On Time *chez* Dummett

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Abstract

I discuss three connections between Dummett's writings about time and philosophical aspects of physics.

The first connection (Section 2) arises from remarks of Dummett's about the different relations of observation to time and to space. The main point is uncontroversial and applies equally to classical and quantum physics. It concerns the fact that perceptual processing is so rapid, compared with the typical time-scale on which macroscopic objects change their observable properties, that it engenders the idea of a 'common now', spread across space.

The other two connections are specific to quantum theory, as interpreted along the lines of Everett. So for these two connections, the physics side is controversial, just as the philosophical side is.

In Section 3, I connect the subjective uncertainty before an Everettian 'splitting' of the multiverse to Dummett's suggestion, inspired by McTaggart, that a complete, i.e. indexical-free description of a temporal reality is impossible. And in Section 4, I connect Barbour's denial that time is real—a denial along the lines of Everett, rather than McTaggart—to Dummett's suggestion that statements about the past are not determinately true or false, because they are not effectively decidable.

Contents

1 Introduction

Michael Dummett is undoubtedly one of the most significant philosophers of the last fifty years. So it is a privilege to honour him and his work. Given that work's emphasis on the philosophy of language and logic, it is something of a question for me, as a specialist in philosophy of physics, how best to do so: a question made harder by the contrast between his semantic anti-realism (justificationism) and my own realism. What I propose is to take three topics in the philosophy of time which Dummett's writings have addressed, and to report on their connection to philosophy of physics. In Section 1.2, I briefly review the themes in philosophy of time that will be relevant. (I will make a point of giving many references, in order to answer Dummett's complaint, in the paper prompting this special issue, that 'specialist philosophers of physics speak a technical language among themselves, and fail to communicate with other philosophers in the mainstream' (2007, p. 25).)

The first topic (Section 2) is uncontroversial (at least, so I say!), and applies equally to classical and quantum physics. It concerns the fact that usually, perceptual processing and oral communication is so rapid, compared with the typical time-scale on which macroscopic objects change their observable properties, that it engenders the idea of a 'common now', spread across space. Within Dummett's writings, the springboard for this is some remarks in his *Frege: the Philosophy of Language*, about how observation relates differently to time than it does to space (1973, p. 388).

The other two connections are specific to quantum theory, as interpreted along the lines of Everett. So here, both the physics and philosophy sides of the connection are controversial. Thus in Section 3, I connect the subjective uncertainty before an Everettian 'splitting' of the multiverse to Dummett's suggestion that a complete, i.e. indexical-free description of a temporal reality is impossible. So far as I know, Dummett first made this suggestion in his (1960); but it is echoed later, in his 2002 Dewey lectures (2003, 2004). Dummett takes this suggestion as the moral of McTaggart's 'proof' that time is unreal.

This latter, dizzying, idea leads in to my third topic. In Section 4, I report Barbour's (1999) denial that time is real: though in another sense than McTaggart's—a sense that in effect combines the ideas of Everett and Arthur Prior. I connect this denial to an idea which Dummett has formulated and explored: hoping, I should add, to find grounds on which he could reject it, rather than grounds for accepting it. Roughly speaking, it is the idea that statements about the past, if true at all, are true only in virtue of present traces (including memories). So far as I know, Dummett first explored this idea in his (1969); but he returned to it in more detail (again, hoping to reject it, not embrace it) in his (2003, 2004).

I end this preamble with two preliminary comments. First: the connections I state are intellectually robust. But I should issue a health warning, about the material in Sections 3 and 4. Namely: the physical ideas, to which I there connect Dummett's writings, are highly controversial. Of course, it is well known that the Everett interpretation (presented in Section 3.2) is contoversial. But I should emphasize that Barbour's denial of time (Section 4.4) is even more controversial. In short: though I endorse these Sections' two bridges from Dummett to physics—I do not vouch for the truth of what is on the far, physics, side of them!

Second: although my philosophical temperament is, unlike Dummett's, realist and naturalist (as will be clear from Section 2 et seq.), I would like to pay tribute at the outset to Dummett's philosophical imagination. I especially admire his over-arching theme that empirical propositions that are not effectively decidable should be treated along the lines intuitionists advocate for mathematical propositions: viz. as not determinately true or false (thus violating bivalence), and more specifically, as obeying intuitionist logic or a close cousin of it. This idea goes back to his early work, e.g. the closing paragraphs of (1959), but is still central to his current thinking—as we will see in Sections 4.1 and 4.2.

1.1 Work for another day

I admit that my choice of these three topics is biassed, in that I have written on them before. Indeed, I cut my philosophical teeth on the first of them. On the other hand, I submit that these topics are not a 'stretch'. Despite different prevailing concerns in philosophy of language and logic, and in philosophy of physics—and despite Dummett's anti-realism, and my own aspiration to be a naturalistic realist—all three topics involve connections close and substantial enough to be worth stating.

Furthermore, I submit that one could well 'play the same game' with other topics Dummett has addressed. As regards time, there are two obvious topics. One is Dummett's rejecting the idea that time is composed of instants, in the way that the classical continuum is composed of real numbers, on the grounds that it admits as conceptual possibilities—a philosopher of physics might say: kinematic possibilities—motions of a body that are so discontinuous as to be surely conceptually impossible (2000, pp. 500-505).[1] He goes on to discuss alternatives. For example: a moment of time might be modelled by the set of rational numbers in some open interval of real numbers, smaller than any time-resolution we shall ever devise; and the value of another quantity such as position will be, not a real number, but the set of rationals in some open real interval, smaller than any measurement resolution we shall ever devise. (For simplicity, Dummett at first envisages that for a given quantity, be it time, position, charge or what-not, all the intervals will be of the same length.)

In response: I applaud the investigation of these alternative models, but cannot pursue it here. Let it suffice to commend some subsequent discussion (Meyer (2005), Dummett (2005), Butterfield (2006, Sections 3, 4)), together with other work on the sort of discontinuous kinematic—and even dynamic—possibilities which Dummett rejects (e.g. Norton 1999, 2008; Perez Laraudogoitia 2009).

A second obvious topic is causal loops and time travel. Again, I will not here pursue this alluring idea; but will just make two points, by way of encouraging further work. First: the springboard in Dummett's writings is his suggestion that backwards causation

[1] For example: he considers a body that oscillates between two places, ever more rapidly in the half-open interval $t \in [0, 1)$, so as to make infinitely many oscillations before $t = 1$; e.g. let the body's position be given by $q(t) = \sin(\pi(t-1))$ for $0 \leq t < 1$.

is coherent, provided that current intentions about whether to perform the action that is a putative sufficient condition of a past event, can be as good evidence about whether the past event occurred as are that event's current traces. (For a more precise statement, cf. his 1964, especially pp. 349-350; cf. also 1954, pp. 327-332, and 1986, pp. 359-362.) I believe that Dummett's suggestion coheres with the basic idea in most defences of the possibility of time travel; and that this idea should be uncontroversial. This idea is that time travel simply imposes a stringent consistency condition on states and their time-evolution, viz. that the initial state ('a youthful Tim, holding a rifle, disembarking from his time-machine in his grandfather's home town') must evolve back to itself (and so via a state like: 'a youthful Tim, holding a rifle, embarking on his time machine, intent on killing his grandfather, the profiteering munitions magnate'). (The example of Tim is from Lewis (1976, pp. 75-80).)

Second: we note that backwards causation and time travel is a topic, not just in current philosophy of physics, but also in physics, admittedly in its most speculative reaches! Good recent work on backwards causation (including as a route to solving the measurement problem of quantum theory) includes Berkovitz (2008), Kastner (2008) and Price (2008); cf. also the brief discussion in the appendix to Dummett's 1986 (p. 370). For a philosopher's introduction to time travel in physics, cf. Earman et al. (2009), Smeenk and Wuthrich (2011).[2]

Besides, time is of course not the only area in which Dummett's writings bear on issues in physics. One obvious area is 'quantum logic', i.e. the proposal that logic should be revised to incorporate the non-distributive structures in quantum theory (rebutted by Dummett (1976); relevant recent work includes Bacciagaluppi (1993, 2007), Stairs (2006)). Another is scientific realism and the perceptual basis of empirical knowledge, addressed by Dummett in his (1979).

1.2 Time, modality and semantics

In this Subsection, I will state what I take to be the main philosophical debate about time, and mention related issues about modality and the semantics of temporal language. Of course, I will not try to settle the debate or related issues. But they are worth stating. For the debate and issues will form the backdrop to all three of my connections.

The main philosophical debate about time is the debate about whether or not 'temporal becoming', the 'movement of the now', is real. Jargon varies. Some authors say the debate is about whether there are 'tensed facts' ('tenserism') or not ('detenserism'); some adopt a notation of McTaggart's (1908)), saying the debate is between the 'A' vs. 'B' ('block-universe') views of time. I shall adopt the first jargon, tenserism vs. detenserism.[3]

[2] By my lights, much current interest centres, *not* on the stringent consistency condition whose feasibility has of course been explored in the setting of classical general relativistic spacetimes; but on some curious features of time travel in quantum theory, according to the Everett interpretation. But these features depend on technicalities of entanglement and mixed states, which would take us too far afield. For an excellent philosopher's introduction, cf. (Wallace 2012, Chapter 10.6).

[3] There are yet other jargons, e.g. 'eternalism' for 'detenserism'. Dummett himself (2004, Chapter 5)

Even the statement of the debate is contentious, some saying that phrases like 'temporal becoming' and 'the moving now', are irredeemably vague or metaphorical. But I think the problem is at worst a matter of the relevant words—'real' and its ilk, like 'objective'—being ambiguous: rather than their being irredeemably vague or metaphorical.

