Time *

1. SPACE, TIME AND RELATIVITY

Many scientists, and some philosophers, still accept the canard that there is no such thing as progress in philosophy. There is no better way to scotch this canard than to see how far the philosophy of time has come in the last hundred years. The advance started with two developments at the start of the last century, one in physics and one in metaphysics, Einstein's 1905 special theory of relativity (Einstein *et al*. 1923), and McTaggart's (1908) *A*- and *B*-series theory of time and change. They revealed unexpected problems with two basic assumptions about time: that it is independent of space, and that it flows. These revelations, and later work in other areas of physics and philosophy, have greatly changed our ideas about time, and still inform the best work on its philosophy.

First, Einstein. Special relativity does not, as some have thought, assert a new unity of time and space. It should never have been news that time and the dimensions of space resemble each other more than they resemble any other way of ordering things, e.g. by their temperatures. To see this, consider first that, at any one time, space is or embodies an array of possible ways (namely spatial points) by which things can be in contact, and so can interact immediately (at those points). What makes this array (and hence space itself) three-dimensional is the fact that there are only three independent ways in which two things *a* and *b* can fail to be in contact at any one time, e.g. by *a*'s being north-or-south, east-or-west, or above-or-below *b*.

This fact about space provides the extended sense in which any array of possibilities may be called a 'space'. It is in this sense that time combines with space to constitute the 'space' we call 'spacetime' (Smart 1955). For whatever else time is, it too is a way in which *a* and *b* can fail to be in contact when in the same place, by being there at different times. And this is the only non-spatial way in which contact can fail. For whenever *a* and *b* (or their surfaces) share any spatial location, they are then and there in contact, and able thereby to interact immediately (if at all), however much they may differ in other ways.

Adding time to space thus completes a four-dimensional array of possible ways (space-time points) by which things can be in contact. This is what marks off time and space from everything else: the fact that people and things can – literally – contact each other by, and

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* *The Oxford Handbook of Contemporary Analytic Philosophy*, ed. Frank Jackson and Michael Smith, Oxford: Oxford University Press, 2005, pp. 615-635. (Please note when quoting from this document that, because it is not a facsimile of the published article but a repaginated copy of the original typescript, quotations may occur on differently numbered pages.)

only by, being in the same place at the same time. The most important part of the answer to the question 'What is time?', which tells us how it differs from everything but space, is that it is one of the four dimensions of spacetime. That is as true in Newtonian as it is in relativistic physics.

But time's being a dimension of spacetime does not make it spatial. Compare for example the 'colour space' shown in Figure 1, which represents the array of possible ways (single colours) by which things can match in colour. This space is three-dimensional, because there are just three independent ways in which two things can fail to match in colour: namely, by differing in hue, brightness or saturation. Yet no one thinks that hue's being a dimension of colour space makes it spatial, let alone that using a spatial dimension to represent it, as Figure 1 does, makes it so. Nor would anyone infer from the fact that hue, brightness and saturation are dimensions of colour space that they must be alike in any other respect, which they obviously are not.

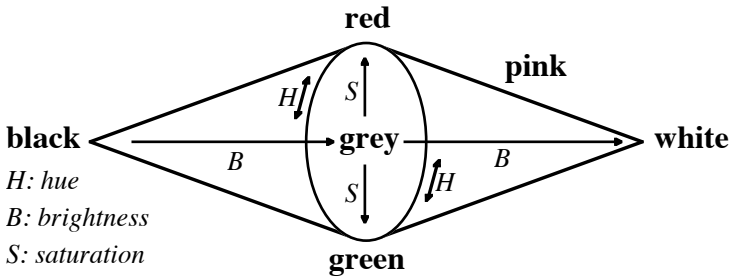

Figure 21.1: 2-D spatial representation of 3-D colour space

It is, as Reichenbach noted in his (1928 §16), no more sensible to draw such inferences from diagrams like Figure 2, which use a spatial dimension to represent time as a dimension of spacetime. Neither the form nor the content of this diagram shows that time is as spatial as spacetime's other dimensions; and relativity does not say that it is. It does indeed link time to space in a new and striking way, but not (*pace* Quine 1960 §36) in a way that spatialises time. But as some may still think it does, it is worth saying again why it does not.

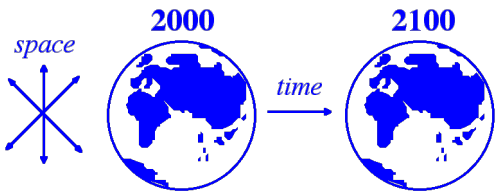

Figure 21.2: 2-D spatial representation of 4-D spacetime space

Note first that relativity uses the speed of light to give spatial and temporal distances a common measure, as when stars and galaxies are said to be *N* light years away. That in itself is nothing: any useful speed can provide a temporal measure of spatial distance, as when a

hotel claims to be five minutes walk from the sea. But in relativity the speed of light, c, does more than this: it provides a fixed exchange rate between spatial and temporal components s and t of a fixed spacetime separation d of any two events e and f, given by

(1) $d^2 = s^2–(ct)^2$,

where s and t vary from one 'reference frame' to another, and a frame may be defined by crediting any object, that is not accelerating, with a specific velocity (which may be zero).

