of this paper is intended to show that there is no such interpretation: either the claim that the future is open yields no substantive consequence, or it is not intuitive. In both cases, it cannot be used against Ockhamism.

There are at least three plausible ways to understand the openness of the future. The first is to define it in terms of existence of alternative possibilities: to say that the future is open is to say that, for some sentence about the future ‘ $p$ ’, it is possible that  $p$  and it is possible that not- $p$ . Here ‘possible’ is to be read as ‘metaphysically possible’, so the claim does not state the obvious fact that there are alternative epistemic possibilities. This interpretation is simple and straightforward because it equates the claim that the future is open with the negation of fatalism, the doctrine that no future event is contingent. Note also that, on the assumption that ‘ $p$ ’ is neither determinately true nor determinately false when it is possible both that  $p$  and that not- $p$ , this amounts to saying that some sentence about the future are neither determinately true nor determinately false.

If the openness of the future is understood in terms of existence of alternative possibilities, then it is consistent with each of the views outlined in Sects. 8.2–8.4. If one endorses presentism or the growing block theory, one can say that, although there is presently nothing ahead of us, it is possible that what will exist is such that

$p$  and it is possible that what will exist is such that not- $p$ . If one grants the actual future and endorses the thin red line, one can say that there are possible futures in which  $p$  and possible futures in which not- $p$ . The same goes for divergence, even though in that case the possible futures have distinct pasts and distinct presents. More generally, this interpretation of the claim that the future is open is consistent with almost any metaphysical views in the debate on future contingents, given that almost everybody rejects fatalism.

The second way to understand the openness of the future is to define it in terms of *indetermination*, understood as absence of determination: to say that the future is open is to say that nothing determines the future. Determination may be defined as a relation between states: given a state  $S$  that obtains at time  $t_0$  and given a state  $S'$  that obtains at time  $t_1$ ,  $S$  determines  $S'$  if and only if the obtaining of  $S$  at  $t_0$ , together with the laws of nature, entails that  $S'$  obtains at  $t_1$ . Determinism is the thesis that, for every time, the state that obtains at that time is determined by the states that obtain at previous times. Indeterminism is the negation of that claim.

None of the views outlined in Sects. 8.2–8.4 entails determinism. Consider presentism and the growing block theory. Suppose that  $t_0$  is the present time and that  $S$  is the state of the universe at  $t_0$ . Then, given a time  $t_1$  later than  $t_0$ , nothing exists in  $t_1$ , even though when we will be in  $t_1$ , another state  $S'$  will obtain. Each of the two views says nothing about the relation between  $S$  and  $S'$ , so it is consistent with the hypothesis that  $S$  does not determine  $S'$ .

Now consider the thin red line. In this case it is important to bear in mind the distinction between moments, the minimal constituents of histories, and times, understood as absolute temporal units. For example, if there are three possible futures, as in Fig. 8.7, each of which includes a different tomorrow, the three tomorrows are simultaneous moments, that is, moments that occur at the same time. The thin red line is consistent with indeterminism precisely because different moments—moments that belong to histories equally compatible with the laws of nature—can occur at the same time. Suppose that  $m_0$ , the present moment, occurs at  $t_0$ , and that  $m_1$  and  $m_2$  are future moments that occur at  $t_1$ . If  $S$  obtains at  $m_0$ , while  $S'$  and  $S''$  obtain respectively at  $m_1$  and  $m_2$ , then  $S$  determines neither  $S'$  or  $S''$ , for it is compatible both with  $S'$  and with  $S''$ .

Finally, consider divergence. In this case, again, indeterminism is tenable because different moments—moments that belong to histories equally compatible with the laws of nature—can occur at the same time. The only difference is that here there is no unique present moment, as in Fig. 8.9. Suppose that  $m_0$  and  $m_1$  are qualitatively identical moments that belong to  $t_0$ , and that  $m_2$  and  $m_3$  are different moments that belong to  $t_1$ . If  $S$  obtains at  $m_0$  and  $m_1$ , while  $S'$  and  $S''$  obtain respectively at  $m_2$  and  $m_3$ , then  $S$  determines neither  $S'$  or  $S''$ , for it is compatible both with  $S'$  and with  $S''$ .

More generally, this interpretation of the claim that the future is open is consistent with almost any metaphysical view in the debate on future contingents, because most theorists of future contingents reject determinism. Determinism entails fatal-

ism: if everything is determined, then no future event is contingent. Therefore, if fatalism is false, the same goes for determinism.<sup>14</sup>

The third way to understand the openness of the future is to define it in terms of causal power: to say that the future is open is to say that we can *affect* the future, in that our present actions have future effects. For example, if we set the alarm of our phone at 7 am, the sound that the phone will emit tomorrow morning is an effect of the movements that we perform tonight. Clearly, the past does not depend on us in this sense, because our present actions do not have past effects. No matter whether we set the alarm or not, what happened yesterday remains the same.<sup>15</sup>

The idea that we can affect the future is clearly consistent with the views outlined in Sects. 8.2–8.4. In each of the three cases, it makes perfect sense to say that an event which occurs at a given time causes another event that occurs at a later time. More generally, this interpretation of the claim that the future is open is consistent with most metaphysical views, for theorists of future contingents mostly take causal power for granted.

To summarize, there are three plausible interpretations of the claim that the future is open: the first is that, for some sentence about the future ' $p$ ', it is possible that  $p$  and it is possible that not- $p$ , the second is that there is indetermination, the third is that we can affect the future. Each of these interpretations is consistent with the views outlined in Sects. 8.2–8.4. This means that the claim that the future is open, on the three interpretations considered, yields no substantive consequence, as it does not divide the space of the possible solutions to the problem of future contingents.

## 8.6 Other Definitions

The three interpretations considered are not the only admissible interpretations. The metaphor of openness may be construed in many ways, so it is legitimate to expect that there are other interpretations on which the claim that the future is open does yield substantive consequences. The problem with such interpretations, however, is that they are definitely less plausible than those considered.

Here is an example. Some philosophers equate the openness of the future with the failure of bivalence: to say that the future is open is to say that future contingents are neither true nor false. On this interpretation, the claim that the future is open yields substantive consequences. However, it is a controversial question whether the future is open in the sense defined. Merely stipulating that openness amounts

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<sup>14</sup> Note that, as explained in Iacona (2013, p. 43), and Correia and Rosenkranz (2018, pp. 116–121), indetermination must not be confused with indeterminateness, understood as absence of a determinate future in the sense considered in Sect. 8.4. There can be indetermination without indeterminateness, because the future can be determinate without being determined.

<sup>15</sup> This asymmetry can be described in terms of counterfactual dependence, as suggested in Lewis (1979).

to non-bivalence does not provide any reason to think that the stipulation captures some pretheoretical intuition.<sup>16</sup>

Here is another example. Some philosophers equate the openness of the future with branching: to say that the future is open is to say that time branches into a plurality of possible futures that are equal in all respects. On this interpretation, again, the claim that the future is open yields substantive consequences. However, it is a controversial question whether the future is open in the sense defined.<sup>17</sup>

The latter question emerges clearly in the dialectic between branching and divergence. According to branching purists, divergence does not preserve the openness of the future. Suppose that Leo wonders whether he can become an established jazz pianist. As far as divergence is concerned, the answer is affirmative if Leo will sell vacuum cleaners for the rest of his life but there is a history in which a quite similar individual, Leo\*, will become an established jazz pianist. However—branching purists may contend—what Leo wonders—is whether *he*, Leo, can become an established jazz pianist, not whether another person has that opportunity. How can Leo's future be open if it only includes the sale of vacuum cleaners?<sup>18</sup>

To this objection it might be replied that divergence does not deny that one and the same individual has alternative possibilities. Let it be granted that 'Leo can become an established jazz pianist' is true. Insofar as divergence explains the truth of this sentence in terms of the existence of a history in which Leo\* becomes an established jazz pianist, the individual to whom is correct to attribute the modal property of possibly becoming an established jazz pianist is Leo, not Leo\*. Certainly, this explanation cannot be taken as a description of what Leo has in mind when he wonders whether he can become an established jazz pianist. But the same hold for any alternative explanation of the same fact. Just as Leo does not think about Leo\*, he does not think that he inhabits two histories that share a common segment and branch towards the future.<sup>19</sup>

It is difficult to judge who is right. The objection against divergence stems from a line of thought that goes back to Kripke and is antithetical to the theory of counterparts defended by Lewis. According to this line of thought, the truth or falsity of a sentence that attributes a modal property to an individual depends on what happens to the same individual in possible worlds other than the actual world.

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<sup>16</sup> Markosian (1995, p. 96), defines openness along these lines. This definition is questioned in Barnes and Cameron (2009, p. 293), Torre (2011), and Hattiangadi and Besson (2014, pp. 254–255).

<sup>17</sup> A definition along these lines is adopted in MacFarlane (2003) and in Spolaore and Gallina (2020).

<sup>18</sup> MacFarlane (2003, p. 326), MacFarlane (2008, pp. 81–82), Diekmeyer (2007, p. 443), express misgivings of this kind.

<sup>19</sup> As Torre (2011) observes, pp. 367–368, few philosophers would agree that something is a genuine possibility for a person only if it belongs to a possible future in which the person literally exists.