Thus here is one possible meaning for detenserism; (it is the meaning I will concentrate on). Past and future things, events and states of affairs (or however one conceives the material contents of spacetime) are just as real as present ones. Abraham Lincoln is just as real as Bill Clinton, just as Venus is just as real as Earth: Lincoln is merely 'temporally far away from us', just as Venus is spatially far away. Similarly for a young child's first grandchild, supposing the child will have one. And this caveat simply reflects the fact that it is hard to know about the future (even harder, perhaps, than it is to know about the past)—not that the future, or its material contents, is of some different ontological status than the present or past. On the other hand, consider a contrary tenser doctrine, often called 'presentism': that only present things etc. are real i.e. past and future things etc. are unreal.[4]

So for there to be a clear dispute between detenserism and presentism—or between detenserism and other rivals, like the idea that present and past things etc., but not future ones, are real—we need to avoid ambiguities in 'is real', 'exists' and similar words. For example,, detenserism should not be just an insistence that we use 'is real' as short for 'has existed or presently exists or will exist'. And presentism should not be just an insistence on using 'exists', 'is real' etc. for 'presently exists'. Rather, we should take it that some distinction between real and unreal, in intension though not of course in extension, is common ground to the parties to the debate. Or at least: it is common ground, as applied to material things, events etc.; we here set aside mathematical and other abstract objects. Then detenserism says, with 'real' (or 'exists' etc.) as applied to material things etc.: all past, present and future things etc. are real. And presentism says, with the same sense of 'real' (or 'exists' etc.): only present things etc. are real.[5]

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notes that there are four possible positions about the reality of the past and the future—that neither is real, or one but not the other, or *vice versa*, or both are—and suggests labelling them respectively as Model (1), (2), (3) and (4). So detenserism would be labelled 'model (4)'.

[4]Here, I say 'things etc.' for simplicity: for the main idea of presentism, it does not matter how you conceive the material contents of spacetime—though of course in more precise versions, it can matter. Presentists include, for example, Prior (1970) and Markosian (2004); and we will see in Section 4 that Barbour is a kindred spirit.

[5]I say 'with the same sense of 'real'', for simplicity: it secures a direct contradiction between detenserism and presentism. But of course different authors can and do make different distinctions between real and unreal; with the result that—even if their distinctions are precise—the contradiction between one man's detenserism and another's presentism can be much less obvious. Indeed, their choice of distinctions might, at a pinch, make their positions compatible. For an argument aiming to secure that 'real', 'exists' etc. have univocal meanings, and thus that our debate is genuine, cf. Sider (1981, pp. xix-xxiv, 16-17). On the other hand: for the view that the debate conflates distinctions that in fact cut across one another—promising some compatibilities—cf. Tooley (1997). Here we return to the point I mentioned when introducing the meaning of detenserism I will concentrate on: viz. that there are other meanings. Some (e.g. Maudlin 2007, pp. 126-142) defend temporal becoming as an objective directedness of the time dimension in a 'block universe' of *my* detenser's kind. But Price has given a masterly rebuttal of this kind of temporal becoming, among others: a rebuttal that combines metaphysics and philosophy of physics (2011, especially Section 3, pp. 281-302).

This debate obviously connects in various ways with those about modality. The principal connection is via using modality to gloss the real/unreal distinction. Thus 'unreal' is often glossed as 'merely possible'. Tensers (i.e. opponents of detenserism) typically say that the future, and maybe the past, is not actual, but merely possible. And similarly presentists say (in terms of things, for simplicity): Abraham Lincoln and Sherlock Holmes are on a par; so are the young child's first grandchild (supposing there is one—it is hard to know), and Darth Vader (supposed fictional, as intended!).

This connection with modality means that in recent decades the debate has been invigorated by developments in modal metaphysics. In particular, Lewis' bold advocacy of the equal reality of all possible worlds (1973, Chapter 4.1; 1986) gave a clear modal analogue of detenserism; and similarly made the contrasting actualist view an analogue of presentism. Not that these analogies made everything cut and dried. In particular, as Lewis himself emphasised:

(i) one should not just identify 'being real' with 'being concrete', since the concrete-vs.-abstract distinction is itself in bad shape (1986, Section 1.7);

(ii) one cannot expect the debates about the identity of items, through time and across possible worlds, to be strictly parallel—not least because here various proposed distinctions between things, events, states of affairs etc. come to the fore. In particular, the *pros* and *cons* of the doctrine that objects persist over time by consisting of temporal parts ('stages'), each confined to its time, may not run parallel to the *pros* and *cons* of the analogous doctrine that objects exist in different worlds by consisting of different objects, each confined to its world (Lewis 1986, Chapter 4.1-4.3).

On the other hand, we should not assimilate this debate to one in *semantics*. Detenserism, presentism and their ilk are not just rival proposals for the semantics of temporal language. There is a temptation to see them like this; (indeed, I think the literature of the 1950s to 1970s was wont to do so; cf. Butterfield (1984)). Thus detenserism seems to go with a simple bivalent semantics which, prescinding entirely from all the complexities of natural language, uses either:

(i) a single domain of quantification containing all objects that ever exist; or

(ii) a linear order of domains, each containing the objects that exist at a single time, so that the quantifier represents present-tensed 'exists'; (here 'object' covers things etc.) With either (i) or (ii), 'now' and other temporal indexicals get a straightfoward time-dependent reference. (For example: If times are treated as objects in the domain, then 'now' can be assigned a time as reference.) Correspondingly, tenserism and presentism seem to go with more complex semantic proposals: say with using three truth-values, or a branching future; or both of these.

But we should beware of the gap between semantics and metaphysics: each discipline is, and should be, beholden to considerations, substantive and methodological, that the other ignores. In the present context, not only might linguists have reasons for or against these semantic proposals, which ride free of metaphysics. Also, the proposals do not straightforwardly express the metaphysical positions, just because formal semantics is not concerned with what is 'real'.

Thus the use of a single big domain of quantification, as on the first proposal, is not implied by all its members being real; so the detenser may well endorse one of the more complex semantics. And the tenser will note that even these proposals do not capture her metaphysical thesis about reality. In particular, any such semantics requires 'now' and other temporal indexicals to be treated just as they were in the simple bivalent semantics. It is part and parcel of doing semantics—whether with two truth-values or more, whether with branching or not—that such indexicals get a straightfoward time-dependent reference. So the 'movement of the now', which for the tenser and presentist is the crucial fact about time, is represented only by the semantics' use of a family of interpretations, related to each other by 'sliding along' the reference assigned to 'now' etc.—exactly as in the simple semantics apparently favoured by the detenser![6]

So much by way of introducing themes about time, modality and semantics. It will be clear how each of my three connections relates, not just to the main debate, but to some of the specific issues mentioned. In brief: Section 2's connection relates to persistence over time, and semantics; Section 3's connection relates to how we understand indexicals; Section 4's connection relates to modality—namely with a bold idea for naturalizing it along the lines of the Everett interpretation of quantum theory!

2 Seeing the present

2.1 Dummett's remarks

My first connection is based on some remarks in the final Section of Chapter 11 ('Thoughts') of Dummett's *Frege: Philosophy of Language* (1973). The Section, entitled 'Token-reflexive expressions' is about whether Frege's doctrine that thoughts have an absolute truth-value has to be modified to allow for token-reflexive expressions. It is long (pp. 382-400), and moves seamlessly from the topic of variable truth-value (especially, from p. 385 onwards, with respect to time), to existence, and then to observation, and then to the semantic analysis of temporal language. But I will focus on his remarks about observation, on p. 388.

Broadly speaking, I will endorse Dummett's remarks—and report how long ago, I was inspired by them to make some philosophical hay of my own. But I will also note a disagreement with Dummett's use of the remarks (later in the Section) to argue that in semantics temporal indicators should be analysed as sentence operators (rather than as terms standing for times).

Dummett writes: 'What we think of as properties of material objects are, typically, things that can be predicated of them at a given time, and may be false of them at another time. The reason is quite obvious. The basic predicates of our language, those which we first learn to employ, are ones whose application can be determined by observation ... [and] ...an observation can determine only how [an] object is at some one time' (p. 388). There is a disanalogy with space here: observation is not thus restricted spatially. Admittedly,

[6] I believe this point is not affected by the complexities of allowing for relativization of truth-value to circumstances of assessment, as well as circumstances of utterance; but I cannot argue the point here.

one may not be able to the whole spatial extent of a very large object at once, but 'most observational predicates apply to an object as a whole considered as it is at a particular time' (p. 388).

Then in a footnote Dummett adds that 'most objects which we observe are close to us, relative to the speed of light and to the rate at which we make observations, so that in practice ... we take observation as revealing the state of the object at the time of observation ... [besides] ... the primary method of determining the application of an observational predicate can often be employed over a wide range of distances at which the object may be placed. Thus for practical purposes, we determine how an object is at a given time by observing it at that time' (p. 388).

These remarks essentially provide two asymmetries between time and space; (some remarks which I have omitted give details about this contrast with space). The first asymmetry (from the main text) is that in order to ascribe most observational predicates we need to observe the whole object; but as the predicate applies to the object 'considered as it is at a particular time', we do not need to observe the object's entire life-history. The second (from the footnote) is that usually we can ignore the time-lags involved in observing distant objects. That is, we can take observation to inform us of objects' properties and relations at the time of observation even if they are not at the place of observation.

2.2 The asymmetries endorsed—and exploited

I endorse both these asymmetries—with some clarifications, and for the same reasons, that I gave long ago. To avoid repeating those discussions, let me just summarise as follows. As to the first, my main reason lies in the fact that whatever our attitude to temporal parts might be, we all accept that objects have *spatial* parts which are genuine objects: people have arms, chairs have legs etc. Thus observational predicates tend to apply to whole objects—not so much because most objects are small enough, or transparent enough, to be observed in their entirety—but because, when they are *not* entirely observable, we take a spatial part of the given object, to be the object to which the predicate really applies. For details, cf. Butterfield (1985, pp. 41-42). Incidentally: Dummett rejects temporal parts, but in recent work says that the detenser should too (2003, pp. 51-52; 2004, pp. 86-88).

As to the second, my main reason is that, indeed, for the senses of sight, hearing and touch, most of the objects we observe rarely change their observable properties during the time-lag involved in the process of observation. (Smell is an exception: we can smell burnt toast long after the toast has stopped burning. So perhaps is taste.) A similar point applies to oral communication. We can usually ignore the time-lag in speech, i.e. take the speaker to (purport to!) believe what he said, at the time the hearer receives and understands the message, and not merely at the earlier time of utterance. Cf. Butterfield (1984a, Sections 2,3).

For this second asymmetry, it is also worth adding some details. For discussions often emphasize only that observation takes very little time, and in particular cite the amazing rapidity of light; and neglect the equally important issue of how long the observed object typically keeps the property in question. (For brevity, I shall set aside the corresponding points about communication.)

Thus there are two temporal factors to be considered:

(i) the typical time it takes to make an observation, i.e. the time it takes for a causal chain to leave the object, reach us, pass through our sensory system and finally yield an observational judgment; and

(ii) the typical time-scale on which the observed object keeps its observable property, i.e. the typical time-interval between changes in the property.