Now let e and f be events that are some time t apart at (say) the north pole, so that, taking the earth to be at rest, s=0. So as t is positive, say t_0, $d^2 = –(ct_0)^2$ must be negative. (This, as s cannot be negative, stops t being zero in any frame, which is why intervals with negative d^2 are called 'timelike', and intervals with positive d^2, where s cannot be zero, 'spacelike'.) Next, take a reference frame in which the earth is moving, thus making s positive, say s_1. Then as d is a constant, t^2 in this frame, t_1^2, must equal $t_0^2+(s_1/c)^2$. And similarly for all other pairs of frames: to keep d constant, s^2 and t^2 must differ by amounts Δs^2 and Δt^2 such that

(2) $\Delta s^2 = c^2\Delta t^2$.

This is what I mean by calling c an exchange rate between s and t for any e and f: its square is the ratio of the differences in their squares between any two reference frames.

The fact that (2) states an exchange rate, not an identity, is not always so obvious, especially when t is measured in years and s in light years. For then, as c=1, (2) reduces to $\Delta t^2 = \Delta s^2$, which can look like an identity statement implying that t is as spatial as s. The quickest way to see that this is not so, and that (2), and hence (1), do not make t spatial, is to relate s to its components in any three orthogonal directions, e.g. the north-south, east-west and up-down distances x, y and z between e and f. Using that relation,

(3) $s^2 = x^2+y^2+z^2$,

to expand (1) into

(4) $d^2 = x^2+y^2+z^2–(ct)^2$,

shows how differently special relativity treats the spatial and temporal components of space-time separations.

2. Cosmology and the present

If relativity does not make time like space, it does link their ontologies. The Leibniz–Clarke correspondence (1717), about whether time and space are entities, or kinds of relations between events and things, treats these questions about time and space separately. But even special relativity's limited interchangeability of spatial and temporal distances shows that there is really only one question: is there more to spacetime than the spatiotemporal relations of events? That question is still open (Earman 1989, Nerlich 1994 pt 2) and all I can say here is that general relativity, by making matter affect the curvature of spacetime, which then

affects matter's inertial properties, makes spacetime look to me like an entity (Redhead 1998).

Besides relativity's implications for the ontology of spacetime, it also poses problems for some accounts of how time differs from space. To see these we need our other innovation in the philosophy of time, McTaggart's two ways of ordering times into *A*- and *B*-series. The latter orders times by the *earlier* relation (or its converse, the later relation), while the former does it by their pastness, presence or futurity. Either way, 'the varied simultaneous contents of a single [time] form an event … a compound substance consisting of simultaneous events' (McTaggart 1927 §306). So in both series the order of times fixes the time order of the universe-wide events *E*, *F*, … that are their contents, and hence that of all the local events which *E*, *F*, … contain. Both series thus require a simultaneity relation, to collect local events into the universe-wide ones from whose order they inherit their own.

The relevance of relativity to this is that it makes simultaneity at a distance relative to a reference frame. Take Polaris (the Pole star), reportedly about 390 light years away. If it is, a light signal that left earth in 2000 and was reflected back from near Polaris would return in 2780. But the earthly year of its reflection, *r*, is not thereby fixed, but varies with our choice of reference frame, i.e. (in effect) with how fast, if at all, we take the earth to be moving through space. In the earth's 'rest frame' *r* occurs in 2390, but other equally good frames place *r* in any year between 2000 and 2780. Different frames will thus combine different local events into the universe-wide events of McTaggart's time series. For while our rest frame combines *r* with events here in 2390, others will combine it with much earlier or later ones. In short, different frames produce different *A*- and *B*-series. Does this matter?

McTaggart considers the possibility of 'several real and independent time series' (oddly enough without mentioning the theory that implies them) and says that 'if there could be any *A*-series at all, and there were any reason to suppose that there were several distinct *B*-series, there would be no additional difficulty in supposing that there should be a distinct *A*-series for each *B*-series' (1927 §§322–3). And nor there would for him, since he takes all events and times to be equally real, wherever they are in his *A*- and *B*-series.

The theories for which relativity poses a problem are those that confine reality to the present (Prior 1970), or to the past and present (Broad 1923 pt I ch. II), so that to become present is to come to exist. Now whether something far off exists can hardly depend on a factually unconstrained choice of reference frame; yet if distant simultaneity does so, then so does what is present at a distance, since to be present there is to be simultaneous with what is present here.

Such theories therefore need a suitably privileged frame to define absolute simultaneity. This may be generated by inferring from our inability to measure a one-way (rather than a round trip) speed of light that its having one, the same in all directions (as my Polaris tale assumes), is not a fact but a convention (Salmon 1975 ch. 4). If it is, then we could, without

denying any facts, give our reflection *r* the earthly date 2390 in all frames by taking light to travel out and back at one-way speeds which, by convention, we take to vary appropriately from frame to frame, and to differ from each other in nearly all frames other than ours.

This however will not do. For first, it is obviously not a convention but a fact that light has a one-way speed, the same in all directions and in all frames (Nerlich 1994 ch. 4). And if it was a mere convention, then whether something exists at a distance could no more credibly depend on it than on a factually free choice of reference frame. This is why few of those who take existence to depend on presence now rely on this verificationist reading of special relativity. Instead, they either deny that its nonspatial dimension is time (Smith, Q. 1993 ch. 7), modify the theory to yield a suitably privileged reference frame (Tooley 1997 ch. 11) or look to other physics, especially cosmology, to remedy its deficiencies (Swinburne 1981 ch. 11). Of these responses, the first two seem to me to need better grounds for rejecting relativity as it stands, and as the theory of spacetime it purports to be, than they have; while I deny that modern cosmology enables remote existence to depend on temporal presence, for the following reasons

The relevant facts are these. On a large enough scale (that of clusters of galaxies), the universe looks much the same in all directions, and seems to be expanding uniformly from every point P within it. Its expansion takes remote clusters of galaxies away from P at speeds, proportional to their distances from P, given by the Hubble constant (0.037 metres per second per light year). This fact lets us define a rest frame at P (the one that makes the Hubble constant the same in all directions) which gives P a unique universe-wide simultaneity relation. But as the universe *is* expanding, anything at rest at P will be moving in the rest frames of all points with a spacelike separation from P. Thus in Polaris's frame, 390 light years to our north, anything at rest in our frame will be moving south at 390×0.037 = 14.5 metres per second. So our rest frame and Polaris's will give the reflection *r* (and all other remote events) different earthly dates, as will all other remote rest frames. And nothing in cosmology makes any of these frames, or the simultaneity they define, better than any other.