The question of which of these two positions is preferable cannot be settled simply by appealing to intuitions.<sup>20</sup>

The point about the two examples considered may be generalized. For any interpretation of the claim that the future is open which equates the openness of the future with a specific logical or metaphysical option in the debate on future contingents, it is trivially correct to say that the claim that the future is open yields significant consequences, given that it rules out other logical or metaphysical options. However, for any such interpretation, it is a controversial question whether the future is open in the sense defined, so the claim that the future is open is not intuitive.

All things considered, there seems to be no interesting reading of the claim that the future is open. On the one hand, there are interpretations, such as those outlined in Sect. 8.5, on which the claim is intuitive but does not yield substantive consequences. On the other hand, there are interpretations, such as those outlined in this section, on which the claim yields significant consequences but is not intuitive. So it seems that there is no coherent sense in which the claim enjoys both properties. This suggests that, as far as the discussion of Ockhamism is concerned, the metaphor of openness is nothing but an empty rhetorical device.

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# Chapter 9

## The Metaphysics of Passage in Dynamical Reduction Models of Quantum Mechanics



Cristian Mariani and Giuliano Torrenço

**Abstract** The Dynamical Reduction Models (DRM) are among the main solutions to the measurement problem in quantum mechanics. DRM proposes to modify the Schrödinger's evolution of standard quantum mechanics by adding a stochastic and non-linear element to the fundamental dynamical equation. By doing so, one can describe the *collapse* of the wave function as a real physical mechanism, without making reference to observers or to experimental apparatus. The collapses happen randomly and spontaneously with a certain probability rate per unit of time, a rate that is specified by the theory. The world of DRM is fundamentally indeterministic. Given this, many philosophers and physicists in the past decades have argued that in DRM the passage of time is not illusory, but is an objective feature of reality. In his recent book, Callender (*What Makes Time Special?*, Oxford University Press, 2017) has extensively argued against the inference from DRM to the passage of time. Very roughly, he argues that indeterminism is not a guide to passage of time. Although we agree with this, in this paper we shall suggest that there is a genuine connection to further investigate between DRM and the metaphysics of passage, one that can be captured in terms of a view of the openness of the future which is Ockhamist in spirit. We will argue that DRM might entail the existence of indeterminate state of affairs, and that these might provide a ground for genuine passage. To do so, we will focus on the relativistic versions of DRM, in particular on Bedingham (Found Phys 41(4): 686–704, 2011), which we take to be the natural place to look at in the context of the metaphysics of time.

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## 9.1 Introduction

We are often told that modern physics suggests a picture of the world where there ultimately is no passage of time. In order for passage to be a genuine feature of the world, arguably it has to be independent from the frame of reference we choose to describe the unfolding of events. The theory of relativity, however, implies that it is impossible to select a preferred frame of reference. This, in turn, makes the notion of absolute simultaneity between any pair of events, as it is needed to describe genuine passage, straightforwardly inconsistent. Although it surely is the one theory that describes directly the nature of spacetime, relativity is not the only successful physical theory of the last century. Quantum mechanics (QM) has been discussed at length by philosophers of science and metaphysicians, and yet surprisingly little has been said about the metaphysical consequences of this theory with respect to the passage of time and the openness of the future. Among the exceptions is Callender's recent book *What makes time special?* (2017), where an entire chapter is dedicated to addressing whether the picture of time that emerges from relativity may be disconfirmed by QM. Callender's conclusion is that it is not. He considers two features of QM, namely (i) non-locality, and (ii) the collapse of the wave function, and argues that none of them can be successfully taken as a ground for what he calls *quantum becoming*—that is, genuine passage of time based on quantum processes. While we agree with Callender's reasoning about (i), we believe that his arguments as to why (ii) cannot be used to ground genuine passage of time can be resisted. This paper is aimed at showing how this can be done.

The *collapse of the wave function* only makes sense within a particular family of interpretations of QM. These can usefully be classified by referring to Maudlin's (1995) three propositions: (A) the wave function completely specifies all physical properties; (B) the wave function always evolves with a linear dynamics; and (C) measurements always have a single, determinate outcome. If we maintain all the three above, the measurement problem emerges. Thus, interpretations of QM deny at least one among (A), (B), and (C). For instance, Bohmian QM denies (A), while Many Worlds denies (C). The interpretations of QM with collapse are those that deny (B), namely Copenhagen and Dynamical Reduction Models (DRM). Since it is a matter of dispute whether the former can be coherently considered a viable solution to the measurement problem, here we will focus on DRM only (as Callender himself does).

Standard DRM, such as the theory proposed by Ghirardi et al. (GRW; 1986), are *not* relativistically invariant. This means that they assume a classical, pre-Einsteinian notion of time with an absolute simultaneity. However, there are recent relativistic extensions of these theories, which combine the openness of the future that comes with nomological indeterminism with the eternalist ontology that is intrinsic to relativistic frameworks. Traditionally, the so-called Ockhamist (see Prior 1967) view of the openness of the future have been seen as the best understanding of the combination of eternalism with genuine openness. We will follow suit, and argue

that in order to incorporate a quantum based account of the flow of time, we need to understand the Ockhamist view as encompassing a form of present indeterminacy.

Note that quantum becoming is not *absolute becoming*, that is a form of generation or coming into being. It is not mandatory to understand the collapse of the wave function in DRM models as a creation *ex nihilo* of something. However, even though the transition underlying quantum becoming is not a transition from non-being to being, it is more substantive than a transition from a state to another. Quantum becoming is supposed to be something more than mere qualitative variation through time, and it is supposed to be more than a fundamental asymmetry along the time-like direction of spacetime. The main aim of this paper is to investigate how the idea of objective collapse can be exploited to contribute to this understanding of temporal flow.

We will proceed as follows. In Sect. 9.2 we introduce the basics of DRM, along with their relativistic extensions. In Sect. 9.3 we focus on the connection between DRM and the metaphysics of passage. We will start by discussing Callender's (2017) objections, along with the motivations for resisting them. In Sect. 9.4 we present our own proposal. First, we show that the ontology of relativistic DRM has to allow for indeterminate state of affairs, which we will account for in terms of a theory of metaphysical indeterminacy following Wilson (2013). Then, we show how this ontology is apt to ground a metaphysically loaded distinction between a fixed past and an open future, thus supporting the claim that DRM vindicates a genuine becoming. Section 9.5 provides some general remarks concerning how our model applies to the relativistic extension of DRM.

## 9.2 Dynamical Reduction Models of Quantum Mechanics

In this section we start by introducing in Sect. 9.2.1 the conceptual framework of the most developed and discussed among the DRMs, namely the theory from Ghirardi Rimini and Weber (GRW for short, 1986). In Sect. 9.2.2 we discuss the crucial conceptual features of GRW, while in Sect. 9.2.3 we introduce the relativistic extensions of this theory.

### 9.2.1 The GRW Framework

In order to overcome the measurement problem, the key hypothesis of GRW is similar to that made by von Neumann with the *collapse postulate*; the linearity of the fundamental equation of quantum mechanics, the Schrödinger's dynamical evolution, has to break at some point in order to explain the definiteness of experimental outcomes. The analogies between von Neumann's and GRW's solutions stop here. In von Neumann, the *collapse postulate* is left unspecified, and many questions

are unanswered: how does the linearity breaks? when and where exactly does this happen? GRW aims to give a precise answer to each of these questions.

In GRW it is assumed that each elementary particle is subject to a random and spontaneous localization, called *collapse*, which happens on the position basis. The choice of position as the preferred basis is justified by the fact that, to use Ghirardi's words, "the most embarrassing superpositions, at the macroscopic level, are those involving different spatial locations of macroscopic objects" (Ghirardi, 2002). The model then specifies what amendments have to be made to the Schrödinger's equation to explain the collapse process. Suppose we start with a physical system with a wave function describing a superposition of being located in two distinct regions of space  $a$  and  $b$  with equal probability. In GRW, when the collapse randomly occurs, the wave function gets multiplied by a Gaussian (Bell curve) that localizes the system almost entirely either in  $a$  or  $b$ . In order to explain when and where this happens, GRW introduces two new constants of nature that specifies the nature of collapse for *individual microscopic constituents*,  $\alpha$  for its accuracy in space, and  $\lambda$  for its frequency in time. In the original model, these are given as follows:<sup>1</sup>

$$\alpha = 10^{-5} \text{ cm} \tag{9.1}$$

$$\lambda = 10^{-16} \text{ sec}^{-1} \tag{9.2}$$

The frequency specified by  $\lambda$  is extremely low: roughly, for an electron a collapse happens once every three hundred thousand years. This explain why microscopic systems (composed of few individual microscopic constituents) show superposition effects, such as the interference pattern in a double slit experiment. As a matter of fact, when a very small number of particles are considered, the rate of collapse is so low to make it very unlikely. Imagine a world with nothing but a lonely electron. In such a world, the electron would be in superposition for hundred of thousands of years before a collapse happens.

What explains why, contrariwise, for macroscopic systems the collapse is almost certain to occur (and therefore why we never experience superposition at a macroscopic scale), is the so-called *trigger mechanism*. If we consider a system with a large number of particles, the rate of collapse is big enough to ensure that for at least one of the component of the system a collapse will occur. And since a system of many constituents will be highly entangled, a collapse of one component will *trigger* the collapse of every other components. This, in turn, ensures the absence of macroscopic superpositions thus solving the measurement problem.