Provided (i) is smaller than (ii), we can (typically!) make a present-tensed observational judgment: such as 'there is a blackbird on the tree in the garden', rather than 'there was (or: was about N seconds ago) a blackbird on the tree in the garden'. In this blackbird example[7], the time (i) is so small—since, in particular, light is so fast—that, although birds often do not stay long on a tree, we can be confident that (i) is smaller than (ii), and thus that the present-tensed judgment is true.

Besides, this point—the importance of comparing (i) and (ii)—applies equally to the standard example of vast time-lags in observation, an example so striking and evocative that countless authors cite it: namely, looking at the stars. Almost all authors cite the example as a case of observing the past. Indeed, the Sun is eight light-minutes away, and the next closest star (or rather star-system: Alpha Centauri) is 4.2 light years away, the next closest is about six light-years away; and so on. But on the other hand, the property we observe is that the star is shining, i.e. burning. And most stars have a lifetime of millions or billions of years[8], while the radius of the Milky Way is 'only' about 50,000 light-years. So for observations of stars on our side of the Milky Way (we are 'near' the periphery of the disc), the time-lag in observation, (i), is at most 50,000 years. That is much smaller than (ii): the millions or billions of years that it takes for most stars to change as regards the property of shining or burning. In short: despite the vast time-lag, you can confidently say of the star you point at: 'It is now burning'.

Finally, an incidental remark about the rapidity of light: which tends to dominate discussions of the speed of observation. Aristotle believed that light is, not a propagation of anything at all (whether rays or waves or particles), but rather the transparency of the medium (typically air, of course). He gives as his reason the fact that at sunrise the entire landscape is illuminated at once. Thus he rejects a propagation travelling so fast over the miles-wide landscape (and then from each house, or tree or hill, to our eyes!), as to look to us as if it arrives everywhere simultaneously.[9] I take it this means that for him, such

[7]Taken from Dummett (2005, p. 680): who uses it for a very different purpose!

[8]The lifetime depends on the mass. The sun will live for about 13 billion years in all (it is now middle-aged). More massive stars burn faster and die younger: e.g. stars with ten times the mass of the Sun will last about 100 million years. But stars with one tenth the mass of our Sun last about 100 billion years.

[9]I thank Nick Denyer for the following passage from *De Anima*, Book 2, Chapter 7 (418b21-26: translated by J.A. Smith): 'Empedocles (and with him all others who used the same forms of expression) was wrong in speaking of light as 'travelling' or being at a given moment between the earth and its envelope, its movement being unobservable by us; that view is contrary both to the clear evidence of argument and to the observed facts; if the distance traversed were short, the movement might have been unobservable, but where the distance is from extreme East to extreme West, the draught upon our powers

a propagation would be 'unimaginably fast' in the literal sense: it is unimaginable, and accordingly to be rejected. And when you think about it, one can only sympathize with his rejection: the speed *is* stunning.

So much by way of endorsing Dummett's second asymmetry: in short, that usually we observe (and in speech, communicate with) the *present*, though spatially distant, state of affairs. But I also believe that this asymmetry leads to convincing explanations of three other time-space asymmetries that might be, and have been, taken to support the *tenser*. Namely:

(i): We more readily take as real the presently existing objects, wherever they are, than the objects that are at some time located here (e.g. Putnam 1967, Dummett 2003, p. 34; 2004, p. 52).

(ii): We are more apt to give sentences time-variable truth-values than space-variable ones (e.g. Dummett 1973, p. 386, 390).

(iii): We think of ourselves as sharing a common, albeit ever-changing, *now*, while we each have a different *here* (e.g. Gale 1964, p. 105).

These explanations are spelt out in Butterfield (1984a, Sections 4-6); and I will not repeat them. Suffice it to say that they are 'naturalistic' appeals to uncontroversial physics and psychology, and so will be welcomed by the detenser as 'explaining away' these asymmetries. They have also been further developed: Callender finds the third asymmetry the most compelling (2008, Section 3), and goes on to add many empirical details to my explanation (2008, Sections 4-6). On the other hand, since the science in these explanations is uncontroversial, I submit that the tenser should also accept them—and so has a responsibility to clarify whether she thinks any of these three asymmetries has a further content, or significance, which is not captured by these naturalistic explanations and which expresses part of her tenserism. So far as I know, this responsibility has not yet been discharged!

Finally, let me clarify that I do not especially intend to press Dummett on this last point. Despite the citations just given, he has not, so far as I know, urged any of (i)-(iii) as a straightforward argument for a tenser position. On the other hand, he does argue (1973, p. 389f.) that the two asymmetries (from his p. 388) which I have endorsed, perhaps together with related considerations, have consequences for semantics. Namely: they make it correct, or at least more natural, to analyse temporal indicators as sentence operators, rather than as terms standing for times. For a detailed critique of this argument, cf. Butterfield (1984b).[10]

of belief is too great.'

[10] A 'halfway house' semantics, in which temporal indicators that qualify singular terms (such as occur in trans-temporal comparisons like 'Toby was fatter in 1980 than William in 1982') are analysed as predicate modifiers, is developed by Butterfield and Stirling (1987, Section 4). For trans-temporal relations as a problem for the presentist, cf. Sider (2001, pp. 25-28).

3 The essential indexical—for branches

I take my cue from Dummett's discussion of McTaggart's argument for the unreality of time (Section 3.1). This leads to the Everett interpretation (Section 3.2), especially the indispensability of indexicals to express the uncertainty before an Everettian 'splitting' (Section 3.3).

3.1 McTaggart's argument

McTaggart's (1908; 1927, Chapter 33) argument forms a cross-roads where several aspects of the tenser-detenser debate meet, such as: the analogies and disanalogies between time and space, the relation between time and change, and the logical behaviour of temporal indexical expressions, especially 'is past', 'is present' and 'is future'.

Broadly speaking, the argument has two parts. In the first part, McTaggart argues that (i) time involves change, and (ii) change requires tensed facts (in his jargon: A-series facts), i.e. the objectivity of temporal becoming. McTaggart's reason for (ii) is that it is necessary, if change is to be distinguished from spatial variation in properties. In the second part, McTaggart argues that tensed facts involve a contradiction. This is a regress argument, in which he envisages iterating the temporal indexicals 'is past', 'is present' and 'is future'.

Dummett's (1960) defence proceeds as follows. He emphasizes that there are analogous regress arguments using spatial indexicals like 'is here' and 'is there' (or 'nearby' and 'far'), or personal indexicals like 'I' and 'you'; and that since McTaggart 'does not ... display the slightest inclination to apply his argument in this way to space or to personality' (p. 353), we should focus on the first part of the argument. Dummett endorses this first part (pp. 354-5); and in recent work, he apparently again concurs (2003, p. 51; 2004, pp. 87-88). He takes its conclusion to be that there cannot be an indexical-free complete description of a temporal reality (while there can be such a description of spatial reality). Here is one of his formulations: 'a description of events as taking place *in time* is impossible unless temporally token-reflexive expressions [i.e. indexicals] enter into it, that is, unless the description is given by someone who is himself in that time' (p. 353).

Dummett then raises the question how to reconcile this conclusion with the second part of the argument, and its avowed conclusion that time is unreal. After all, as Dummett says: the first part the argument seems to demonstrate 'the reality of time in a very strong sense, since it shows that time cannot be explained away or reduced to anything else' (p. 356). He suggests a reconciliation. Namely: he thinks that McTaggart is assuming that anything real must have a complete—that is: observer-independent, or indexical-free—description. He ends by raising the worry that McTaggart's conclusion that time is unreal is self-refuting: for even if the world is really atemporal, our apprehension of it surely changes. This worry prompts Dummett, in his last paragraph, to toy with applying *modus tollens*—directing it at the assumption he has just attributed to McTaggart. That is: he toys with the idea of denying that anything real must have an indexical-free description.

I of course cannot address all the themes Dummett raises; let alone other possible interpretations of McTaggart.[11] In this Section, I will only develop the idea of the 'essential indexical'; (and Section 4 will pick up on Dummett's closing discussion of whether time being unreal is self-refuting).

As we have just seen, Dummett here articulates this idea as specific to time, and as the conclusion of the argument's first part. But nowadays most philosophers take a more low-key view. They see the 'essential indexical' as applying equally to space and to personality; and as implying, *not* that there are 'perspectival facts' in some sense (the temporal variety being tensed facts), but only that indexicals are indispensible for conveying the contents of our thoughts and sentences.[12]

Broadly speaking, I endorse this low-key attitude to the idea of the essential indexical. But I want to report how the Everett interpretation of quantum theory yields a novel application of the idea. For it is an application with three features that might appeal to Dummett. First: it meshes somewhat with Dummett (1960)'s taking essential indexicality to be about time rather than space. For some of the considerations about the future being open etc. that prompt Dummett's view, are endorsed by the Everettian branching: roughly speaking, the open future is understood as the effective, but not fundamental, indeterminism associated with the 'collapse of the wave packet'. Second: it is metaphysically revisionary, albeit in a very different way than Dummett's anti-realism. Third: to understand it, one needs considerations drawn from the philosophy of language—which the philosophy of physics literature, to its credit, has already deployed.

3.2 The Everett interpretation

3.2.1 Everett's proposal for the measurement problem: a bluff?

I begin by describing the measurement problem and the Everett interpretation's response to it. The measurement problem ('Schroedinger's cat paradox') is the threat that the lack of values for physical quantities such as position, momentum and energy, which is characteristic of quantum theory's description of microscopic systems such as electrons, should also infect the familiar macroscopic realm of tables, chairs etc., with their apparently definite values for position, momentum etc. The threat is clearest if one considers a measurement situation. Quantum theory apparently predicts that measuring, for example, the momentum of an electron, when it is in a state that is not definite for momentum,

[11] By my lights, the main rival is Mellor's diametrically opposite interpretation (1981, Chapter 6, especially p. 92f). He rejects the first part of the argument, and endorses the second as showing temporal becoming (in his jargon: tensed facts) to be contradictory.