To this Swinburne and others reply with another definition of simultaneity made possible by the universe's uniform expansion. For suppose identical clocks here and on Polaris had stayed at rest in their local rest frames ever since the Big Bang. Then we can define simultaneity between here and Polaris as the same time since the Big Bang as measured by such clocks, and similarly for all other remote locations. And while the simultaneity relation given by this 'cosmic time' differs from that given by any local rest frame, as Figure 3 shows, it is a very credible way of picking out what is happening *now* anywhere else in the universe.

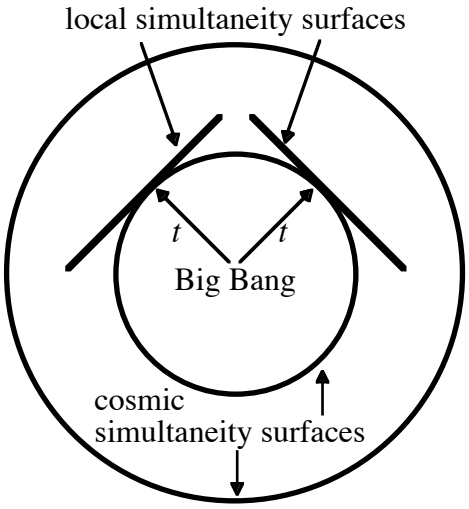

Figure 21.3: Cosmic and local simultaneity relations

The credibility of this way of defining temporal presence does not however extend to the idea that remote existence depends on it. For the continuing uniqueness of the present so defined depends on a permanent universe-wide large-scale isotropy, i.e. on the size, shape and contents of the whole of spacetime. But this makes the present depend on what exists elsewhere in spacetime rather than the other way round. Cosmic time, far from rescuing the idea of existence depending on temporal presence, if anything raises the stakes against it.

3. TIME AND CHANGE

The existence of many equally good pairs of *A*- and *B*-series may make it hard to deny reality to parts of them; but it is, as McTaggart sees, no objection to the series themselves. Nor does it vitiate his claim that, for the nonspatial dimension of spacetime to be temporal, it must be the dimension of change.

Change here I take to be temporal variation in the properties of things. By this I mean that changes are things having, at different times, incompatible properties, i.e. properties that no one thing could have at the same time. There are of course many families of properties whose members are incompatible in this sense, like mass, temperature, size and shape. And by properties here I mean *intrinsic* properties, not the relational properties whose variations McTaggart also called changes but we do not, since we think things can gain or lose them without changing at all, as when a sibling's birth makes one lose the relational property of being an only child. Whether we should limit real changes to intrinsic properties – and what makes properties intrinsic (Langton and Lewis 1998) – may indeed be debated; but not here. All we need here are undeniable instances of change, which temporal variations of mass, temperature, size and shape certainly are.

Time is certainly the dimension of change in this sense: variations must be temporal to be changes. But why is spatial variation not change? Admittedly, some properties, like size and shape, cannot vary spatially across an object. But some can, yet their spatial variations – like

a poker's being hot at one end and cold at the other – are still not changes. Why not? It is not enough to say that temporal variation is what 'change' *means*, since that does not explain why we limit its meaning in this way. So why do we, and what light can our doing so shed on how time differs from space?

Note first that what stops a difference between different things, like one poker's being hot and another cold, being a change is that here there is no one thing that changes. But if this is all that stops differences being changes, a poker's temperature varying along its length should also be a change. And if it is not because this too is only a difference between different parts of it, such as its two ends, then why is not a poker's cooling also just such a difference, between different temporal parts of it?

Whether objects extended in both space and time have temporal as well as spatial parts is a moot point (Armstrong 1980; Simons 1987 ch. 5; Mellor 1998a ch. 8.2). But settling it will not tell us what makes time and space differ. For it obviously will not if pokers do have temporal as well as spatial parts; while if they do not, this difference between time and space must surely follow from, rather than explain, a more basic one. What might that be?

McTaggart's answer invokes the apparent flow of time. First, he argues that change needs more than temporal variation. For if a poker is hot at one *B*-time t and cold at another, t', then it always was and always will be hot and cold at those times: those *B*-facts never change. The only facts that change are *A*-facts, like the poker's being hot *now*, which is a fact when t is the present time and not when t' is. This is why McTaggart thinks that only the *A*-series, whose continuous changes constitute the flow of time, can make time the one and only dimension of change that we all agree it is.

But is he right? The *A*-series does after all have spatial analogues. Imagine yourself in York, on the London–Edinburgh railway line. Then York is *here* (the analogue of *now*), Edinburgh is about 200 miles *north of here* (analogous to *later than now*) and London about 200 miles *south of here* (*earlier than now*). And just as only at t is t the present time, so only in York is York the (spatially) present place. In Edinburgh, York is not here but 200 miles south of here, while in London, London is here and York is 200 miles north of here. And similarly in all other spatial directions.