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<sup>1</sup> Notice that different values for  $\alpha$  and  $\lambda$  have been proposed over the years. What is important to notice is that different choices might entail discrepancies with empirical results. For instance, Adler (2003) proposed to increase the value of  $\alpha$  by around  $10^9$ , and this hypothesis has been empirically falsified, see Bassi et al. (2010).

Contrary to von Neumann's *collapse postulate*, GRW does not refer to any mysterious divide between micro and macro. The dynamics of the model treats every system equally, thus providing a unified dynamics for every physical systems. The only difference between micro and macro, for GRW, lies in the number of constituents. A macroscopic object, such as an experimental device, is made of very large number of entangled particles: this is why, when we make a measurement, the interaction between device and target system will cause the collapse of the latter by becoming entangled with it.

### 9.2.2 *The World According to GRW*

We have introduced the general conceptual framework of GRW. We shall now ask how the world is like according to this theory. First, notice that the dynamics of GRW is fundamentally indeterministic. If we start with two identical systems, and apply the very same GRW dynamics to both of them, these can well evolve into distinct states. Thus, according to GRW, God plays dice after all. Embarrassing as this might be to someone, this conceptual consequence is definitely not alien from the general framework of quantum mechanics. In this sense, one could say that GRW is the only realist interpretation of QM that takes this lesson seriously. We shall see in Sect. 9.3 that the fundamental indeterminism of GRW is what has been taken by many as the core motivation for believing in genuine passage of time. Here we focus on a different, very distinctive feature of GRW that contributes to ground genuine passage. This feature pertains not the dynamics of the theory, but rather its *ontology*.

So far, we have been discussing what makes GRW special mainly by referring to the dynamical evolution of the theory. Let us ask now, whether this interpretation of quantum mechanics tells us something new about the world independently of its indeterministic dynamics. Right after the model was proposed by Ghirardi Rimini and Weber in 1986, it became clear that a few technical amendments were needed in order to fully develop a satisfactory account of all physical phenomena. Leaving the details aside, two main issues emerged. First, the model was not Lorentz invariant, and it soon became clear that a relativist extension had serious drawbacks. We will come back to this in Sect. 9.2.3. Second, Ghirardi and his collaborators realised that *mass* plays a crucial role within the model, both for technical and conceptual reasons. As for the former, to mention but one, it was noticed that the rate of collapse needs to distinguish between different particles (for electrons, which have a lower mass, the rate is roughly 2000 times lower).<sup>2</sup>

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<sup>2</sup> Other reasons include the treatment of indistinguishable particles (see Pearle 1989, and Ghirardi et al. 1990), and the distinction between the notion of distance in Hilbert space and distance in 3D space (see Ghirardi et al. 1995).

More important for us, are the conceptual reasons for taking mass to play a crucial role in the theory. Among the motivations for developing GRW, perhaps the most important one is to provide a *realist* physical theory of what happens in the physical world. GRW is not about what we experience when we make experiments (like arguably standard QM is), but rather is about what is ultimately out there in the world, in other words, the *ontology*. If we look at the formalism alone, however, it seems that GRW is describing the multidimensional wave function and its evolution through time. While some believe that this is enough and endorse a wave function ontology (Albert 1996; Lewis 2003), some others have attempted to specify the ontology of GRW in the 3D space. Following the insights from Allori et al. (2008), we shall call the fundamental ontology in 3D space the *primitive ontology* posited by a certain theory. In the case of GRW, two main options have emerged in the literature. The first, designed by Ghirardi himself together with Grassi and Benatti (1995), is known as GRW Mass ( $GRW_M$  for short). According to  $GRW_M$ , the ontology of the theory is given by the whole mass of the universe spread across 3D space. As we suggested earlier, the choice of mass in order to give the ontology was in large part independently justified. Another option as an ontology for GRW was proposed by Tumulka (2006), and named GRW Flash ( $GRW_F$  for short). For Tumulka, the events given by each collapse of the wave function, what he calls the flashes, represent what is ultimately out there in the world. The whole set of these collapse give the primitive ontology. Every macroscopic object, such as the Tour Eiffel, is nothing but a galaxy of these point-like events in 3D space. As we will see shortly in Sect. 9.2.3, one of the core motivations behind  $GRW_F$  is to provide a relativistic version of GRW. Before that, however, we introduce a very important distinction in the ontology of  $GRW_M$  and  $GRW_F$ , one that will be important for the rest of this paper.

In  $GRW_F$ , the fundamental ontology is fully specified by events in 3D space. These are fully determinate, in the sense that there is always a fact of the matter about when and where they occurs (as we saw earlier, this is in fact given by the rate of collapse). In  $GRW_M$ , on the other hand, it is not clearly the case the fundamental ontology is fully determinate. In fact, while the mass of macroscopic systems *is* determinate, for microscopic systems such as the lonely electron of the example above, *before* the collapse there is no fact of the matter about its location. To use Bell's words, non interacting electrons in GRW "enjoys the cloudiness of waves" (1987). It thus seems that the fundamental ontology of GRW is made of the whole mass spread across the universe, but also that a part of the mass is not fully determinately located. Ghirardi et al. (1995) notices this important feature of the ontology of  $GRW_M$ , but dismiss the problem by assuming that *for all practical purposes* the indeterminate part of mass is in principle *not accessible*. Their take on this issue has however been disputed (see Clifton & Monton 1999, *inter alia*), since it seems to threaten the realist inspiration behind the whole project of GRW. While we cannot here give a full reconstruction of this debate, it is nonetheless important to stress that in order to preserve a realist attitude towards the theory, a possible option is to allow for microscopic systems to be located in different places. How is this to be explained, from a philosophical perspective?

What we take to be the most promising way, is by exploiting an account of metaphysical indeterminacy. In a recent paper, Calosi and Wilson (2018) suggest that quantum mechanics, in various of its interpretations, entail the *failure of value definiteness*. In short, certain properties cannot always be assigned a definite value in the theory. To give an example, we know that *incompatible observables*, such as position and momentum, cannot be jointly assigned with infinite precision to any microscopic physical system. Calosi and Wilson proposes to interpret the failure of value definiteness as an instance of worldly, metaphysical indeterminacy. In this paper we shall assume that the kind of indeterminacy regarding the mass in  $GRW_M$  can be accounted for by a model like Calosi and Wilson's. As we will argue in Sect. 9.4, this kind of metaphysical indeterminacy affecting  $GRW_M$  is what ultimately might suggest a novel way of grounding genuine passage of time.<sup>3</sup> There is however another worth discussing to set up our arguments, namely the incompatibility between  $GRW_M$  and relativity.

### 9.2.3 The Relativistic Extensions of GRW

GRW is not relativistically invariant in its original form. Moreover, the task of providing a relativistic version of it are made hard by the difficulty of reconciling relativity and quantum non-locality. The reason is quite straightforward, and it has been debated in several forms over the past decades (see Maudlin 1994 for a detailed discussion). Given non-locality, spacelike-separated events seem to influence each other in a way that conflicts with relativity. And while assuming a preferred foliation of space-time would give the prospects of solving the conflict (see e.g. Dürr et al. 2014, in the case of Bohmian mechanics), this would clash with the conventional general understanding of relativity, and therefore it is not usually considered as a welcome consequence. Is a relativistic extension of GRW possible without assuming a preferred foliation? In recent years, two proposals have been put forward, by Tumulka (2006) and Bedingham (2011). The core idea, as we shall now see, is that the *indeterministic* nature of the theory is what plays the prominent role.

Space-time according to pre-relativistic physics posits an absolute notion of simultaneity. This means that, if you take any pair of events  $e$  and  $f$ , the temporal structure of the world is such that there always is a fact of the matter about whether  $e$  precedes  $f$ , or  $f$  precedes  $e$ , or they happen at the same time. And within this setting, the ontology of the world is given by the sequence of configurations of whatever inhabits the world (particles, fields, and so on). Each configuration is simply a maximal set of simultaneous events, which we call a *foliation* of space-time.

On the contrary, in a relativistic setting the space-time does not provide a way to define a unique *foliation*. This is best appreciated by considering events that are

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<sup>3</sup> We take *grounding* to be a relation of metaphysical priority between facts that carries explanatory import.

so-called space-like separated (they lie outside each other light's cone). For these pairs of events, there is no fact of the matter about which one happens earlier and later, nor of course that they happen at the same time.

Not every classical, pre-relativistic physical theory posits absolute simultaneity. In fact, this is precisely why classical electromagnetism was made relativistic relatively easily. Basically every prediction of electromagnetism was recovered *without* in any way assuming absolute simultaneity. Of course, this suggests that this theory never needed this concept to be formulated in the first place.

Quantum mechanics, however, does require a notion of absolute simultaneity to explain certain phenomena, namely Bell's inequalities. If we want our relativistic extension of the theory to recover every prediction, Bell's inequality included, we cannot reject absolute simultaneity so easily. In the case of GRW, as we saw in the previous subsections the configuration of the universe at a certain time is given by the quantum state, and this evolves in such a way that it spontaneously and randomly collapses into definiteness. And crucially, if we take the quantum state of the universe, any of its collapses would require an absolute simultaneity.