[12] This view was argued for, wittily and persuasively, by Perry (1979) and Lewis (1979); and since then, it has been often endorsed and developed. Examples in the philosophy of time are: Mellor (1981, Chapter 5, especially p. 78f), Butterfield (1984c, pp. 77-85) and Sider (2001, pp. 18-21). The view also has precursors, whom Perry cites, e.g. Castaneda. Butterfield (1986) gives a definition of content (for utterances and for propositional attitudes) that strikes a compromise between Perry and Lewis, who advocate contents that are psychologically narrow and have a relativized truth-value, and authors like Stalnaker and Evans who, in a 'neo-Fregean' way, advocate contents with absolute truth-values.

(a ‘superposition of momentum eigenstates’) should lead to the pointer of the apparatus having no definite position—it should be in a superposition of position eigenstates.

By about 1935, standard quantum theory had settled on the following response to this problem. One postulates that the quantum state of both the microscopic system and the apparatus changes discontinuously after the measurement interaction, so that the apparatus’ pointer gets a definite position. (This postulate is called the ‘projection postulate’; the change of state is called, more colloquially, the ‘collapse of the wave-packet’.) This is of course unsatisfactory, since ‘measurement’ is vague. And there is worse trouble: the projection postulate contradicts quantum theory’s usual law of how states change over time, viz. the Schroedinger equation, which prescribes a continuous and deterministic evolution.

Everett (1957) proposes that one can solve the measurement problem without any recourse to the projection postulate. In brief: he claims that the universe as a whole has a quantum state, which always evolves according to the Schroedinger equation. Agreed: the measurement problem suggests this state will be a superposition corresponding to many different definite macroscopic realms (‘macrorealms’). But Everett suggests that we should explain our experience of a single definite macrorealm, by postulating that all the various definite macrorealms are actual. Thus the universe (what philosophers nowadays call ‘the actual world’) contains a plethora of Everettian ‘worlds’, where each such ‘world’ is something like the familiar macroscopic realm, with all tables, chairs etc. in definite positions. But the worlds differ among themselves about these positions, i.e. about where the various macroscopic objects are; and we just happen to be in one world rather than any of the others.

Hence the various jargons. The Everett interpretation is also called the ‘many-worlds interpretation’. The universe, since it contains all these worlds, is called the ‘multiverse’. And the worlds are also called ‘branches’ since, as we shall discuss below, they are like branches of a tree, branching in one direction only—towards the future, not the past.

This dizzying vision obviously calls out for philosophical clarification, since it involves central metaphysical topics such as possibility and persistence through time. Indeed, it also bears on the relation between mind and matter. For some versions of Everett’s proposal envisage an ontology of many ‘minds’; i.e. they claim that to each sentient brain (a human’s, a cat’s ...) there corresponds a plethora of minds (or if you prefer, mental states): their experiences differing about such matters as the location of macroscopic objects; (cf. Donald 1997). So a philosophical literature about it has grown up: especially since the 1980s, with the growth of philosophy of physics.[13] As a result, the Everett interpretation has become in the last twenty years a leading approach to understanding quantum theory.

As I see matters, there have been three main developments: three reasons why the Everett interpretation now deserves to be centre-stage in quantum philosophy.[14] And to explain essential indexicality for branches, I need to review all three. But before

[13]The state of the art is represented by Saunders et al. (2010), and Wallace (2012): both of which are outstanding. My own efforts were Butterfield (1995, 1996, 2002a).

[14]This is not to deny that the interpretation remains controversial; and indeed, not precisely defined.

doing so (Section 3.2.2), it will be helpful to describe why the Everett interpretation was widely regarded until about 1990 as obscure and-or inadequate, even to the point of being condemned as a mere *bluff*.

Recall Everett's two main claims. Quantum theory can be interpreted:

(i) with no funny business about a measurement process inducing the quantum state to "collapse" indeterministically, according to which of the alternative outcomes occurs; and

(ii) with no theoretical posits supplementing the state (traditionally called "hidden variables") so as to represent which outcome occurs—or indeed to represent any other physical fact.

So Everett's view is that the deterministic Schroedinger equation is always right, in the sense that the quantum state of an isolated system always evolves in accordance with it. And the quantum state 'is everything' in the sense that values are assigned to physical quantities only by the orthodox rules. In particular, no quantity is preferred by being assigned, in every state, a value. (Contrast the pilot-wave approach, which proposes such values, usually for the quantity position.) But to reconcile this uncollapsed and un-supplemented quantum state with the apparent fact that any quantum experiment has a single outcome, Everett then identifies the Appearances—our apparent macroscopic realm, with its various experiments' outcomes—with one of a vast multiplicity of realms: the 'worlds' or 'branches'.

But however sympathetic one might feel to this dizzying vision, one naturally asks for a precise and general definition of a 'branch'. From the 1960s to the 1980s, Everettians usually defined 'branch' in terms of the pointer-quantity of a measurement-apparatus. So, rather like the pilot-wave approach, there was a preferred quantity with a definite value, albeit relative to a branch. But this sort of definition was not general enough, since there would no doubt be an apparently definite macroscopic realm, even if no experiments were ever performed, or no measurement-apparatus ever existed.

Agreed, this lacuna was understandable, since formulating a truly satisfactory definition would require one to consider all the various aspects of the "emergence" of the classical physical description of the universe. But it seemed that as long as the lacuna remained unfilled, the Everett interpretation was at best a vague promissory note.

Kent (1990) is a fine example of this sort of critique. Another influential voice was that of John Bell. For example, in his masterly introduction to interpreting quantum theory, he endorses the accusations of obscurity and vagueness, saying that the Everett interpretation 'is surely the most bizarre of all [quantum theory's possible interpretations]' and seems 'an extravagant, and above all extravagantly vague, hypothesis. I could almost dismiss it as silly' (Bell 1986, pp. 192, 194). Hence Bell favoured two other interpretations: supplementing the quantum state, as in the pilot-wave approach, or revising the Schroedinger equation, so as to describe the collapse of the quantum state in detail, as a physical process. As he puts it elsewhere: 'either the wave-function, as given by the Schroedinger equation, is not everything or it is not right' (1987, p. 201). But as I said: since 1990, Everettians have made three major improvements to their interpretation; and

I now need to review them.[15]

3.2.2 Three developments: decoherence, patterns and probability

3.2.2.A: Decoherence The first development is the theory of decoherence. (So this is mostly a matter of physics; the second development will be mostly philosophical, and the third a mixture of physics and philosophy.) Although the fundamental ideas were established in the early years of quantum theory (and were clear to maestros such as Heisenberg, Bohm and Mott), detailed models of decoherence were only developed from about 1980.

'Decoherence' means, in this context, the 'diffusion of coherence'. This is the fast and ubiquitous process whereby, for appropriate physical quantities, the interference terms in probability distributions, which are characteristic of the difference between a quantum state (a 'superposition') and a classical state (a 'mixture'), diffuse from the system to its environment.

In a bit more detail: at the end of the process, the quantum probabilities for any quantity defined on the system are as if the system is in one or other of a definite set of states. In many models of how a system (such as a dust-particle) interacts with its environment (such as air molecules), this set consists of coherent states. These are states which, considered as probability distributions, are sharply peaked for both position and momentum; so that a system in any such state is presumably nearly definite in both position and momentum. (But the distributions have enough spread so as to obey Heisenberg's Uncertainty Principle, which vetoes simultaneous precise values for position and momentum.)

For our purposes, decoherence has two important features: one positive, one negative. The positive feature is flexibility. Thus we expect the classical physical description of the world to be vindicated by quantum theory—but only approximately. Only some subset of quantities should have definite values. And maybe that subset should only be specified contextually, even vaguely. And maybe the values should only be definite within some margins of error, even vague ones. Decoherence secures this sort of flexibility. For the selection of the quantity that is preferred in the sense of having definite values (relative to a branch) is made by a dynamical process—whose definition can be legitimately varied in several ways. Three examples: the definitions of (i) the system-environment boundary, and of (ii) the time at which the interaction ends, and of (iii) what counts as a state being 'sharply peaked' for a quantity, can all be varied.

[15] Owing to lack of space, and in order to give the Everettians due credit, I shall only report the Everettian proposal, not the various criticisms of it that can be made. But I repeat the health warning at the end of Section 1's preamble. Although Everettians have with these three developments made great strides towards rebutting the traditional accusations of obscurity or inadequacy, their interpretation remains controversial.

Sad to say: John Bell died in 1990, so that his writings do not engage with these developments. In any case, the Everett interpretation is not the only target of Bell's accusations of obscurity and vagueness. He has similar doubts about two others in his list of six possible interpretations: namely, Bohr's complementarity interpretation, and the idea that consciousness induces the collapse of the quantum state (1986, pp. 190, 191, 194).

The negative feature is that decoherence does not just by itself solve the measurement problem. More precisely: it does not imply that the system is in one of the set of states (typically coherent states). It implies only that the quantum probabilities are as if the system were in one. Furthermore, the theory implies that the system is in fact not in one of those states (on pain of contradicting the original hypothesis that the total system-plus-environment is in a superposition, not a mixture). To put it vividly, in terms of Schroedinger's cat: at the end of the decoherence process, the quantum state still describes two cats, one alive and one dead. It is just that the two cats are correlated with very different microscopic states of the surrounding air molecules. For example: an air molecule will bounce off a wagging upright tail, and a stationary downward one, in different directions!

3.2.2.B: Patterns The second development is the application to the problems of quantum ontology, especially Schroedinger's cat, of the philosophical idea that an object in our 'higher-level' ontology, e.g. a cat, is not some kind of aggregate (e.g. a mereological fusion) of microscopic objects, but rather a dynamically stable pattern in them, of a special type—which type being spelt out by what we believe about cats (by our 'theory of cats'). This idea is of course associated with functionalism in the philosophy of mind, e.g. Dennett (1991); for the present application, cf. especially Wallace (2012, Chapters 2 and 3).

This idea promises to snatch victory from the jaws of defeat: the defeat just registered, that decoherence apparently does not by itself solve the measurement problem. Thus some of today's Everettians say that in the Schroedinger's cat scenario, the final quantum state's describing two cats, one alive and one dead, is a matter of the state encoding two patterns—and the description is entirely *right*.

This becomes a bit clearer if we adopt a specific representation of the quantum state, for example position. Then, roughly speaking: the final state is a wave-function on the cat's classical configuration space, with two peaks: one peak over some classical configurations corresponding to a perky cat, e.g. with a wagging upright tail, the other peak over some classical configurations corresponding to a dead cat, e.g. with a stationary downward tail. But in that case: according to the idea of cats as patterns, the quantum state does indeed represent two cats.