This however no more makes space like time than relativity makes time like space. The mere description of a spatial *A*-series does not entail its reality, i.e. that on top of facts about how far north or south of each other London, York and Edinburgh are, there are also facts about which of them (if any) is here, and about how far from here, and in which directions, the others are (Williams 1992). So what distinguishes time from space may be precisely that the temporal *A*-series is real and its spatial analogues are not. For since, as we have seen, time's being one dimension of spacetime does not stop it differing from the others, this could be just what the difference is. It could be a primitive and inexplicable fact that one of space-

time's dimensions has a real *A*-series, this being what makes it the dimension of change that we call time.

4. The ontology of the A-series

This however is a poor theory, since it raises serious questions that it can neither answer nor show to be unanswerable. For example: why has spacetime only one dimension with a real *A*-series (and what would the world be like if it had more); why is this the dimension picked out by relativity; and so on. If time does differ from space in this way, the difference (like that between temporal and spatial parts) must surely follow from something more basic.

But perhaps there is no difference here, for perhaps not even time has a real *A*-series. So McTaggart argues, which is why he says that time is unreal. For if time entails change, and that entails an *A*-series, then no *A*-series means no change and so no time. But then, if the temporal terms like 'earlier' that define the *B*-series have no application, there is no *B*-series either. There is merely McTaggart's (1927 §347) '*C*-series': a real dimension of what we call spacetime, but not one that deserves to be called time.

Put like this, McTaggart's denial of time is less incredible. For not only, as he notes, is it Kant's view (1781 A33); in his sense he shares it with all those who, like Quine (1960 §36), think time is spacelike. Still, credible or not, the question here, since no one denies that spacetime *has* a nonspatial dimension that we all call time, is how this dimension differs from the other three. But then, *pace* McTaggart and Smith (1993 ch. 7: see §2 above), it is better to keep calling the dimension 'time' than to drop that question just because it fails McTaggart's test for being the dimension of change.

But does it fail that test? Many philosophers still think not (Oaklander and Smith 1994 pt 2), and McTaggart's (1927 §329–32) argument that it does, sound though I think it is, is too famous and contentious to be restated yet again in his way. It does however have a non-spatial analogue that may sway agnostic minds. This starts with the personal analogue of *now* and *here*, namely *me*, and consequent analogues of the *A*- and *B*-series. The former relates people to *me*, as in *my* cousin, neighbours, employer, etc. The latter relates them not to me but to each other, as in Mike's cousin, Jill's neighbours, Jack's employer, etc. How are such pairs of 'series' related?

First, these personal *A*-series are parasitic on their *B*-series counterparts. For the latter are definable by who is related to whom, regardless of which of them, if any, is me; and those *B*-relations then fix all their corresponding *A*-relations. Thus if Hugh is Mike's cousin and I am Hugh, I must be Mike's cousin; and similarly in all other cases. So these personal *A*-and *B*-series can only differ if there is in reality more to *my* being Mike's cousin than to *Hugh's* being Mike's cousin; which will be so only if my being Hugh is itself a substantial part or aspect of reality.

Yet it cannot be, as an analogue of McTaggart's argument shows. Of course, when Hugh says 'I am Hugh', that *A*-statement is true, and when Mike says 'I am Mike', that is true too. The question however is what facts, if any, make these statements true; and before I can answer that I must say what I mean here by 'facts'. I cannot mean facts in any sense which makes it trivially true that

'I am Hugh' is true if and only if it's a fact that I am Hugh,

since that sense is obviously too weak to tell us what, if anything, *makes* it true, and hence a fact, that I am Hugh. For in this sense it is also trivially true that

'Murder is wrong' is true if and only if it's a fact that murder is wrong.

But this truth cannot show that, for murder to be wrong, the world must contain values: expressivist and other non-cognitivist theories of value which deny this are not so easily refuted. What we want to know is whether, in a more serious sense of 'fact', 'Murder is wrong' is *made* true by facts containing values. That is the question, and it is a serious question about the ontology of value, not a trivial question in the theory of truth.

This is the serious truthmaking sense of 'fact' in which I say that the *A*-fact that I am Hugh cannot be what makes Hugh's *A*-statement 'I am Hugh' true. For as Hugh and Mike cannot both be me, that fact would make Mike's *A*-statement 'I am Mike' false, which it is not. Likewise, the *A*-fact that I am Mike cannot be what makes Mike's statement true, since that would make Hugh's statement false. In other words, taking these *A*-statements to be made true by corresponding *A*-facts only generates contradictions, by requiring the *A*-fact that I am Hugh both to exist, to make Hugh's 'I am Hugh' statement true, and not to exist, to enable Mike's 'I am Mike' statement also to be true.

But if these *A*-facts cannot make these *A*-statements true, *B*-facts clearly can. Statements of the forms 'I am *x*' and '*x* is my cousin' (where '*x*' is a term like 'Hugh', not one like 'me') can be made true respectively by being said by *x* and a cousin of *x*. And similarly for all other personal *A*-statements: they can all be made true by facts about which *B*-people say what, and how they are related to whom, regardless of which of them is me. And only by taking such *B*-facts to be what make all personal *A* statements true can we, without contradiction, say what does so.

Similarly with temporal *A*-truths like 'It is now noon' said at noon and 'It is now midnight' said at midnight. The first statement cannot be made true by its now being noon, for that would make the second statement false. Nor can the second be made true by its now being midnight, for would make the first statement false. Here too, taking these *A*-statements to be made true by corresponding *A*-facts only generates contradictions, by requiring the fact that it is now noon both to exist, to make the noon 'It is now noon' statement true, and not to exist, to enable the midnight 'It is now midnight' statement also to be true.