A step forward in building a relativistic version of GRW was made by Tumulka (2006). According to him, if we regard the probability of collapses to give us the correct predictions of the theory (which is in fact the case), then the question of how to make GRW relativistic turns out to be, more simply, the issue of whether we are able to recover the predictions about the probability distribution of collapses *without* assuming absolute simultaneity.

Tumulka in his paper does precisely so. First, he assumes that the ontology of the theory is just made by events in 3D space given by the collapse of the wave function, which has calls the *flashes*. To recover the predictions of the theory, is therefore to recover *all* the probability distribution of the flashes. In full relativistic spirit, Tumulka defines what he calls a *seed flash* as an initial condition for each particle onto an arbitrary Cauchy surface.<sup>4</sup> Each *seed flash* possesses its proper time, over which we can define its future and past light cones. In full generality, the relativistic equations for the collapses can then be written disregarding absolute simultaneity, and focusing instead on the space-time foliations of each *seed flash*.

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<sup>4</sup> A referee to this journal worries that the definition of a seed flash in terms of the particles looks metaphysically suspicious. In effect, in Tumulka's proposal microscopic particles, along with macroscopic objects, are not fundamental entities, and are rather constructed out of galaxies of events. We believe that the reviewer is raising an interesting issue here, and to the best of our knowledge very little has been said on this topic in the literature. A plausible response, on behalf of Tumulka, is that the definition of the seed flashes in terms of the particles only reveals that the particles are fundamental in an epistemological sense, in order to formulate and make sense of the theory. This should not entail that they are also metaphysically fundamental. We thank the anonymous reviewer for raising this crucial issue, and we refer to future developments of our work for a further scrutiny.

Indeterminism plays a crucial role in achieving Tumulka's results. As noted by Maudlin (2019), in fact, if we take a pair of separated electrons in the singlet state:

The initial quantum state of the particles is completely symmetric between the two sides, so if the quantum state provides a complete physical description, then the electrons have the same physical characteristics. Nonetheless, the outcome of the experiment breaks this symmetry: On the one side there is an "up" outcome and on the other "down". (214)

The crucial point here, is that in a fundamentally stochastic theory like GRW, the symmetry is broken simply by *chance*; the collapse happens one way, or happens the other, randomly. This also explains why all the probabilistic predictions of the theory can be retained even when it comes to Bell's type of experiments. To compare, consider the same situation in Bohmian mechanics to see why the prospects of making this interpretation relativistic are not as promising. Since Bohmian mechanics postulates the existence of the particles together with a deterministic dynamical evolution of them, to break the symmetry between the two electrons in the singlet state this theory cannot refer to chance. In Bohmian mechanics, contrary to GRW, there has to be something about the particles themselves or about the experimental setting (which again is made by particles) to explain why one outcome occurs instead of the other.

Another, arguably successful extension of GRW to a relativistic setting was made by Bedingham (2011) for the Mass density approach. The crucial idea is the same of Tumulka: to recover the predictions of the theory we need only to define collapses of mass within a sequence of foliations, and starting from the initial conditions so that any subsequent collapse of a certain portion of mass will happen in the future light-cone of it. As noted recently by Maudlin (2019), however, giving its background ontology, the Mass relativistic extension has some interesting consequences.

For example, starting with a "particle" in an equal superposition of traveling to the east and to the west, the matter density will contain equal-density lumps moving in both directions. If a single screen is set up far away in one direction, then the lump traveling that direction will continue until it meets the screen: the matter density grows from half of the particle mass to its full value, and a mark is formed on the screen. The other way corresponds to not finding the particle at the screen, and the matter density is reduced to zero. The key question is what happens to the other lump, the one that has no screen to interact with. Since the matter density at a point is a function of the quantum state along its past light cone, the other lump continues until the measurement event at the distant screen is in its past light-cone. At that point, the matter density on that side either increases to double its value (if the particle is not found at the screen) or is reduced to zero (if the particle is found). One is tempted to say that the quantum state "collapses along the future light-cone of the measurement event at the screen", although the disposition of the matter density in space-time is not so much due to how the quantum state behaves as to how the matter density at a point is calculated from the quantum state. (213)

It is clear from the tone of this passage that Maudlin does not see this observation as an objection to the model. Rather, he simply wants to highlight what looks like a somewhat weird consequence of it. The weirdness according to Maudlin is roughly that, in effect, in relativistic  $GRW_M$ , sometimes (in EPR scenarios) the collapse of the quantum state produces the collapse in the future light-cone of a certain portion of Mass, although usually the Mass density is calculated from the quantum state.

However, the same quantum state that produces the collapse is, after all, in turn given by the mass calculated from the quantum state of the lump where the screen is. So the weirdness is only apparent: the collapse never happens because of “how the quantum state behaves”, to use Maudlin’s expression. It is always the mass density that allows us to calculate the quantum state.

A difference to be noted between Tumulka and Bedingham proposals is that, given the background ontology they work with (flashes and mass density, respectively), only the latter seem to allow for some *indeterminacy* in the ontology. If all there is in the world are the flashes, strictly speaking there is no indeterminacy in the world. On the other hand, as we suggested above, it is possible to regard the *non-accessible* part of mass in the mass density approach as indeterminate. The same consideration applies for the relativistic extension of the theory. If we consider again Maudlin’s example, one is tempted to conclude that the mass of the two equal-density lumps *before* one hits the screen is, in fact, indeterminate.

### 9.3 Callender’s Objections to Quantum Becoming

In this section we shall review the objections from Callender (2017) to the idea that DRMs might suggest genuine passage of time. In Sect. 9.3.1 we focus on the connection between indeterministic evolution and passage, and ultimately agree with Callender that such a link is spurious. In Sect. 9.3.2 we shall then turn our attention to the idea that genuine passage might be found in the ontological distinction between superpositions and eigenstates. Callender has given reasons to reject this idea as well, but we will show that his arguments are unmotivated.

#### 9.3.1 *Indeterminism and Openness in DRM*

Recall from the introduction that theories like GRW aim to overcome the measurement problem by rejecting Maudlin’s proposition (B), namely the claim that the dynamical evolution is always linear. The core argument we often meet in the literature for quantum becoming that is based on GRW has the rejection of (B) as one of its premises.

1. The wave function sometimes evolves with a non-linear and stochastic dynamics;
2. If the evolution of the wave function is non-linear and stochastic, then there is genuine passage of time;
3. There is genuine passage of time.

We find this argument in many physicists and philosophers. For instance, here is Lucas (1999):

There is a worldwide tide of actualization—collapse into eigenness—constituting a preferred foliation by hyperplanes (not necessarily flat) of co-presentness sweeping through the universe—a tide which determines an absolute present [...] Quantum mechanics [...] not only insists on the arrow being kept in time, but distinguishes a present as the boundary between an alterable future and an unalterable past (1999, 10).

And here is Gisin:

Admittedly, time is a complex notion, or series of notions with many facets, time may be relative, difficult to grasp, etc. But time exists. Moreover, time passes. With spontaneous collapse theories, time exists and passes, the world out there exists and undergoes a stochastic evolution (Gisin, manuscript, p. 7).

The argument is valid, and premise (1) is an assumption of DRM. Premise (2) is thus what we shall focus on. How can the particular dynamical evolution of DRM entail genuine passage?

Callender (2017) considers a few options. First, one could argue that if the dynamical evolution is stochastic, then the world is fundamentally *indeterministic*. This is indeed true for DRM. However, there exist plenty of philosophical arguments to show that fundamental indeterminism is neither necessary nor sufficient for passage of time. For instance, here is Pooley:

Suppose that the laws of nature are indeterministic in the sense that specification of the world's history up to a certain time, together with those laws, does not fix all future facts. To say that the future is open might only be to say that the future is not nomologically determined in this sense. But that the past and present, together with the laws, do not fix all future facts does not entail that there are no such facts. In tenseless terms, there can be a unique actual continuation of the world to the future of some time  $t$ , but this continuation need not be the only one compatible with the actual laws and the way the world is up to and including  $t$ . (2013: 322)

The mere fact that indeterministic laws of nature—together with all the facts about what is present and what is past—do not determine a unique future, does not mean that there is no such future. Hence indeterminism *per se* does not entail absolute becoming, or any form of becoming than a transition from a determinate state to another determinate state, even though many aspect of the transition itself may be undetermined by the laws. Whether or not the laws entail a unique future, from a metaphysical perspective there still remains the problem of the different ontological status of the future with respect to the present and the past.<sup>5</sup> Furthermore, as argued by Lewis (1986), and Markosian (1995), indeterministic laws would not just make the future open, but would make the past open as well, thus in fact leading to a clash with the intuition that there is an asymmetry between

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<sup>5</sup> See Correia and Rosenkranz (2019: 1.4.1) for different characterisations of the openness of the future in terms of existence and location.

past and future when it comes to passage of time.<sup>6</sup> For the above reasons, we believe Callender is correct when he claims that DRM cannot ground the genuine passage of time in virtue of the indeterministic nature of the fundamental law.