In other words: we see that we should take the measurement problem to be solved by exactly what decoherence secures: a final state describing a living cat and a dead one. In brief: the philosophical idea of higher-level objects as patterns vindicates the Everettian vision of a multiplicity of objects.

It is worth stressing (as Wallace, for one, does) that this line of thought is independent of quantum theory's details; and so it is also independent of its various weird features (e.g. non-locality). The point is closely analogous to one which we all unhesitatingly endorse for several other physical theories. Namely, theories in which states can be added together to give a sum-state, while the component states are dynamically isolated, or nearly so (i.e. do not influence each other). Examples include the theory of water-waves, or electromagnetism. So, says Wallace, we should also endorse it in quantum theory, and accept that there are two cats.

For example: the water in Portsmouth harbour can get into a state which we describe as, e.g. a wave passing through the harbour's centre heading due West; or into a state which we describe as a wave passing through the centre heading due North; or into a state which is the sum of these. But do we face a 'Portsmouth water paradox'? Do we agonize about how the Portsmouth harbour water-system can in one place (viz. the harbour's centre) be simultaneously both Westward and Northward? Of course not. Rather, we say that waves are higher-level objects, patterns in the water-system; and that there are two waves, with the contrary properties, one Northward and one Westward. Similarly for the electromagnetic field in a certain region, and e.g. pulses of laser light travelling in different directions across it.

And similarly, about the quantum wave-functions defined on the classical configuration space. There is a state with two cats, one alive and one dead. And of course, there are also myriad other states, the vast majority of which do not represent macroscopic objects (patterns!) which we might recognize (as cats or as dogs or as puddles or as mud or ...).

3.2.2.C: Probability The third development is the invention of various ideas and arguments about probability. These are addressed to two apparent problems about probability which the Everett interpretation faces: a qualitative one and a quantitative one. I will explain these in turn, but then concentrate on the former. For it is there that the idea of the essential indexical applies, as I promised in Section 3.1.

The qualitative problem is that probability seems to make no sense, if all possible outcomes of a putatively probabilistic process in fact occur—as the Everettian says they do. For according to the Everettian, the quantum state always evolves deterministically, even during quantum measurements and the other processes such as radioactive decay, that are traditionally taken as indeterministic 'collapses' of the quantum state into just one of various possible outcome states. Thus the Everettian says that during such a process, the quantum state evolves to include a term (i.e. a summand in a sum) for each possible outcome, and that the universe splits into many branches, in each of which one of the outcomes occurs.

I think that all Everettians (both nowadays and yesteryear) should agree that the answer to this problem must lie in invoking *subjective uncertainty*. The basic idea will be an analogy with how probability is taken as subjective uncertainty, for a deterministic process of the familiar classical kind. For such a process, a unique future sequence of states is determined by the present state (together with the process' deterministic law). But the agent or observer does not know this sequence in advance, either because she does not know the present state in full detail or because she finds it too hard to calculate the future sequence from the present state.

Similarly, says the Everettian: probability can be taken as subjective uncertainty, for a deterministic process of the *unfamiliar* Everettian kind. For such a process, a unique future sequence of 'global' states is again determined by the present quantum state (together with the Schroedinger equation). And here, unlike the classical case, one can assume the agent or observer does know the present state, and how to calculate from it the future sequence. But the agent or observer is nevertheless uncertain since, thanks to the impending 'branching' or 'splitting', she will not experience any such future 'global' state, i.e. she will not experience the outcomes corresponding to all its terms. At each future time, she will only experience one outcome—and is thus uncertain about which. Thus this kind of uncertainty, compatible with full knowledge of the global state and the laws, is rather like the self-locating uncertainty discussed by philosophers under the heading 'the essential indexical' (cf. again Perry 1979, Lewis 1979).

So much by way of a brief statement of the Everettians' answer to the qualitative problem. But the phrase 'rather like' papers over a debate about the exact nature of this uncertainty. I will take this up in Section 3.3. Before doing so, I set the stage by briefly reviewing: (i) the second apparent problem about probability, i.e. the quantitative problem, and (ii) how Everettians nowadays propose to answer it.

(i): I can introduce the quantitative problem by again imagining that a quantum system is subjected to a sequence of measurements. Then according to the Everettian, the quantum state evolves over the course of time so as to encode all possible sequences of outcomes: formally, it has a term (i.e. a summand in the sum) representing each sequence of outcomes. For example, consider a toy-model in which there are ten measurements, each with two outcomes (H and T say!). Then there are $2^{10} = 1024$ sequences of outcomes; and so the Everettian will say there are 1024 terms in the quantum state.

Since according to the Everettian, each such sequence actually occurs, it seems at first that the probability of a sequence should be given by the naive 'counting measure': each sequence has probability 1/1024. And so more generally, it seems that the probability of an event corresponding to a set of sequences, such as three of the ten measurements having outcome H, is the sum of the elementary probabilities of its component sequences. But this amounts to assuming that the two outcomes H and T are equiprobable (and that the measurements form independent trials in the sense of probability theory). And this spells disaster for the Everettian. For the counting measure probabilities bear no relation to the orthodox quantum Born-rule probabilities; (called 'Born-rule' probabilities, after Max Born who in 1927 first stated the probabilistic interpretation of the quantum state, for the special case of position probabilities). And so 'counting worlds' seems to conflict with quantum theory's treatment of probability.

(ii): Today's Everettians have a twofold answer to this. (An Everettian can endorse each part independently of the other, but has every reason to endorse both.) The first part is to point out that decoherence, thanks to its flexibility, refutes the toy-model with its naive counting measure. (Cf. Section 3.2.2.A, above.) That is: on any precise definition of 'branch' for the systems concerned, there will be trillions of branches, wholly independently of the number of kinds of outcome registered by the measurement apparatus (in my example: just two, H and T). And more important: because decoherence is vague, there is *no* definite number of branches which we need to—or could!—appeal to in order to give an account of probability. In short: the naive counting measure is a chimera and a canard—to be rejected out of hand.

The second part of the answer is that Everettians have developed various arguments, even rigorous theorems, that justify the values of the quantum probabilities; (as the jargon has it: 'justify the Born rule'). I will summarize one such line of argument. It was initiated by Deutsch in 1999, and developed by Wallace from 2002 onwards; it is nowadays called 'the Deutsch-Wallace programme'. (For details, cf. Saunders et al. (2010, Chapters 6-12), Wallace (2012, Chapters 4 to 6); the former includes criticisms of the approach.) Justifying the Born-rule may sound, to someone not immersed in quantum philosophy, a very arcane topic. But in fact, this topic engages closely with familiar central issues in philosophy of probability, like chance, credence and the relations between them, such as David Lewis' 'Principal Principle' (1980).

The Deutsch-Wallace programme builds on the previous Everettian answer to the qualitative problem, i.e. the invocation of subjective uncertainty. Recall the tradition, in subjective decision theory, of representation theorems to the following effect: an agent whose preferences for gambles (encoding certain degrees of belief and certain desires) conform to a certain set of axioms, which look to be rationally compelling, must have degrees of belief that are represented by a probability function. (Such theorems go back to authors such as Ramsey, de Finetti, Savage and Jeffrey.)

There is a lot to say, both technically and philosophically, about such theorems. But for our purposes, we need only note that these theorems do not dictate a specific probability function. This is of course as one would expect: surely, rationality should not dictate specific degrees of belief in arbitrary propositions!

But Deutsch and Wallace prove theorems with precisely this feature, about the specific scenario of making gambles on the outcomes of quantum measurements. And the probability function that is dictated by their axioms (which, as in the tradition, look to be rationally compelling) is precisely the orthodox Born-rule of quantum theory! To sum up: we have here an argument to the effect that, *pace* the above objection to the naive 'counting measure', the Everettian framework not only accommodates, but even *implies*, the Born rule.[16]

Even from this brief and vague statement, it is clear that these representation theorems are very remarkable: one might say, amazing! Indeed, they are remarkable, both technically and philosophically, and are a gold-mine for the philosophy of probability.

To sum up this Subsection: it is clear that, even apart from the philosophy of time and the essential indexical, the Everett interpretation is full of philosophical interest. And this is not just because the original vision of 'branching' or 'splitting' desperately needs to be made precise in relation to topics such as ontology and probability. Also, and more positively: the three developments of the last twenty years have both substantially improved the Everett interpretation and connected it in richer detail with such topics.

[16] A bit more precisely: Deutsch and Wallace show that an agent, who is about to observe a sequence of quantum measurements, who also knows the initial state of the quantum system to be measured, and who is forced to gamble on which outcomes she will see (in the Everettian sense of 'splitting'), and whose gambling behaviour is subject to certain rationality axioms—must apportion her degrees of belief (as shown by her gambling behaviour) in accordance with the Born-rule.

3.3 How to understand branching?

I return to the qualitative problem about probability presented at the start of Section 3.2.2.C: how can talk of probability, uncertainty and similar concepts make sense in a situation where all possible outcomes occur? The answer to this is controversial, and I will only report the recent views of Wallace: views which I favour, and which have the merit, for connecting to Dummett's views, of invoking considerations in the philosophy of language. So what follows is a glimpse of Wallace (2005; 2006; 2012, Chapter 7). (Note: Wallace emphasizes that his views develop earlier work by Saunders. For discussion, including contrary views, I also recommend e.g. Greaves (2004); and the debate between Saunders and Wallace and Tappenden—for references, cf. the latest round, Tappenden (2011).)

It will help to focus, as the literature often does, on as simple a case of Everettian branching as possible. For example, consider a quantum measurement with just two possible outcomes, say 'up' and 'down' for a measurement of spin (which is a two-valued quantum quantity). We also want to set aside the sort of uncertainty about the future that arises even under classical determinism (mentioned in Section 3.2.2.C): namely, when an agent or observer does not know the present state in all its details and-or lacks the skill to calculate the future state from all those details. So to focus better on what is distinctive of the Everettian case, we envisage an observer of the quantum measurement, Anna, who knows all the relevant details—the prior state of the quantum system being measured, the details of the apparatus etc.—and suffers no limitations about calculating. In particular, Anna can calculate the two outcomes' Born-rule probabilities. ('Probabilities', as we call them! Of course, the Everettian's right to call them that is what is at issue.) Since we are concerned with the qualitative problem about probability, not the quantitative one, we may as well take the outcomes to be equi-probable: each with probability one-half.