That, in substance, is McTaggart's argument. To reject it, one must say that, at noon, the midnight statement 'It is now midnight' is false (cf. Smith, Q. 1993 ch. 4.3). But this is like

Hugh saying that Mike's statement 'I am Mike' is false, which is absurd. Of course 'It is now midnight' *would* be false if said at noon, just as 'I am Mike' would be false if said by Hugh. But said when and by whom they *are* said, these statements are as plainly true at all times and for all people as (to give a spatial example) a north-pointing 'York 200 miles' sign in London is at all places.

And then it is as plain in the temporal as the personal case what makes *A*-statements true. Being said at noon is what makes 'It is now noon' true, and similarly for *A*-statements about the past and future. Any statement of the form '*e* is (*N* days) past' is made true by being made (*N* days) later than *e*; just as any statement of the form '*e* is (*N* days) future' is made true by being made (*N* days) earlier than *e*. The facts that make *A*-statements true are all *B*-facts.

5. The semantics of the A-series

Or are they? Is it really just a *B*-fact that *e* is earlier than another event *f*? Not for McTaggart, for whom *B*-facts need *A*-facts to make them temporal, and so something more than *C*-facts. In other words, the temporal meaning of 'earlier', which defines the *B*-series, depends on the meanings of 'past', 'present' and 'future' that define the *A*-series; and this remains a common view (Gale 1968 Part II).

Yet it is not true. We saw in §2 how both *A*- and *B*-series share the same concept of simultaneity; and they also share the same concept of being *earlier*. For the link between the two series is undeniable: the past is earlier than the present, and the present earlier than the future, in the very same sense in which *e* is earlier than *f*. And then, as in the personal case of §4, the *B*-series must come first, since that depends only on what is earlier than what, regardless of where anything is in the *A*-series. So, for example, *e* is earlier than *f* independently of their ever-changing *A*-locations; but not conversely, since *e*'s being earlier than *f* makes *e* always less future or more past than *f*. And this will be so even on the *A*-theory that *e* is made earlier than *f* by becoming present earlier than *f*: for that too is an unchanging *B*-fact about which of two events (*e*'s becoming present, *f*'s becoming present) is the earlier.

The fact is that temporal, personal and spatial *A*-concepts all depend on their corresponding *B*-concepts, not the other way round. Indeed it is only their *B*-concepts – of the properties and relations that distinguish different people, places and times – that distinguish these three sets of *A*-concepts. For given the former, the difference between the latter reduces to that between *me*, *here*, and *now*: since any *A*-statement, however complex, is equivalent to a *B*-statement plus one or more *A*-statements saying who *I* am, where *here* is and/or which *B*-time is *now*. And what differentiates these basic *A*-concepts, by making them refer respectively to whomever has them, and to where and when they do so, is the kind of *B*-belief that the *A*-beliefs they occur in combine to yield.

Take for example my *A*-beliefs that I am Hugh, and that I am male, which yield the *B*-belief that Hugh is male. I say (Mellor 1998b) that the fact that the *B*-belief they yield is

personal is what makes these *A*-beliefs personal rather than temporal or spatial, i.e. makes them refer to me, rather than to the place or time I hold them at. Similarly for spatial and temporal *A*-beliefs, like my beliefs that today is 16 August 2001 and fine: what makes those *A*-beliefs temporal is that the *B*-belief they yield, that 16 August 2001 is fine, is temporal. But if combining to yield temporal *B*-beliefs is what makes *A*-beliefs temporal, then the latter must get their content from the former. And so they do: our *A*-concepts of past, present and future are defined by our *B*-concept of being earlier: all events located at any *B*-time *t* are automatically present at *t*, past at all earlier times and future at all later ones.

How then do we get our *earlier* concept, and differentiate it from spatial concepts like being above, or to the left? The answer is that we learn to recognise its instances, as when we see that '1' appears earlier than '2' on a digital clock, and to distinguish them from (e.g.) seeing '1' to the left of '2' on a clock with hands. What makes our temporal and spatial concepts differ is that we can tell the difference between temporal and spatial *B*-relations – the very difference we have yet to explain.

However, before explaining that difference, we must meet two well-known objections to this *B*-account of temporal concepts. The first is that we see things as temporally present, but not as spatially present. Thus while I can see that my clock's hands are moving at some spatial distance from here, I can never see them as moving at a temporal distance from now: whatever we see, we see as present. Is this not a basic difference between the temporal and spatial concepts that experience gives us: the former being *A*-concepts, the latter not?

No: the idea that we see events as present comes from confusing what we see with the experience of seeing it, which is indeed always present. But that is a mere tautology, a consequence of the fact that the experiences we think are present are those we have while we are thinking that. While as for *what* we see, that never *looks* present – or past, or future. We cannot for example see which of two celestial events is the earlier by seeing which looks more past. If we could, cosmology would be far easier than it is, since we could *see* how long ago what we see in telescopes happened, which of course we cannot. We cannot even refute people who claim to see the future in a crystal ball by pointing to the visible pastness of what they see, for there is no such thing (Mellor 1998a chs 1.5, 4.3).

Why then do we mostly take what we see to be temporally present? The reason is that the light which shows us nearby events travels far faster than we usually need to react to it (Butterfield 1984). This is especially true of events, like the approach of predators, partners or food, on our timely reaction to which we depend for survival. If we let our eyes tell us that these events were future, we would not act on them in time; and if we let them tell us that they were very past, we would not act on them at all; and either way we would die out. It is in order to survive that we need the default habit of believing that what we see is present, which is why evolution has bred this habit into us.