### 9.3.2 *Passage and the Ontology of Superpositions*

Nonetheless, Callender himself alleges another reason for thinking that collapse theories of quantum mechanics might support genuine becoming. The core idea is to argue that the mathematical distinction between *eigenstates* and *superposition states* is a ground for the distinction between an *open future* and *fixed past*. Roughly, through such a mapping what you would get is that whatever system is in a superposition state will somehow indicate facts about openness. And similarly, everything that is represented by the theory as being in an eigenstate is meant to reproduce fixed facts. And once such a metaphysical distinction is found within the theory, the claim the quantum mechanics entails a genuine becoming would be vindicated. The main problem, as noticed by Callender himself, is that it is far from clear whether the mapping between *eigenstate/superposition* and *open/fixed* is a sharp, unambiguous one.

[...] the symmetry of Hilbert space implies that we can write out our wavefunction in any of an indefinite number of bases, e.g., position, momentum, spin. A wavefunction that is a superposition in one basis may not be a superposition in another; for instance, the wavefunction of x-spin down is a superposition of up and down spins in the z-spin direction. Here a collapse to fixity in x-spin buys openness in z-spin. (2017, p. 95)

The mechanism of collapse, by itself, does not pick up a preferred basis. Therefore, whenever a superposition on a certain basis disappears due to collapse, what happens is that the observable corresponding to another basis will immediately turn into a new superposition, provided it is incompatible with the first one (as it is in the example given by Callender of the x and y spin, and in virtually every case of superposition). Callender is here thinking of the collapse of the wave function as it appears in textbook quantum mechanics, wherein no basis is privileged over the other. However, if we consider DRM instead, there always is a preferred basis—for instance, in the classic GRW theory, this was position. Therefore, we should only care about position superposition states and position eigenstates when we speak about the asymmetry between fixed past and open future.

Callender grants that much, but then reminds us that “in any realistic collapse theory such as GRW one doesn’t get collapses onto eigenstates, but only near eigenstates” (2017: 95). Hence, even granting, by focusing only on position states, that there is a mapping between superposition/eigenstate and the open/fixed distinction, in GRW type of interpretation collapses are never to eigenstates, but only

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<sup>6</sup> On the various ways in which the asymmetry can be understood (and a defence of its ontological reading) see Grandjean (2019).

near ones. And without eigenstates, the thought would go, we will not end up having openness properly. The lack of eigenstates is a general problem for GRW (see Lewis 1995), and one that is independent from any discussion on genuine becoming. It is known in the literature as the *tails problem* (Albert & Loewer 1990), and it is actually considered by many philosophers and physicists to be the main flaw of DRM. It is fair to point out, however, that many solutions to the tails problem are on offer (for a recent review of the literature, see Gao 2018 ms), and Callender does not give motivations for rejecting any of them. In this paper we will assume that a solution to the tails problem can be given (without taking a stance as to which one is correct), and we therefore conditionalize our result on the solutions to the tails problem.

To sum up, in this section we have shown, in agreement with Callender (2017), that the argument that leads from DRMs to genuine passage of time should not be grounded on the indeterministic dynamics of these theories. We then suggested that the place to look at is instead the possible mapping between superposition/eigenstate and the open/fixed distinctions. Callender's motivations for believing that this mapping does not provide a faithful metaphysical ground for passage are not, as we have indicated, conclusive. In the next section, we shall deepen the connection between passage and the ontological status of superposition states. To understand such a mapping, we first need to understand the ontological meaning of the distinction between superposition states and eigenstates. In  $GRW_M$  and in its relativistic extension, as we suggested in Sect. 9.2, this can be achieved by focusing on the status of indeterminate mass states.

## 9.4 Indeterminacy and the Open Future in DRM

Although a full characterisation of DRM-based genuine passage is out of the scope of this paper, we will show how the kind of openness of the future that DRM, within an Ockhamist framework, allows can contribute to it.

Firstly, let us introduce what may be called the *standard Ockhamist account* of the openness of the future on a branching time model. The basic idea is that the evaluation of tensed claims in general, and thus future-tensed claims about contingent matters (i.e., future contingents) in particular, is relativized not only to the moment of utterance  $i_u$  (as usual for tensed claims), but also to histories  $h_1, h_2 \dots, h_n$ , namely to nomologically possible continuations of what has happened up to  $i_u$ .

Assume that at  $i_u$  I utter "In thirty years there will be flying cars." The proposition expressed by my utterance can be analysed in terms of a kernel present-tense proposition  $\langle$ There are flying cars $\rangle$ , the future sentential operator *It will be the case that*, and the metric determination (attached to the sentential operator) *in thirty years*.

FLYING CARS <It will be the case (in thirty years) that there are flying cars>

In the standard Ockhamist setting, FLYING CARS cannot be evaluated in relation to  $i_u$  alone, but it requires the specification of a history that passes through it, usually designed as “ $h_n/i_u$ ”. Only relative to a particular history  $h_n$  FLYING CARS has a determinate truth value. Assuming the subject matter of FLYING CARS is contingent, and  $i_u$  is the present, in certain histories we find a future in which people go around in flying cars, while in others humanity has not developed such a technology on a large scale.

How to make sense of the fact that we seem to have said something meaningful and not “incomplete” at  $i_u$  nonetheless is an interesting question,<sup>7</sup> but it is not of crucial importance here. One can make a provisional assumption and select a story for the sake of carrying out an evaluation,<sup>8</sup> or can elaborate a non-bivalent semantics<sup>9</sup> or can defend the idea of an irreducible relativistic semantics.<sup>10</sup> On any account, there is a sense in which the present time, that is  $i_u$ , does not contain all the information that is required to settle the truth value of FLYING CARS, and thus FLYING CARS is (semantically) unsettled with respect to  $i_u$ . Note that this introduces an element of indeterminacy in the present. Two clarifications are needed with respect to the notion of indeterminacy in the present that we encounter in the standard Ockhamist account. Firstly, such indeterminacy does not entail that the present is *constituted* by any indeterminate state of affairs. We can introduce the notion of constitution as explained below.

**Constitution** A state of affairs partially constitutes a time  $t$  if and only if it obtains at  $t$  and it is exclusively “about” what is going on at  $t$

The notion of “being about” is notoriously a vague one, but for our purposes suffice it to say that *no* future-tensed state of affairs that obtain at the present time is about the present time; they are all about what *will be* the case at future times. Thus, no future-tensed state of affairs can constitute the present.<sup>11</sup>

Secondly, the indeterminacy in the present is explanatorily linked to (indeed, grounded on) the openness of the future. We can make this claim more rigorous by appealing to two roles times can play in claims concerning the obtaining of state of affairs, which we will refer to through the expressions “at  $t$ ” and “as of  $t$ ”, respectively. Intuitively, if a state of affairs obtain at  $t$  then  $t$  is the temporal

<sup>7</sup> On the assertion problem, which originates in Belnap and Green (1994), see Belnap et al. (2001), and Santelli (2017), PhD Thesis.

<sup>8</sup> Cf. Prior (1967) on “prima facie” assignment. Cf. also Ohlstrom on the “thin red line”.

<sup>9</sup> Cf. See Varzi (2007) for an overview of the supervaluationist options.

<sup>10</sup> MacFarlane (2003).

<sup>11</sup> The notion of constitution that we use is not innocent and could meet some resistance. Someone believing in irreducibly future-tensed properties may want to have the present constituted by future-tensed state of affairs or facts too. In the literature, Lucretian presentism (Bigelow, 1996) is probably the position less sympathetic to our characterisation of constitution. Note, however, that what we say is compatible with the present being constituted by past-tensed state of affairs.

position of its obtainment, and if as of  $t^*$  a state of affairs obtain at  $t$ ,  $t^*$  contains “all that it takes” for the state of affairs to obtain at  $t$ . We then take the first notion as a primitive that can be characterised as in (at  $t$ ) below, while the second notion is explicitly defined in (as of  $t$ ) below.

- (at  $t$ ) If a state of affairs F obtains/fails to obtain at  $t$ , then the proposition P that expresses F is true/false at  $t$ . If it is indeterminate whether F obtains at  $t$ , then P is unsettled at  $t$
- (as of  $t$ ) As of  $t$ , a state of affairs F obtains/fails to obtain/is such that it is indeterminate whether it obtains at  $t^*$  if and only if the states of affairs that constitute  $t$  entail/fail to entail/neither entail nor fail to entail that F obtains at  $t^*$ .

If, along with state of affairs talk, we also allow for the notion of a state of affairs’ *internal negation*, indeterminacy with respect to the obtainment of F can be construed as being indeterminate which of F and its internal negation not-F obtains.