So: what should Anna's attitude be before the measurement? There are two rival lines of thought: intuition pulls in two directions. I shall follow Saunders and Wallace in endorsing the first line. But of course, my aim is not to contribute to the debate; to do that in so small a space, for a debate so vigorous, would be a tall order! I aim only to summarize Wallace's views, so as to exhibit: (i) the appeal of the 'essential indexical' and (ii) the role of considerations from the philosophy of language.

So here is the first line of thought. Anna should feel uncertain of the outcome, despite her knowledge of all the physical details, and even if she is a convinced Everettian. For she will not observe both outcomes. Rather: according to the Everettian (and Anna herself, if she is convinced) Anna, along with other emergent macro-objects like the apparatus and its pointer, will split in the course of the measurement, some of her successors seeing 'up', and some seeing 'down'—and of course, some others seeing no outcome because the measurement goes wrong, or they faint during the measurement, or they slip on a banana-skin and get concussed, or ... . But we can leave these unfortunates aside: they do not affect the ensuing argument.[17] So we can take it that any successor sees 'up', or

[17]Of course, in a well-designed experiment, in a well-run lab (without banana-skins!), these unfortunates will have low Born-rule probability, and would therefore also be discounted in many other discussions,

sees 'down'. And of course, no successor sees both outcomes—although both occur in the Everettian multiverse. Hence the uncertainty before the measurement.

Hence also the idea that the proposition about which Anna is uncertain is indexical, or self-locating, in the sense of the phenomenon of the essential indexical: though of course, the 'dimension' of indexicality is—not one of that familiar trio, space or time or personality, but—what one might call 'branchness'. However, it is natural to express the indexicality with 'I' and similar words like 'my successor', since our discussion is concerned with a person's uncertainty, and we naturally envisage that the time and place of the measurement can be robustly identified between the different Everettian branches and can be known by the person. Thus Anna, sitting with eyes closed at 11.59 at the Cavendish Lab., Cambridge, waiting to open them at noon in order to see the outcome, will find it natural to say: 'I wonder whether I [or: my successor], at noon in Cambridge, will see 'up''. (But cf. Butterfield (1995, pp. 141-142): which (i) warns that, though this use of 'I' is natural, it does not imply metaphysical doctrines about personal identity, and (ii) points out that we can indexically specify branches by 'this branch' etc.)

I endorse the intuitions of the last two paragraphs; (following Saunders and Wallace). But on the other hand, I admit that it violates some apparently compelling principles about knowledge, expectation and uncertainty. Thus Greaves (2004) states two such:

> ... whatever she knows she will see, she should expect (with certainty!) to see. So she should (with certainty) expect to see spin-up, and she should (with certainty) expect to see spin-down. (Not that she should expect to see both: she should expect to see each.) (p. 440) ... I [meaning in this context: any rational person] can feel uncertain over P only if I think there is a fact of the matter regarding P of which I am ignorant (p. 441).

Greaves goes on to develop her own account of Everettian branching, which has come to be called 'the fission programme'; as against Saunders and Wallace's 'subjective uncertainty programme'.

I will not go into further details about this dispute. Suffice it to make three points; the second and third will be the positive and important ones. First: Wallace replies to the apparent appeal of the principles formulated by Greaves. In particular, he diagnoses an ambiguity between: a true non-technical interpretation, which is no problem for the Saunders-Wallace subjective uncertainty view; and a contentious technical one; (cf. especially his (2006, p. 667f; 2012, Chapter 7.6.)

Second: Wallace (especially 2005; 2012, Chapter 7.3-7.5) spells out two rival proposals for the semantics of a language spoken by people in a universe subject to Everettian branching; and he considers the case where they know the universe branches, and the case where they do not—and the case where they discover that it does! (Wallace says 'model' not 'proposal': but I prefer the latter, since 'model' has many other uses, especially in semantics!) I will only need the main contrast between these proposals, not their details. For that contrast will be enough to show that the proposals underpin, respectively, the

e.g. of the confirmation of quantum theory—assuming we have a solution to the quantitative problem.

rival intuitions about Anna's state of mind, her certainties and uncertainties, and about what we should say about them. My third point will then be about how to choose between the proposals.

Both proposals assign to sentences truth-conditions (not conditions of assertibility or justification—apologies to Professor Dummett!) in terms of 'possible worlds', i.e. roughly, total possible courses of history.[18] The contrast comes in how each conceives of a possible world. For the first proposal, a possible world is an Everettian branch. For the second proposal, a possible world is a trajectory through the quantum mechanical state-space, i.e. a specification for each time of the quantum state of all the systems concerned—in principle, the quantum state of the whole universe. So on the second proposal, a possible world is an entire branching structure, with all its branches.

This contrast is enough to show how the proposals will differ radically on propositions about the future—and so will line up, respectively, with the two rival intuitions about Anna. Thus consider the first proposal. It will function like a branching semantics of the sort often advocated by semanticists (especially tense-logicians) and metaphysicians to model the idea of 'fixed past, open future'. The simplest version of such a semantics will say that a proposition, evaluated at a time t (where 'time' denotes a node in the tree, rather than a 'rank', i.e. set of nodes at the same 'height'), which is about the future, is true just in case what it says holds good on every branch through t. For example: let the proposition be, in the usual tense-logical notation, $F_n p$, 'It will be the case in n units of time that p'. Then the proposition $F_n p$ is true at the node t provided p is true at all nodes that are n units to the future of t.

Let us apply this to the case of Anna's measurement, with t being 11.59—i.e. before the measurement, in a branch defined informally by the past macroscopic ('coarse-grained') history of Anna, her apparatus, her laboratory, her environment ... the universe—and with the measurement being completed at noon. We get the following verdicts:

(i): 'the spin will be up' and 'the spin will be down' are both false at t; since each fails to hold in some of the future branches through t;[19]

(ii): 'the spin will be up or the spin will be down (but not both)' is true at t.

Agreed, we have obtained these verdicts from what is merely the simplest truth-clause for a future-branching semantics. There are two points here. First, I have followed Wallace's (2005) proposal that sentences ascribed truth-values relative to a time, i.e. a node in the tree; whereas he prefers now (2012, Chapter 7.3-7.5) to ascribe truth-values relative to a branch. But I shall not pursue this contrast.

Second, there are future-branching tense-logics that model the idea of a single actual future, with respect to which future-tense propositions are to be evaluated. Namely, they

[18] But the proposals may be closer to Dummett's concerns than meets the eye, largely because they are focussed on future uncertainty. Thus Wallace surmises (personal communication) that they could be restated, *mutatis mutandis*, in terms of conditions of assertibility or justification.

[19] It is tempting to say, not just 'fails to hold in some branches', but also 'fails to hold in about half of the branches'. As explained in Section 3.2.2.C, this is legitimate—provided that the quantitative problem of probability has been solved, that the Born-rule probabilities for the two outcomes are indeed about one-half, and that one means 'about half' in the sense of the Born-rule measure, rather than in the sense of some (non-existent!) counting measure on branches.

single out, relative to every node t of the tree, one future branch through t: it represents the 'actual' future in that the truth-clauses for $Fp, F_n p$ refer only to it, not the other future branches through t.

But for present purposes, we should stick to this simplest proposal, for two reasons. First, for Everettian branching, all the future branches through t are equally real: recall that we, and our branching semantics, are not trying to model indeterminism or stochasticity as ordinarily or classically understood. Second, recall that our overall aim is to model—to better understand—Anna's certainties and uncertainties, and so her degrees of confidence, encoded in her subjective probabilities. Thus to clarify the contrast with the case of classical indeterminism, we assumed that she knew all the details of the initial quantum state, and suffered no calculational limitations. Accordingly, since high subjective probability controls assent to propositions (*ceteris paribus*, and allowing for Gricean rules of conversation), it is to the *credit* of this simple proposal that its verdicts for truth and falsity match Anna's certainties and uncertainties: for example, her willingness at 11.59 to assent to (or even assert) 'the spin will be up or the spin will be down (but not both)', and her then rejecting both 'the spin will be up' and 'the spin will be down'.

On the other hand, let us now consider the second proposal. According to this, a possible world is uniquely specified by an initial quantum state of the systems concerned (in principle, the universe), and its deterministic (i.e. orthodox unitary) time-evolutes. So a possible world comprises an entire branching structure. As a result, the semantics in terms of worlds, thus defined, does *not* branch: it is linear. Although—assuming Anna's measurement is correctly performed—there will be branches future to $t = 11.59$ with spin up, and also branches with spin down, all these branches are contained in the same possible world. Thus the truth-clause for propositions about the future will be 'blind' to worlds' inner structure, and so we get the following verdicts:

(i'): 'the spin will be up' and 'the spin will be down' are both true at t; since each holds in some of the future branches through t; (again, we might say 'about half the branches'—cf. footnote 19);

(ii'): 'the spin will be up or the spin will be down (but not both)' is false at t.

Third, and finally: How to choose between these proposals? This is where, according to Wallace, philosophy of language—as against semantics or logic—enters the arena. (At last, I fulfill my promise to connect with this area of Dummett's interests!) More specifically: principles of interpretation enter, in particular the principle of charity; or perhaps better, the principle of humanity. For present purposes, we need such principles only in a very rough form, such as the following. First, charity: we should so interpret people's words that the beliefs we thereby take them to express are (by our lights!) mostly true. Or perhaps better, as proposed by the principle of humanity: their beliefs come out as mostly true (by our lights!), except when we can explain their error, for example by their not having as much evidence as we do.

Thus Wallace argues that these principles clearly favour the first proposal, especially for the interpretative situation in which *he* finds himself: namely that of a convinced Everettian whose task is to interpret the speech and behaviour of others, such as Anna, who conduct quantum measurements. He sees that these people profess uncertainty about measurement outcomes, i.e. they assent to and reject propositions, very much along the lines of (i) and (ii), rather than along the lines of (i') and (ii'). Thus charity (or humanity) dictates that we favour the first proposal over the second.

4 The reality of the past?

4.1 A curious similarity

My third connection between Dummett's writings and the philosophy of physics is a curious similarity between an idea he formulates—roughly, that statements about the past, if true at all, are true only in virtue of present traces—and the denial of time by Julian Barbour, the physicist and historian of physics (1999).