This brings me to the other objection to a *B*-theory of *A*-concepts, its apparent implication that an *A*-belief is just a kind of *B*-belief, e.g. that a predator is approaching when I believe it is. Yet thinking at *t* that something is happening *now* is never the same as thinking it is happening at *t*. Take Prior's (1959) example of my thanking goodness at *t* that an unpleasant experience is over. As Prior says, to realise that it is over is not to realise that it ends before *t*, a fact I could have known (and thanked goodness for) in advance. Perry (1979) makes a related point about personal *A*-beliefs: to vary his example, no *B*-belief of mine that Hugh Mellor, the author of *Real Time II*, the occupant of 25 Orchard Street, etc., is due to finish this paper this week will make me do so unless I believe *I* am due to do so. Similarly for spatial beliefs: the *B*-belief that I am to leave a train at Cambridge will not make me do so until I acquire the *A*-belief that Cambridge is *here*.

This is a general phenomenon. Apart from beliefs about (e.g.) what always was, is and will be, few if any *A*-beliefs can be *B*-beliefs, since they affect our actions differently. So no *B*-theory that identifies *A*- with *B*-beliefs, by giving *B*-translations of *A*-statements, can be right. The realisation that *B*-theories not only cannot but need not do this (Smart 1980) planted the seed of the so-called 'new theory of time', whose growing influence is variously assessed in Oaklander's and Smith's (1994) collection of that title.

The chief problem facing the new theory is this. If what makes any token utterance *k* of (e.g.) 'It's fine now' true is its being made when the weather's fine, how can that *B*-truth-condition not be what *k* means? The best-known answer (Kaplan 1989) is to divide the meaning of 'It's fine now' into a *content* (its *B*-truth-condition), which varies with *t*, and a *character* (the function from *t* to this content), which does not. Then at *t*, while 'It's fine now' has the same content as 'It's fine at *t*', it has a different character, and that is how their meanings differ.

I think this is wrong, and that 'It's fine now' only means its 'character', the function from *t* to its truth condition at *t*. Kaplan only makes its 'content' (that function's value at *t*) part of what it means in order to preserve the thesis that 'if what we say differs in truth value … we say different things'. But this begs the question against *A*-theorists, for whom 'It's fine now' does always say the same thing (that it's fine *now*), even if what it says is not always true. While even *B*-theorists may jib at making 'It's fine now' say at *t* what 'It's fine at *t*' says: for this implies that (i) it says something different every instant and (ii) only those who know *when* they are saying 'It's fine now' know what they are saying.

This is why I take all temporal *A*-sentences to mean the functions from any *B*-time *t* to their *B*-truth-conditions at *t* (Mellor 1998a ch. 7). Similarly, I take 'Cambridge is here' to mean the function from any *B*-place *s* to its truth-condition at *s*, namely that *s* is at or within Cambridge; 'I am male' to mean the function from any *B*-person *x* to its truth-condition when said or thought by *x*, namely that *x* is male; and so on. This is how I take *A*-sentences to differ in meaning from the *B*-sentences that say what *B*-facts would make them true: their *B*-truth-

conditions, the values of the functions that I say are their meanings, vary from time to time, place to place or person to person, while the functions themselves, which are what the *B*-sentences state, do not. This also shows, as Kaplan cannot, how at any time *t* we can know what 'It's fine now' means, and believe it, without knowing what *t* is. For we need not know that in order to know what this function of *t* is, or to believe it, i.e. to believe that, whatever the truth condition is that is this function's value for the relevant *t*, it holds.

But whether these functions exhaust the meanings of *A*-sentences or not, they certainly give them the right truth values, e.g. making 'It's fine now' true when and only when it is said in fine weather. That is enough to show why these *A*-sentences are untranslatable by *B*-sentences. For whether or not the same thing can be said truly at one time and falsely at another, no two sentences can mean the same if one is true and the other false at the same time (and place, and for the same person). And while *B*-sentences are true, if at all, at all times and for everyone, most *A*-sentences are at best true only at some times and for some people. That is why they cannot be translated even by the *B*-sentences that say when, where and for whom they are true, and therefore why no *B*-theorist need claim that they can.

So far, so good for the new theory of time. But not good enough for its opponents, who deny that all true *A*-sentences can be made true by *B*-facts (Smith, Q. 1993 ch. 3). Imagine a time *t* when, as no one has written or is thinking or saying anything, there are no mental or physical tokens of any sentence, and in particular not of

'There are no tokens now'.

So although this is true at *t*, it cannot be made true by *B*-facts about true tokens of it, since no tokens of it can be true. This certainly refutes the so-called token-reflexive theory, that what makes a sentence true at any time (and place and for any person) is whatever would make its tokens true at that time and place and for that person. But if that is not what makes sentences true, what does?

The answer here is obvious enough: what makes 'There are no tokens now' true at any *t* is the fact that there are no tokens at *t*. But it is also problematic: for if there are no tokens at *t*, *what* is made true at *t*, and by what? To the first question my answer is of course this function, which I say is what 'There are no tokens now' means, and is true at any *t* if and only if its value there, the truth condition that there be no tokens at *t*, holds. To the second question, my answer is simply the absence of tokens at *t*. Both answers raise further questions – such as how absences can be truthmakers – that I cannot discuss here, but on whose answers the content and prospects of the new theory of time will depend.

6. WHAT A-BELIEFS DO FOR US

Suppose however, if only for argument's sake, that the new theory of time is true: that most *A*-sentences are untranslatable by *B*-sentences and yet are made true, when they are true, by

B-facts. Why then do we use such sentences? If it cannot be to state facts, there being no *A*-facts to state, what do we use them for?