With those two specification in mind, we can pinpoint the standard Ockhamist account along the following lines. If it is unsettled whether there will be flying cars in thirty years, then as of now, it is indeterminate whether the state of affairs that [there are flying cars around] or the state of affairs that [there are no flying cars around] obtains in 2050 (assuming now it’s 2020). But when thirty years elapses, it will no longer be indeterminate which state of affairs obtain in 2050. More generally, for any time  $t$ , some time  $t^*$  (with  $t^* > t$ ), and every proposition of the form  $\langle It \text{ will be the case that } \phi \rangle$  (where  $\phi$  is present tense, and does not contain hidden references to the future) that is unsettled at  $t$ :

- (i<sub>O</sub>) As of  $t$ , it is indeterminate which of the two future-tensed state of affairs [it will be the case that  $\phi$ ] and [it will be the case that not- $\phi$ ] obtains at  $t$
- (ii<sub>O</sub>) As of  $t$ , it is indeterminate whether [ $\phi$ ] obtains or [not- $\phi$ ] obtains at  $t^*$
- (iii<sub>O</sub>) As of  $t^*$ , it is determinate which between the two future-tensed state of affairs [it will be the case that  $\phi$ ] and [it will be the case that not- $\phi$ ] obtains at  $t$
- (iv<sub>O</sub>) As of  $t^*$ , it is determinate whether [ $\phi$ ] obtains or [not- $\phi$ ] obtains at  $t^*$

The standard Ockhamist account is the thesis that the locus of indeterminacy is the future *insofar as it is still future*. The future is open because there is indeterminacy with respect to what *future*-tensed state of affairs presently obtain, and such indeterminacy in the present is in turn (given that the present is otherwise constituted only by determinate state of affairs) explained by the indeterminacy with respect to which “corresponding” present-tensed states of affairs *will* obtain. More schematically, the view can be construed as OCK-Openness below.

**(OCK-Openness)** The future is open if and only if for any times  $t$  and some time  $t^*$  (with  $t^* > t$ ), and for some  $\phi$ , (i<sub>O</sub>) to (iv<sub>O</sub>) holds, and (i<sub>O</sub>) because (ii<sub>O</sub>)

To illustrate, assume that as of  $t$ , there is indeterminacy with respect to which future-tensed state of affairs obtains at  $t$ , namely whether [it will be the case in thirty

years that there are flying cars around] or [it will be the case in thirty years that there are flying cars around] obtain. Therefore, the present time is indeterminate, but only because as of the present there is indeterminacy with respect to what states of affairs constitute future times. But when future times in turn become present, the indeterminacy will be resolved: there is *no* indeterminacy as of  $t^*$  with respect to which one of the two (mutually exclusive) states of affairs [there are flying cars around] and [there are no flying cars around] obtains at  $t^*$ .

Although consistent, OCK-Openness captures only one aspect of the idea of openness that we find in DRM, namely the thesis that the future will *resolve* the indeterminacy of the present, because the collapse of the wave function as a physical process is the passage from the indeterminate to the determinate. The indeterminacy in the present, thus, is captured in what Jessica Wilson calls the *meta-level*, rather than the *object level* (see Wilson 2013, the account is specifically applied to the quantum case in Calosi & Wilson 2018): it is a form of instability in which (future tensed) states of affairs obtain, which merely reflects the instability in which corresponding (present tensed) states of affairs will obtain. This feature of OCK-Openness makes it the case that it leaves out a crucial aspect of the view suggested by DRM, namely the thesis that the indeterminacy in the present is substantive and possibly primitive, or at any rate not grounded on the openness of the future but rather foundational of the latter.

Let us consider a simple example. If we know, say, that the electron  $e$  has spin-down on the  $x$ -axis (suppose because we measured it), we thereby also know that its spin on the other two axes cannot in principle be assigned. We then have the following states:

$$(a) \quad e = |\downarrow x\rangle$$

$$(b) \quad e = |\downarrow x\rangle = \frac{1}{\sqrt{2}}|\downarrow z\rangle + \frac{1}{\sqrt{2}}|\uparrow z\rangle$$

$$(c) \quad e = |\downarrow x\rangle = \frac{1}{\sqrt{2}}|\downarrow y\rangle + \frac{1}{\sqrt{2}}|\uparrow y\rangle$$

Where (a) means that the electron is in an *eigenstate* of having the value *down* for the observable  $x$ -spin, and (b) and (c) express the empirical fact that being in an *eigenstate* of the observable  $x$ -spin implies being in a *superposition* of the observables that are incompatible with  $x$ -spin, namely  $z$ -spin and  $y$ -spin respectively. In DRM, presently obtaining state of affairs about superposition can be construed as indeterminacy of the value of a property. With respect to the example, we can say that  $e$  does not have a definite value for the properties  $y$ -spin and  $z$ -spin.

Crucially, the electron possesses *now* such an indeterminate status, and that fact is not grounded on there being indeterminacy with respect to which among the possible outcomes (the definite values for the  $y$ -spin and the  $z$ -spin of  $e$ ), as of now, we find in the future. Rather, the indeterminacy in the future is grounded on the present being *constituted* by states of affairs about  $e$ 's superpositions. Therefore, the indeterminacy of the present resides in states of affairs that are entirely about the present, they are not future-tensed in any obvious sense. In other words, DRM suggests that the indeterminacy in the present should be captured in the object level fashion, as exemplification of (present tensed) states of affairs that are intrinsically

indeterminate, rather than at the meta-level, in terms of an instability in which states of affair obtain (on object- and meta-level, see above). More precisely, we will adopt the following notion of Wilson-style indeterminate state of affairs to characterise such an indeterminacy in the present.

**(Wilson-style Indeterminate State of Affairs)** A state of affairs is (Wilson-style) indeterminate *iff* a certain object instantiates a determinable property, but more than one determinate of that determinable.<sup>12</sup>

In order to understand why object level indeterminacy in the present explains the indeterminacy that characterise the future, consider the following toy example, which involve a case of indeterminacy in the present that is less controversial from a metaphysical point of view, namely representational indeterminacy. Everyone has experienced indecision with respect to what to do. Imagine a Senator who is undecided with respect to whether to approve or not a bill that will be voted upon this evening at 18:00. At noon, she is still utterly undecided whether she will vote yes or no in the 18:00 voting. As of noon, it is thus undetermined whether at 18:00 she will vote yes or no. The relevant state of affairs about the Senator that constitute noon here can be thought of as composed by a determinable (e.g., *being in a mental state about tonight voting*) and more than one determinate of that determinate (e.g., *intending to vote yes, intending to vote no*). Those states of affairs ground the present indeterminacy of the 18:00 voting with respect to the Senator's behaviour.

The example concerns representational indeterminacy, but it can be easily generalized. We can say that state of affairs have as constituents individuals ( $s_1, s_2, \dots$ ) exemplifying properties. Those properties are determinable properties ( $D_1, D_2, \dots$ ), and each determinable property has its own corresponding pool of determinate properties ( $A_D, B_D, \dots$ ). In the quantum case, we have states of affairs constituted by physical systems, such as the electron  $e$ , determinable properties such as the  $y$ -spin, and their corresponding determinate properties, such as  $down_{y-spin}$  and  $up_{y-spin}$ . In line with Wilson's idea introduced before, we can say that when a state of affairs exemplify a determinable property  $D$  and more than one of its corresponding determinate properties  $A_D, B_D$ , etc. ... there is an (Wilson-style) indeterminate state of affairs. For clarity of exposition, we can use a slash “/” between the various determinate properties involved in indeterminate states of affairs. Thus,  $[s, D, A_D/B_D]$  is a indeterminate state of affairs that is constituted by a system  $s$ , a determinable  $D$ , and determinate properties  $A_D$  and  $B_D$ . That is, in the quantum case, it is the state of affairs of the system  $s$  being in a superposition state with respect to the value of  $D$  (one of its observables).

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<sup>12</sup> This is the *glutty* version of indeterminacy. Wilson allows also for a *gappy* version in which no determinate of that determinable is instantiated. Calosi and Mariani (2020) also discuss a further variant in the case of quantum mechanics, which they call *relativized glutty*. We believe there are good reasons for preferring the *glutty* approach, at least in the case of DRM (see Mariani 2022), so this will be our only focus in this paper.

A theory of the openness of the future that includes not only the idea that the future will resolve present indeterminacy as OCK-Openness, but also that it will do so *in virtue of* the presently obtaining indeterminate states of affairs can thus be formulated as DRM-Openness below. The core of the theory is the characterisation of the relation between indeterminate states of affairs of the form  $[s, D, A_D/B_D]$ <sup>13</sup> and the state of affairs  $[s, D, A_D]$  and  $[s, D, B_D]$  concerning the same system  $s$  and determinable  $D$ , but only one of the determinate property  $A_D$  or  $B_D$ . Such a relation can be expressed by the following four clauses. For any time  $t$  and some time  $t^*$  (with  $t^* > t$ ) and some quantum system  $s$ , determinable  $D$ , and some of  $D$ 's determinate  $A_D$  and  $B_D$ :

- (i<sub>D</sub>) As of  $t$ , an indeterminate state of affairs  $[s, D, A_D/B_D]$  obtain at  $t$
- (ii<sub>D</sub>) As of  $t$ , it is indeterminate whether  $[s, D, A_D]$  obtains or  $[s, D, B_D]$  obtains at  $t^*$
- (iii<sub>D</sub>) As of  $t^*$ , it is determinate which between the two future tensed state of affairs it will be the case that  $[s, D, A_D]$  and it will be the case that  $[s, D, B_D]$  obtains at  $t$
- (iv<sub>D</sub>) As of  $t^*$ , it is determinate whether  $[s, D, A_D]$  obtains or  $[s, D, B_D]$  obtains at  $t^*$

According to DRM-Openness, the indeterminacy with respect to what states of affairs constitute the future is explained in terms of presently obtaining Wilson-style indeterminate states of affairs.