To be sure, there are three crucial differences between the two ideas. First: Dummett's views about the idea—which I will follow him in calling, for short: that the past is unreal—have varied over the years, as Dummett has explored the issues. (He first articulated the idea in his (1969), and returned to it in more detail in (2003, 2004).) On the other hand, Barbour gave a canonical statement of his denial of time in his (1999).

Second and more important: as will be clear below, none of Dummett's formulations are exactly Barbour's doctrine. In summary, the main difference is that:

(i) according to Dummett's idea: all states of affairs about spatiotemporally localized subject-matters are unreal, except (a) those that happen to be now known to hold (or not to hold), and (b) those whose holding good or not is now effectively decidable; while

(ii) according to Barbour: all states of affairs about spatiotemporally localized subject-matters are equally real—or what comes to much the same thing: equally unreal![20]

Agreed, that summary is indeed obscure—but it will be clear by the end of Section 4.4! And in any case, there is another difference, which is already comprehensible. It concerns past-future symmetry. Barbour's denial of time is the same for the future as for the past. But Dummett's idea, at least in many of his formulations, tends to condemn the past to a more endemic unreality than the future. For on the one hand, singular observational statements about the future seem effectively decidable—we naturally envisage making an expedition to the place and time in question, with instruments, if need be, in hand. On the other hand, for analogous statements about the past, there is no such procedure: although we can scrutinize all the present evidence (traces), this gives no guarantee of getting any evidence either way about the statement in question.

Third: Dummett is clear that he does *not* believe in the unreality of the past—nor

[20] I have stated the ideas in terms of states of affairs. But nothing hangs on this jargon. I could have spoken of things or events or facts; compare Section 1.2's shorthand, 'things etc.', for however one conceives the material contents of spacetime. I have also stated them 'ontically, not semantically', as Barbour but not Dummett would tend to. Dummett would speak of statements e.g. about the past being neither true nor false, except (a) those that happen to be now known to be true or false, thanks to present evidence (traces), and (b) those that are effectively decidable. But again, I believe that nothing hangs on this way of stating the ideas.

does he wish to. He focusses on it just because it seems, worryingly, to be implied by his advocacy of truth as justifiability. By this latter, I mean the over-arching theme of his work, which I praised in Section 1's preamble. In yesteryear, it was usually called Dummett's 'anti-realism' (or 'intuitionism'); nowadays, he calls it 'justificationism'. More details in Section 4.2. On the other hand, Barbour is clear that he *does* believe his denial. And, at least so far as I know—and to the extent that we may 'speak with the vulgar' about whether his views change in a time that he denies!—he has endorsed this statement since then, e.g. in his (2006, pp. 149-152).

Nevertheless, I submit that the two ideas are similar enough to be worth putting beside each other—thereby inviting the reader to make a comparison. And fortunately, although Barbour's view is Everettian in some respects, it will be possible (and clearer) to state it using only a broad idea from classical physics, especially mechanics. We will need only the idea of instantaneous states of the system (the universe!) being given by configurations, such as arrangements in space of various point-particles. But I should stress here that, to find any *reasons* for Barbour's view, as against just stating it, one has to turn to quantum physics: more specifically, to Barbour's interpretation of an approach to quantizing general relativity, called 'quantum geometrodynamics'. That is a complex and controversial subject within physics, and I set it aside completely (cf. Butterfield (2002, Section 3.2) for a discussion), except to repeat the health warning I gave in Section 1. Namely: Barbour's reasons are more controversial than the Everett interpretation: indeed, I would say they are idiosyncratic.

I will again first adumbrate Dummett's discussions (Section 4.2). Then, as a prerequisite to understanding Barbour's view, I expound a view I shall call 'spontaneity' (Section 4.3). Finally in Section 4.4, I state Barbour's view.

4.2 Dummett's discussions

In his (1969), Dummett formulated a kind of anti-realism about the past. It is based on his over-arching theme: that empirical statements that are not effectively decidable violate bivalence, and should obey intuitionistic logic or a close cousin of it.

Thus the opening point is the fact that statements, or at least most statements, about the past are undecidable. Though we can of course search for evidence for or against the statement, we are not guaranteed to find any evidence, let alone evidence we would consider conclusive. Besides, we are pretty sure that for countless ('most') statements about the past, even about straightforward observational matters, we will never have evidence for or against it. For example, consider: 'it rained on the battlefield of Hastings, eleven days before the battle in 1066'. Or (if the chroniclers recorded the weather much more assiduously than I imagine they did): 'there was once a *Tyrannosaurus rex* where Nelson's Column now is'. This seems to imply that statements about the past are neither true nor false, except (a) those that happen to be now known to be true or false, thanks to present evidence (traces, including memories), and (b) those few (if any) that are effectively decidable. For, these exceptions aside, there is nothing *now* in virtue of which they can be true.

But as mentioned in Section 4.1, Dummett has never welcomed this conclusion. When he returned to the topic in his (2003, 2004), now calling his approach to the theory of meaning 'justificationism', he wrote:

> I am indeed attracted by a justificationist account of meaning; at the same time, I have long been worried about reconciling the reality of the past with that account ... When I began to write [my (1969)], I had hoped to arrive at one or the other conclusion: that antirealism about the past was a benign and acceptable view; or that it was incoherent, and that its incoherence would expose a fallacy in the argument for a justificationist theory of meaning. In the result, the conclusion that I reached was the most disappointing possible. Antirealism about the past was *not* incoherent; but it was not believable, either. I have been perplexed by this matter ever since (2004, p.45).

Similarly, in reply to Peacocke's (2005) discussion of his (2004), he writes that the application in his (1969) of justificationism to the past resulted

> ... in a doctrine very hard indeed to believe. The doctrine was also, to me and surely to most people ... repugnant: it involved, in language unacceptable to a proponent of that doctrine, that past events, the memory of and evidence for which had dissipated, were expunged, not merely from our knowledge, but from reality itself: they were no more; they had not happened. ... I felt bound to accept that it was a genuine consequence of justificationism. But I remained deeply uneasy about this conclusion ... My Dewey lectures were an attempt to show that a justificationist could allow a statement about the past to be true in the absence of any present evidence for it (2005a, p. 672)

This is not the place to pursue that attempt. Suffice it to report, as an advertisement for Dummett, a reason he gives why 'the justificationist cannot make it a criterion for the truth of a statement that we possess the means of verifying it' (2005a, p. 674). The reason lies in the fact that 'truth is what is transmitted from the premises of a valid argument to its conclusion' (ibid.); and there are countless cases where we have the means to verify, and even have verified, the premises, but we lack the means to verify the conclusion. Dummett gives the example of Euler's famous argument (theorem) that anyone walking across all the bridges of Koenigsberg must walk across at least one bridge more than once. Thus: 'we can easily conceive of observers stationed at each bridge, each of whom leaves his post as soon as he sees the walker crossing that bridge but reports only later without giving the time of crossing; we have then no means of identifying a bridge he has crossed twice' (2004, p.44; also 2003, p. 27; 2005a, p. 674).

From this, Dummett concludes: 'the justificationist must therefore retreat to saying that an empirical statement is true if it *could have been* verified (2005a, p. 674). Similarly: 'a statement about the past could be true if someone at the relevant time could have verified it, even though all reason for asserting it may have blown away' (2004, p. 45); and expressed a bit more generally: 'the justificationist explains truth in terms of what is, or can be, or could have been known' (2004, p. 92).

He also remarks: 'this conclusion ... must come as a relief to anyone attracted to such an account of meaning and yet troubled about the reality of the past' (2004, p. 44). Thus for him, the task becomes one of stating and defending an exact construal of 'could have been verified', and similar phrases, that secures the reality of the past, yet without collapsing into the opposing realist view (in particular, endorsing bivalence). For that task and for assessment whether he succeeds, I recommend, in addition to Dummett's writings, the critiques by Peacocke (2005) and Moretti (2008).

4.3 Spontaneity

I turn to what I will call 'Spontaneity'. Explaining (but not endorsing!) this doctrine is a necessary preliminary to stating Barbour's view. (For it will be yet another sense in which one might 'deny that time is real'.) Besides, some of the comments below about Spontaneity carry over directly to Barbour.

Spontaneity presupposes the idea of a set of many possible courses of history, where each course of history is a 'block universe' *a la* detenserism. But Spontaneity then proposes that unbeknownst to us, the actual history jumps between disparate instantaneous states.

To explain this, let us suppose we are given, either in metaphysics or in physical theory, a set of possible courses of history. Setting aside for a moment the debate between detensers and tensers, we naturally think of one of these as 'real' or 'actual' (also: 'realized' or 'occupied'). And—especially in physics, if not metaphysics—we think of these possible histories, including the actual one, as continuous in time. That is, we think of a possible history as a sequence of instantaneous states of the world (in metaphysics) or of the system (in physics); and we think of the set of all possible instantaneous states as having a topology, or some similar 'nearness-structure', so that it makes sense to talk of states being close to each other. And because, as we look about us, we seem to see the state of the world changing continuously, not in discrete jumps, we naturally think that the possible histories should be not merely sequences of instantaneous states, but continuous curves in the (topological or similar) space of such states. So we think of a collection of curves, each curve representing a possible course of history; and we think of one such curve as real, as actual.[21]

Now I can state Spontaneity more fully. It denies that the possible histories (including the actual one) need to be continuous in this sort of sense, and even that 'larger' discontinuous changes need be less probable. It urges that the possible histories, in particular the actual one, jump about arbitrarily in the space of instantaneous states.

This mind-bending doctrine calls for three comments: rather a lot, but they will shed a lot of light on Barbour.

(1): *Locked in the present*: At first sight, Spontaneity seems flatly incompatible with our impression that the state of the world changes continuously. But it might just

[21] I have deliberately avoided being precise about technical matters such as the topology of states, and whether to require some kind of smoothness (differentiability) as well as continuity. For they differ from one theory to another; and make no difference to the discussion to follow.

be compatible. For the advocate of Spontaneity will argue that our evidence for that impression—indeed, all evidence for all empirical knowledge!—consists ultimately in correlations between experiences, memories and records that are defined at an instant. Thus: a present observation is not checked against a previous prediction, but rather against a present record of what that prediction was. John Bell put the point as follows:

> ... we have no access to the past. We have only our 'memories' and 'records'. But these memories and records are in fact *present* phenomena. The instantaneous configuration ... can include clusters which are markings in notebooks, or in computer memories, or in human memories. These memories can be of the initial conditions in experiments, among other things, and of the results of those experiments. (1981, p. 136; cf. also his (1976a), p. 95.) [22]

This predicament, that epistemologically we are 'locked in the present', implies that any jumps of the type that Spontaneity advocates would not be perceived as such. Immediately after the jump, the new instantaneous state, at which the actual history has arrived, contains records fostering the illusion that the state in the recent past was near (in the topology of the state-space) *it*—and so not near the actual predecessor, which is now a jump away.