The most important thing that the *A*-beliefs *A*-sentences express do for us we saw in §5: they enable us to act when and where we need to do so. Only *my A*-belief that Cambridge is *here*, and here *now*, will get me off the late train from London, and similarly in other cases. Whenever we need or want to act at particular times and/or places, we need *A*-beliefs to make us do so. Why is this?

I say (Mellor 1998a ch. 7.3) that the reason we need *A*-beliefs is that we are *agents*, most of whose actions depend on our beliefs, and depend for their success on when we do them. It is of course no news that our beliefs affect what we do, since we mostly do what we believe will get us what we want. When I go out to shop, or take a coat to keep warm, my actions are caused not only by what I want but by what I believe: that the shops are open, that it is cold outside, and so on. This much is obvious, the only question being why some of these beliefs must be *A*-beliefs, as they evidently must: that the shops are open *now*, that it is cold outside *here*, and so on.

To see why this is, consider how I catch the late train to Cambridge from London. I leave a London pub in time to get to King's Cross station just before 11:15, because I believe the train I want to catch leaves there then. But it takes more than this to make me leave the pub when I do, since I have wanted to catch this train, and believed that it leaves King's Cross at 11:15, for hours. To make me leave the pub, I must also get the *A*-belief that the time to do so – say 10:45 – is *now*. And when I do get that belief, I will leave the pub whether or not it is true, i.e. whether or not I get the belief at 10:45. Here as elsewhere, the truth values of my beliefs are irrelevant to how and when they make me act.

What they are relevant to is whether my actions succeed. Only if the beliefs that make me leave my pub (that King's Cross is just under thirty minutes away and it is now 10:45) are true will I succeed in getting to the station just before 11:15. This link too is general, since truth is the property of beliefs which ensures the success of the actions they combine with our desire to cause, i.e. ensures that those actions will do what we wanted them to do (Whyte 1990). Thus if, as I believe, the shops are open when I go out, I will get to shop, and if not, not. If, as I believe, it is cold outside, the coat I put on to keep me warm will do so, and if not, not (since I would be warm anyway). And so on. This is not of course to say that we cannot act successfully on false beliefs, when their falsity cancels out, as when I leave the pub late but catch my train anyway because King's Cross is closer than I thought. But luck like this is too rare to refute the rule that, generally, the truth conditions of our beliefs are those in which the actions they help to cause succeed.

The relevance of this rule is that, as my examples show, the success of our actions almost always depends on when and where they are done. I must leave for the station in time to catch the train; shop hours and outdoor temperatures vary from time to time and place to

place; and so on. So for our actions to succeed, they need to be caused by beliefs that are indeed true when and where we have them, but are not true always and everywhere. So true *B*-beliefs, just because they *are* true always and everywhere, are not enough. We also need *A*-beliefs, precisely because *their* truth values, and hence *B*-truth-conditions, can vary across time and space. Without these we could not time or place the myriad actions which, if they are to get us what we want, must be done at the right *B*-time and the right *B*-place. That is why, even in a world with no *A*-facts, agents will always need *A*-beliefs.

But to be capable of timely action, it is not enough to have *A*-beliefs: we must have them when they are true. And so on the whole we do. We make mistakes, naturally: not all our *A*-beliefs are true, any more than all our *B*-beliefs are; but many are. But as, unlike *B*-beliefs, *A*-beliefs are not always true, we must keep changing them, at intervals ranging from several times a second for beliefs about what I am now seeing, to once a decade or more for beliefs about where I live or whether so-and-so is still alive.

Still, however stable some of our *A*-beliefs are, we have so many that we are always having to change some of them – from future to present to past – to try and keep them true. These changes, when conscious, are what we interpret, rightly or wrongly, as the flow or passage of time. So that is another thing our ever-changing *A*-beliefs will do for us, even in a *B*-world. They will give us an experience of time flowing that is as real as their changes and even, when they change at the right time, true in the sense of giving us true *A*-beliefs. This is the truth in Grünbaum's (1964 p. 324) view that, if physics needs only *B*-facts, 'the becoming [present] of an event, as distinct from its merely being, is … no more than the entry of its effect(s) into the immediate awareness of a sentient organism'. But then this must not be read as saying that there are mental *A*-facts which put the mental beyond the reach of a *B*-physics. For if a *B*-physics can explain belief at all, it can certainly explain *B*-facts about what *A*-beliefs we have, how we get them, how they make us act, and what *B*-facts make them true.

7. Time and causation

In calling temporal variations in our *A*-beliefs 'changes', I have again assumed that time is the dimension of change. But I have still not said what makes it so if time does not flow. What then, if not the flow of time, distinguishes time from space, and makes it the dimension of change?

The obvious answer to the first question is causation. It is after all a striking fact that most causes and effects are separated in time as they need not be in space. Many effects are where their causes are, as when heating water causes it to boil. And those that are not may be in any spatial direction from their causes, as when fires throw out heat all round, whereas none are known to precede them. Hence the theory of Robb (1914) and Reichenbach (1928 §21) that time is the dimension of causation and that what distinguishes *earlier* from *later* is the fact that causes precede their effects.