**(DRM-Openness)** The future is open if and only if for any time  $t$  and some time  $t^*$  (with  $t^* > t$ ) and some quantum system  $s$ , determinable  $D$ , and some of  $D$ 's determinate  $A_D$  and  $B_D$ : (i<sub>D</sub>) to (iv<sub>D</sub>) holds, and (ii<sub>D</sub>) because (i<sub>D</sub>)

To see an application of the theory, consider again the previous example of the electron  $e$  and the state corresponding to  $y$ -spin of  $e$ . We have an individual, the electron  $e$ , a determinable, the observable corresponding to  $y$ -spin, and two determinates of that determinable, *down* and *up*. Thus, at the time at which the state occurs, call it  $t$ , we have:

- (i<sub>e</sub>) As of  $t$ ,  $[e, y\text{-spin}, \text{down}_{y\text{-spin}}/\text{up}_{y\text{-spin}}]$ <sup>14</sup> obtains at  $t$
- (ii<sub>e</sub>) As of  $t$ , it is indeterminate whether  $[e, y\text{-spin}, \text{down}_{y\text{-spin}}]$  obtains or  $[e, y\text{-spin}, \text{up}_{y\text{-spin}}]$  obtains at  $t^*$
- (iii<sub>e</sub>) As of  $t^*$ , it is determinate which between the two future tensed state of affairs it will be the case that  $[e, y\text{-spin}, \text{down}_{y\text{-spin}}]$  and it will be the case that  $[e, y\text{-spin}, \text{up}_{y\text{-spin}}]$  obtains at  $t$
- (iv<sub>e</sub>) As of  $t^*$ , it is determinate whether  $[e, y\text{-spin}, \text{down}_{y\text{-spin}}]$  obtains or  $[e, y\text{-spin}, \text{up}_{y\text{-spin}}]$  obtains at  $t^*$

<sup>13</sup> For simplicity, we assume that only two determinates are involved.

<sup>14</sup> This can be easily generalized from spin to any other observable properties of a quantum system. Take a system  $s$  and one of its observables  $O$ , with distinct eigenstates  $|\psi\rangle$  and  $|\phi\rangle$ . Any linear combination  $|\omega\rangle = a|\psi\rangle + b|\phi\rangle$  is a superposition. The resulting quantum state  $|\omega\rangle = a|\psi\rangle + b|\phi\rangle$ , obtaining at a certain time  $t$ , is then to be interpreted as  $[s, O, \psi/O/\phi O]$ .

DRM-Openness is a theory about the status of the future, which is crucially based on the construal of a *superposition* state as a (Wilson-style) indeterminate state of affairs. Through it, we can provide an explanation of what it is for the future to be *genuinely* open in terms of being connected in a certain way to an indeterminate state of affairs that holds in the present (in the strong sense that it constitutes it).<sup>15</sup> How can we use DRM-Openness to provide an explanation of what it is for time to *genuinely* passing? Although DRM-Openness does not explicitly involve the notion of (spontaneous) *collapse*, the idea is clearly in the background in the characterisation of the *relation* between the indeterminate state of affairs presently obtaining and whatever *determinate* state turns out to be the case at a successive time. We can thus take DRM-Openness as a first step of an explanation of what is for a determinate outcome to “turn out to be the case” at a future time. This means that DRM can be used to specify a notion of becoming that is not as robust as absolute becoming (a transition from nothing to something), but that is more robust than mere qualitative variation through time. By undergoing a DRM-based becoming, a quantum system passes from being in a metaphysically indeterminate state with respect to a certain observable (and hence not instantiating *any* value for it), to being in a determinate state with respect to it (and hence instantiating a determinate value for it).<sup>16</sup>

We do not want here to be committed to anything more specific; in particular, on whether the theory of the passage of time that would result is (or should be)

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<sup>15</sup> As a reviewer has noticed, our account is somehow “hybrid” between an object level account and a meta-level account, since it encompasses both object-level indeterminate facts obtaining in the “unstability” of certain related facts. Even if hybrid account that take both level as equally fundamental may be criticised on parsimony reasons, our account takes as fundamental the object level indeterminacy in the present, and construe the corresponding meta-level indeterminacy as derivative. Hence, it is not clear that parsimony reasons apply to it.

<sup>16</sup> A referee pointed out that it is unclear why this case is metaphysically more substantive than the case of qualitative variation through time for classical systems—for instance, a liquid passing from not having a temperature of 5°C to having such a temperature. Structurally they look the same: we have a situation in which a system (the particle) does not instantiate a property (*having a determinate value for observable O*) followed by a situation in which the system instantiates it. We disagree. Also the case of absolute becoming can be described as a situation in which a system does not instantiate the property of *existing* followed by one in which it instantiates it. One may object that the property of *existing* (if there is such a thing) is non-qualitative, whereas the property of *having a determinate value for observable O* is a good example of a qualitative property for quantum systems, as good as *having a temperature of 5°C* for classical systems. However, this rejoinder is based on a confusion between the property *having a determinate value for observable O* and some more specific property *having value N for observable O*. On the one hand, we agree that when a quantum system passes from having an indeterminate state with respect to an observable *O* to having a determinate state with respect to *O*, it always *also* gains a qualitative property, such as *having value N for observable O*. On the other hand, there is a difference between the classical case, in which the system passes from 3 to 5°C, say, and hence *remains* in a determinate status with respect to the observable temperature, and the quantum case, in which the system passes from having no value at all for *O* to having value *N*, and hence *changes* from being indeterminate with respect to *O* to being determinate with respect to it. This latter change of status strikes us as significantly different from a mere change in qualitative profile.

a *reduction* of genuine passage to something more primitive, or an *elucidation* of a metaphysically primitive notion. We want only to point out two things here, which will be relevant in discussing the relativistic extensions of spontaneous collapse theories. Firstly, given the explanatory priority of the presently obtaining indeterminate states of affairs, a DRM-Openness based model of the passage of time is one that we may call of a *Munchhausen* style: the present pulls itself towards the future and away from the past. Spontaneous collapse is, or entails the existence of, a *transition instant*, namely an instant whose content is explanatory prior to *other* (future) instants. As an analogy, think of the idea of an instantaneous velocity. It is usually understood as reducible to the value that a property defined on temporal extensions (“ordinary” velocity) takes when considered in a limit case. But it can also be taken as primitive, and used to define the ordinary notion of velocity over a temporal span. If the definition is taken as expressing metaphysical priority of the *definiens* over the *definiendum*, then the position that a ball rolling on a pool table (say) will have in two second *is grounded* on the instantaneous velocity (and the position) that the ball has now. Analogously, the future coming into existence of a determinate state of affairs is grounded on the present collapsing state of superposition.<sup>17</sup> Secondly, although in commenting the explanatory applications of DRM-Openness we have used a jargon involving terms for tensed properties, such as “present” and “future”, the theory is formulated in perfectly *kosher* for a B-theorist. The theory talks about temporal relations. Given the relevance of the asymmetry of the relative positions in time, we can use the theory to state what happens when an instant is *considered as present*. This is different from saying that they theory allows us to say what happens when we make the hypothesis that an instant *is* (objectively) present. This feature of the theory makes it clearly more

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<sup>17</sup> One could wonder, as a reviewer to this paper did, what would happen to an isolated electron according to our model: does time pass for it? According to DRM, if we take an isolated electron the probability of a collapse is very low (once every hundred million year). Therefore, it looks like time does not pass for the isolated electron after all, if we assume for instance that the electron will never undergo a collapse. However, when considering whether time passes or not, we should look at the entire universe, and not just at one isolated particle. The consequence of this however, is that if we imagine an universe populated by a lonely electron, time does not in fact pass in such a universe. We understand this might look like an unwelcome consequence of our view, and yet we believe it is not as counterintuitive as it might first seem. Indeed, the passage of time is a contingent feature of the world in our picture, as it should be expected in a framework in which the passage is grounded in physical facts. Hence, it should come as no surprise that the lonely electron universe may turn out to be one in which time does not pass. However, in the *actual* universe, one that is populated by a very large number of entangled particles, the probability of collapse is instead very high (once every  $10^{-7}$  s), and this explain why time passes. Again, this is how it should be since our account is based on a theory (DRM) which is meant to apply to our world (it “aims” to be empirically true, not to describe structural features of the space of metaphysical possibility). Maybe the reviewer is unhappy with this reply, since it may be that two worlds that are *nomologically* the same, could be still such that in one time passes and in the other it doesn’t (the almost empty world and our world may be both such that the laws encoded in DRM are true). But it is not clear to us that the passage of time has to be grounded *uniquely* in the laws of nature, rather than in the laws plus some other factual element, such as the *de facto* large amount of entangled systems.

friendly to a relativistic application. More specifically, already in its non-relativistic formulation (i.e. DRM-Openness above), the theory does not assume or entail an absolute notion of simultaneity or a preferred frame of reference.

## 9.5 Considerations on Relativistic Extensions of the Proposed View

DRM-Openness is crucially based on two elements: (1) a certain ontology of *superposition* states interpreted as (Wilson-style) metaphysically indeterminate states of affairs, and (2) the Ockamist take on *openness* of the future, according to which the existence of the future is not a defeater of the genuine indeterminacy of what will come. As we argued in the last paragraph, those two elements can be seen as parts of a realist theory of temporal flow, and both of them seem not to be “hostile” to a relativistic generalisation.