(2): *Scepticism?*: But philosophers will recognize that this idea, that we are 'locked in the present', is very questionable. One obvious objection one might offer against it is that even our most immediate mental states have a duration; and for some states, a long duration may even be necessary—can you feel deep grief for only a second? This undermines Spontaneity's claim to be able to characterize our evidence as records etc. at an instant.

Here, I say 'philosophers will recognize' and 'obvious objection', because Spontaneity is in effect a form of scepticism: viz., scepticism about what occurred in the past. More precisely: Spontaneity becomes such a form of scepticism, if one defines it as saying, not that the actual past course of events *was* a discontinuous sequence of states, jumping about very differently from what we naively believe; but rather that for all we know, the actual past could have been such a sequence.

So an obvious strategy for replying to Spontaneity is to adapt strategies fashioned for the more familiar case of scepticism about the external world. And the objection above is just the analogue against Spontaneity of the familiar objection against scepticism about the external world: that our evidence cannot be characterized except in terms of that world.

(3): *The content of perception*: This objection against the idea that we are epistemologically 'locked in the present' (and hence against Spontaneity) should be distinguished from a different idea, which also seems to be evidence against Spontaneity—but which is readily enough answered.

This second idea is that in some cases the *content* of perception requires continuity.

[22] Bell's paper, arguing that spontaneity fits the Everett interpretation, was influential in philosophy of physics, not least on Barbour himself and me (Butterfield 1995, Section 7; 1996).

(So the distinction from (2) turns on the familiar contrast between a mental state and its content.) The obvious cases involve visual perception of motion: e.g. watching a kingfisher in flight (Barbour 1999, pp. 17, 264). Such cases are indeed evidence against Spontaneity, *if* the content is veridical—e.g. if the kingfisher really has a continuous flight-path.

But an advocate of Spontaneity can dig in her heels. That is, she can say that the contents of such perceptions just are *not* veridical, except occasionally—when no 'jump' occurs in the relevant time-period. And she can explain away the compelling appearance of continuous motion, by saying that the state to which history jumps, when one judges, say, 'the kingfisher is flying to the right over the centre of the pond', involves the simultaneous presence in the brain at that time of (delusive!) 'records' of configurations of the kingfisher a bit to the left of the pond's centre. (Barbour's answer will be similar. He will also appeal to the simultaneous presence in the brain of delusive records; but with the difference that according to him, there is no actual past motion, not even a jumpy one!)

4.4 Barbour's vision: time capsules

I can now state the essentials of Barbour's denial of time. In short, it is a hybrid of Spontaneity and a strong realism about all the possible instantaneous configurations—a realism analogous to Lewis' well known realism about all possible worlds (1986).[23] Here, as mentioned at the end of Section 4.1: 'configurations' means, roughly, 'state', in a sense appropriate for a mechanical theory, e.g. the instantaneous arrangements in space of all the point-particles in the system.

Recall that Spontaneity has a single real course of history among the many merely possible ones: its novelty is to hold that this single actual history jumps about—instead of being a continuous curve in state-space. On the other hand, Lewis' modal realism—adapted to the state-space of some theory, rather than to Lewis' set of all logically possible worlds—makes no heterodox claims about dynamics. Its novelty is to hold that the possible courses of history (each nicely continuous) are all equally real—instead of just one curve in state-space being picked out as real.

Barbour proposes to go further than Spontaneity's denial that the actual history is continuous. He denies that there is an actual history (either past or future): there is *just* the space of all possible instantaneous states of the universe. So here 'all possible configurations' does not mean all logically possible configurations, but rather 'all the configurations of our mechanical theory'. The set of them is called 'the configuration space' (Barbour is a Machian; so for him, the mechanical theory will use relative configurations: but we can ignore this aspect of his views.)

And on the other hand, Barbour takes these configurations to be all equally real, just as Lewis holds the various possible worlds (i.e. possible courses of history) to be equally real. He of course concedes that one can mathematically define sets of configurations;

[23]Another way to think of it is that Barbour's view is a hybrid of presentism and a Lewis-like realism about all the possible instantaneous configurations.

and in particular continuous curves (since the configuration space will presumably have a topology), and even curves that obey some laws of motion, e.g. as given by a 'least action' principle, as in mechanics. But these sets and curves are 'just mathematical': there is no actual physical history faithfully represented by one of the sets—not even (*à la* Spontaneity) by a discontinuous set.

That is Barbour's core idea. He obviously needs (as did Spontaneity in Section 4.3) to explain away our impression that there is history, and a continuous one to boot. More specifically, he needs to argue that we are epistemologically 'locked in the present', and that the content of any perception that requires temporal duration (e.g. motion-perception) is, despite appearances, false.

Barbour (1999) goes part of the way to doing that. In particular, as regards the second issue—the delusiveness of motion-perception—he takes (what we call!) perception of a kingfisher flying to the right over a pond to involve the brain containing a whole collection of (what we call!) records of configurations of the kingfisher and the water. But not just any collection. Not only are these configurations similar, i.e. near each other in some topology or metric on configurations; also, they can naturally be given a linear order, so that they correspond to points along a curve in the configuration space; (1999, pp. 29-30, 264-267). And as we saw in Section 4.3, the advocate of Spontaneity who 'digs her heels in' has a similar position: she says that motion-perception involves the simultaneous presence in the brain of records that are misleading about what occurred in the actual past—a similar position, except that for her, 'simultaneous' and 'actual past' make sense!

Note that both positions are much more radical than the claim that motion-perception involves the simultaneous, or roughly simultaneous, presence in the brain, of records of very recent low-level perceptual states. *This* claim is nowadays a commonplace of empirical psychology: how else but by some sort of integration or coarse-graining of several such records could perception of motion be distinguished from perception of stasis? (For some details, cf. e.g. Callender (2008, Section 6).)

So according to Barbour, our impression that there is history arises from some configurations of the universe (including those we are part of) having a very special structure: namely, they 'contain mutually consistent records of processes that took place in a past in accordance with certain laws' (1999, p. 31). More precisely, they contain subconfigurations that falsely suggest such a past. Barbour has a memorable name for such configurations; he calls them *time capsules*. So in short: a time capsule is any instantaneous configuration that encodes the appearance of history, for example a history of previous motion; and Barbour proposes that time capsules explain away our impression that there *is* history.

Barbour develops this vision in several ways. Perhaps the most important is his suggestion that in quantum physics, the quantum state gives time capsules relatively high probability. But I have set aside quantum physics. Instead I will explain two further points developing the idea of a time capsule. Barbour puts them somewhat metaphorically; (they are clearest at pp. 302-305). But they are worth stating precisely and generally. For together they give Barbour a kind of coarse-grained surrogate of history, and so they might make his position more credible; at least perhaps to a Dummettian anti-realist about time!

(1): *Records*: The first point is that one time capsule can 'record' another. That is, one time capsule can contain records of another, without the other similarly containing records of the first. Here the phrase 'C_1 contains records of C_2' is of course colloquial—we are 'speaking with the vulgar'. According to Barbour, it is short for something like 'C_1 has sub-configurations that according to 'vulgar' dynamical laws are time-evolutes, or causal consequences, of some sub-configurations of C_2'. Furthermore, C_1's records of C_2 are often in its fine details, rather than its more obvious features. The intuitive idea (with an actual history, and the records existing later in time!) is familiar, both in science and everyday life. For example, a rock from one epoch contains in its fine details a fossil which records the structure of an organism that lived in some prior epoch. The scene of the crime today contains in its fine details fingerprints which record the suspect's being there yesterday.

(2): *Repetitions*: The second point is that one time capsule can in this sense contain myriadly many records of another, and even many records of one and the same sub-configuration of the other. Again the intuitive idea is very familiar. Many different fossils from one epoch (all sub-configurations of one vast configuration) tell overlapping but mutually consistent stories about some prior epoch. Today the suspect's fingerprints are all over the scene of the crime, and furthermore, his handkerchief soaked in the victim's blood is under the desk. Furthermore, we must allow that in general, the different records will not be wholly consistent with each other: geologists and detectives often confront conflicting pieces of evidence—and today's newspapers tell overlapping but not wholly consistent stories about yesterday's events.

By putting points (1) and (2) together, Barbour can recover a coarse-grained surrogate of history. We have already seen the main idea in his treatment of motion-perception: the intrinsic structures of each of a set of configurations can define a linear order on the set. But now we are to suppose that the set of configurations being considered is not just a relatively simple set of (what we call!) perceptual records of a moving object, but a vastly complex set of time capsules, each containing many fine details. Indeed, Barbour's vision is that we should consider configurations of the whole universe. So now any such linear order will be defined by the way that the fine details of a configuration C_1 are records of another C_2. It will not be defined just by a relatively simple comparison of the more obvious features of the configurations—like distances to portions of water, in the simple example of perceiving a bird's flight over a pond.

Furthermore, Barbour proposes that these fine details will not prescribe a unique curve (linear order) through each configuration. Again, the intuitive idea is familiar in everyday life; (and even in science, apart from the special, albeit familiar, cases of physical theories that are deterministic—such as Newtonian mechanics once we consider not only configurations but also their rates of change). All the fossils in all the rocks from one epoch do not record every detail of life in the prior epoch. All the details of the scene of the crime today may record who is the murderer, but do not record every detail of the murder—did the murderer breathe an even number of times while in the room? In general, today's fine details only record some of the more obvious features of yesterday.

But of course, Barbour, with his denial of history and his belief in the equal reality of all configurations, proposes to boldly extrapolate this intuitive idea. According to him, the fact that today's fine details do not prescribe a unique past is not just a matter of our having lost information about the actual past—there was no such past.

So much by way of summarizing Barbour's view. As I have hinted, I myself give it no credence; (my (2002) gives more details). But I commend it to metaphysicians of time as a vision to contemplate—and to rebut or endorse! And I commend it especially to Dummett, with an invitation to compare it to the 'anti-realist' views on time that his own writings have so brilliantly explored.

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