Before going a bit more into the details of such a generalisation, let us dispel a worry. It could be argued that already in a non-relativistic setting, DRM assumes no metaphysical indeterminacy, or at least not at the fundamental level of reality (cf. Glick 2018). Recall from Sect. 9.2 that whether or not DRM entails any fundamental indeterminacy will depend on how we interpret the model. If the wave function is fundamental (as for Albert 1996, Lewis 2003, among others), then the indeterminate states of affairs are (at best) derivative. If we adopt  $GRW_F$  approach, there is a primitive ontology that contains only flashes, which are events in 3D space. Once again, no fundamental indeterminacy here. However, as we suggested earlier, on  $GRW_M$ , the mass density can be seen as generating indeterminate states of affairs, namely those that Ghirardi et al. (1995) calls *non-accessible* or *unstable* states of affairs. Thus, if we want to extend DRM-Openness to a relativistic DRM, we shall focus on the model proposed by Bedingham (2011), which is precisely a relativistic version of  $GRW_M$ .

This is our proposal. In order to adapt DRM-Openness to a relativistic setting (let’s call the new theory *DRM-R.Openness*), we need to do two things. Firstly, we restrict the indeterminate states of affairs that enter into the explanatory relation with respect to the future indeterminacy (the one expressed by “because” in the core claim) to those involving mass density. This can be done by using “D” as a constant for the mass density determinable, and restricting the range of the variables  $A_D$   $B_D$ , etc. to its determinables. Secondly, we relativize to frames of reference in a Minkowskian spacetime the operators “At  $t$ ” and “As of  $t$ ”. And this can be done simply by introducing a index for frames of references  $FR$  to the temporal parameter  $t$ , on the background of some coordinate specification for a Minkowskian spacetime (“At  $t_{FR}$ ” and “As of  $t_{FR}$ ”).

The explicit reformulation is as follows. For any frame of reference  $FR$  specified in a given coordination system defined on a Miskonsian spacetime, and any of its

temporal parameters  $t_{FR}$  and  $t_{FR}^*$ , with  $t_{FR} > t_{FR}^*$ ,<sup>18</sup> and some quantum system  $s$ , mass density determinable  $D$ , and some of  $D$ 's determinate  $A_D$  and  $B_D$ :

- (i<sub>R</sub>) As of  $t_{FR}$ , an indeterminate state of affairs  $[s, D, A_D/B_D]$  obtains at  $t_{FR}$
- (ii<sub>R</sub>) As of  $t_{FR}$ , it is indeterminate whether  $[s, D, A_D]$  obtains or  $[s, D, B_D]$  obtains at  $t_{FR}^*$
- (iii<sub>R</sub>) As of  $t_{FR}^*$ , it is determinate which between the two future tensed state of affairs it will be the case that  $[s, D, A_D]$  and it will be the case that  $[s, D, B_D]$  obtains at  $t_{FR}$
- (iv<sub>R</sub>) As of  $t_{FR}^*$ , it is determinate whether  $[s, D, A_D]$  obtains or  $[s, D, B_D]$  obtains at  $t_{FR}^*$

**(DRM-R.Openness)** The future is open if and only if for any temporal parameter  $t_{FR}$  and some temporal parameter  $t_{FR}^*$  (with  $t_{FR} > t_{FR}^*$ ) and some quantum system  $s$ , mass-density determinable  $D$ , and some of  $D$ 's determinate  $A_D$  and  $B_D$ : (i<sub>R</sub>) to (iv<sub>R</sub>) holds, and (ii<sub>R</sub>) because (i<sub>R</sub>)

To see the implication of this transformation of the theory, let us go back to Maudlin's (2019) example of an equal-weight superposition of a particle to travel to the east or to the west, with a single screen set up far away in one direction. Until the particle reaches the screen, we should imagine that it is indeterminately spread in both directions. When half of the mass density arrives at the screen, the particle is forced to collapse. Two things can happen, either it collapses at the screen, in which case we see a mark, or it does not. In both cases, the quantum state of the particle is immediately reduced at the screen (to either 1 or 0, respectively). What happens where there is no screen, however, is that the state does not reduce to 1 or 0 *until* the screen-measurement is in the past light-cone.

The consequences of this situations are many; we believe it is worth pointing to at least two of them, which may be at first sight problematic. Firstly, whether or not something is DRM-R.Open will depend on where you happen to be located in space-time, and has to be established with respect to your past light-cone only, not on the totality of the space-time. Hence, although the relativization is to frames of reference, the selection of a frame of reference will in general depend *both* on the location where we consider an observer to be *and* where the target phenomenon is supposed to happen. This is reflected in the formalisation by the fact that *two* temporal parameter ("At  $t_{FR}$  and "As of  $t_{FR}^*$ ", with  $t$  possibly different than  $t^*$ ) and not only one are involved.

In the above example, if you are where the screen is, and until the collapse happens due to the fact that the mass of the particle hits the mass of the screen, the particle is in an indeterminate state of affairs, and hence future tensed claims about its hitting the screen are indeterminate. If you are located where there is no

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<sup>18</sup> Notice that given that the temporal parameter are of the *same* frame of reference  $FR$ , the relation of temporal succession  $>$  is always well-defined on them, even if it is in general not a total order on the totality of events in spacetime.

screen, since the indeterminacy is not resolved until the experiment on the screen is in the past-light cone, the future will be open for a “longer” period of time.

We grant that this might look counterintuitive, but recall that even in the non-relativistic version, our model is meant to evaluate openness with instants *considered as present*, and not with respect to an absolutely objective present. Hence even in the non-relativistic version whether a future tensed claim or not is open is not an absolute matter but depends on what value of  $t$  and  $t^*$  we are considering. The only difference between DRM-Openness and DRM-R.Openness is, unsurprisingly, that in the relativistic version the relevant points of evaluation are not instants in an absolute foliation of spacetime, but instants in a given frame of reference. In such a framework, differences in how things are relative to *spacetime points* that are space-like separated are to be expected.

Once again, it might be useful to consider the difference with respect to Bohmian mechanics, and how things in Maudlin’s scenario stand according to it. Since the particle is never in an indeterminate state, there are not Wilson-style indeterminate states of affairs that can ground the openness of claims about its future fate, neither if we consider the screen side, nor if we consider the other side. Maudlin (2019) correctly maintains that this difference is based on the fact that DRMs are indeterministic theories, while Bohmian mechanics is not. To recall, it is *sheer chance* that enable us to break the symmetry between the two sides, east and west.

A second issue worth discussing concerns the *tails of the wave function* in DRMs. While discussing Maudlin’s example, we were granting that the states at both sides reduce to either 1 or 0 after that the measurement occurs. As pointed out earlier in Sect. 9.2.2, however, 1 and 0 are eigenstate of position observable that, in  $GRW_M$  are in turn based on the Mass Density operator.<sup>19</sup> And since (given the tails problem) there are no eigenstates of Mass in  $GRW_M$ , it could be argued that this poses a treat to our model. There are two responses to this worry, which we will now briefly consider.

First, let us repeat that we are happy to conditionalize the validity of our model to the eventuality that the *tails problem* will be solved. Of course, depending on the solution to this problem our model will need to be adjusted. In a way,  $GRW_M$  is also a solution to this problem, because we get as a mathematical result that we can practically neglect the low-density Mass which composes the tails. Therefore, our model will simply need to specify the openness is to be evaluated without caring about the part of the mass that we can neglect. Although this will require certain adjustments, we see no in principle reason why it cannot be done.

But more importantly, we should consider that the tails themselves also have positive consequences when it comes to making DRMs relativistic, as pointed out, among others, by Pearle (1997):

I want to give one more reason for tails: I can’t see how to make a relativistic theory without them. If you have a tail, no matter how small, and you know the field which the state vector

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<sup>19</sup> Indeed Ghirardi et al. (1995) explicitly defines the Mass Density operator in terms of the number of particles, which in the original 1986 model was giving the position of macroscopic objects.

evolved under, you can run the evolution equation backwards and recover the statevector at any earlier time. If on the other hand, the tail was completely cut off, you get a nonsensical irrelevant earlier statevector. [...] One can go to another reference frame, and in doing so the frame sweeps backwards in time. I cannot see how you could get sensible results in another Lorentz frame without having the tail to tell you how to do it. (Pearle 1997: sec. 5.3).

Pearle's idea here, is that without the tails we would not be able to explain the transition from a certain state to another. If instead we have the tails, no matter how small, we can always in principle reconstruct the earlier state by going backward in time. Translating into  $GRW_M$  talk, this means that the evolution of the accessible part of the mass cannot be explained without the existence of the non-accessible part, that is the tails.

## 9.6 Conclusions

In this paper, we have argued for an explanatory connection between DRM models of quantum mechanics, in particular their “deep indeterminacy” aspect, and the metaphysical thesis of realism with respect to the passage of time. Although Callender's (2017) objections to quantum becoming are serious ones, our proposal evades the difficulties that he highlights with respect to connecting the collapse of the wave function with an objective flow. Indeed, by exploiting an Ockhamist take on the nature of the indeterminacy of the future, we have sketched a relativistic version of the model, in which the theoretical ingredients at the basis of a realist account of the passage of time are preserved.

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