Whether this theory will do depends on what we mean by causation. It will not do if, with Hume (1748 §60), we define a cause as 'an object, *followed* by another …', since this uses time and its direction to define causation. Nor will it do if, like Mackie (1974 ch. 7), we think effects are 'fixed' by their causes becoming present, for then causation gets its direction and efficacy from the flow of time. Others, however, like Lewis (1973), who do not use time to distinguish causes from effects, can without circularity use causation to give time a direction (Le Poidevin 1991 ch. 7). Thus while Tooley (1997 ch. 4) links causation to the flow of time, as Mackie does, he uses the former to define the latter and, by denying that the future exists, enables causes not merely to 'fix' their effects by making them present but to bring them into existence.

Causal theories may thus be held without circularity by *A*- or *B*-theorists. But they face other objections (Smart 1969; Sklar 1985 chs 9–10), such as the causal independence of many temporally ordered pairs of events, and the apparent simultaneity of much causation, as in Kant's (1781 A203) ball causing a hollow in the cushion it rests on, or a train whose rigidity requires its engine to set it moving all at once. These two objections can be met, for example by making causation link fields at all temporally ordered spacetime points, and by denying that anything can be *perfectly* rigid (Mellor 1998a ch. 10.3–4). But as none of these defences is unassailable, they need bolstering by positive reasons for adopting a causal theory of time order.

One reason is that the theory can explain the difference between relativity's timelike and spacelike intervals (see §1) by making light the fastest transmitter of causation, thereby explaining why causation never links events whose separation is spacelike. (Nonlocality in quantum physics, which looks like unmediated causation at a spatial distance, only really threatens the weaker 'sense of locality that requires that correlation between spacelike separated events always be factorable out by a common cause' (Skyrms 1980 p. 127).)

Another reason is that the theory lets *B*-theorists explain why we can perceive but not affect the past, and affect but not perceive the future. There is of course really only one thing to explain here, since perception is as causal a process as action: what stops our senses showing us the future is what stops our actions affecting the past, namely the fact that causes precede their effects. This fact however is explained very differently on different theories of time and causation: of those mentioned above, Mackie explains it by the 'fixity' of the past, Tooley by the non-existence of the future. But for those who put all times on a modal and ontological par, a causal theory of time order gives by far the best explanation of these striking differences between past and future.

Better still, a causal theory can explain Kant's (1781 B50) famous definition of time as 'the form of inner sense', i.e. of our experiences, whose order must therefore be temporal. This fact however does not explain why causes precede their effects; whereas a causal theory

can explain how we perceive the time order of our own experiences, as follows (Mellor 1998a ch. 10.5).

Suppose I perceive the time order of two events, *e* and *f*, by first seeing *e* and then seeing *f*. The time order of these perceptions fixes the time order I thereby perceive: the event I see first will be the event I see to *be* first. But what, if not unconscious visual processing (Dennett 1991 ch. 6.3), makes this so? Something must, since I could see *e* and *f* without seeing their time order at all; but what? The answer is causal: my perception of *e* so affects my perception of *f* that the latter also tells me that *e* precedes *f*. So the time order that these perceptions make me perceive is fixed by their causal order: if my perception of *f* had affected my perception of *e* in the same way, I would have seen *f* precede *e*. That is why, if the causal order of my perceptions fixes *their* time order, what I see first is what I thereby see to *be* first.

Of course my perceiving *e* precede *f* will not in general entail that *e* in fact precedes *f*, as when I perceive lightning to precede a simultaneous thunder clap because light travels faster than sound. But if whatever links *e* and *f* to my perceptions of them takes the same time to do so, their time order *will* be what I perceive it to be. So if, in particular, *e* and *f* are not external events but internal experiences, all of which take a similarly short time to intimate themselves to me, they are bound to have the time order I perceive them to have. That is how causation gives us the almost infallible knowledge of the time order of our own experiences that makes Kant's definition of time so appealing: the real form of his inner sense is causation.

Last, and best of all, a causal theory can explain why time is the dimension of change (Le Poidevin 1991 ch. 8; Mellor 1998a ch. 10.6, 2001). In my view, it does so by supplying the necessary condition for change, noted in §3, that there be a single thing that changes. For a thing cannot keep its identity unless it also keeps some of its properties. Some of mine, for example, like being an animal, may be essential to me, i.e. such that I could not lose them, since nothing that lacked them could be me (Wiggins 1980 chs 2–3; Olson 1997). But even if no property of mine is essential in this sense, so that I could change by sufficiently numerous stages into a pillar of salt, no one thinks I could survive the simultaneous loss of *all* my intrinsic properties. So while any one property of mine *is* changing, I must, in order to preserve my identity through that change, keep enough other properties of mine *un*changed.

Now what keeps properties unchanged over time is the same as what makes them change: causation. My present height, temperature, views of time and other fairly constant properties of mine are what they are now because, since nothing has happened to change them, that is what they were a minute ago. The causation of stasis may be less obvious than that of change, but it is no less real, and no less necessary to secure the identity that is needed to make a difference a change.

This is why spatial variation in a thing's properties, for example from the hot to the cold end of a poker, is never a change. Because causation cannot link facts across spacelike intervals, no poker can have any property at one end just because it has the same property at

the other end at the same time. That is what stops a poker's two ends being not just two parts of a single thing, but a single thing in two places at once, thereby stopping any difference of properties between them being not just a difference but a change in the poker as a whole. And that is why, if time is the dimension of causation, only temporal variation can be change.

8. Epilogue

These are my reasons for agreeing with Robb, Reichenbach and their followers that time is the causal dimension of spacetime. I agree with them because I think no other view of time explains as much and faces fewer objections. However, until there is more consensus about what (or even whether) causation is, this view must remain both provisional and vague. There is still much to do in the philosophy of time.

Still, as we have seen, it has already been transformed in the last hundred years by developments in several areas. Einstein changed our ideas of how time differs from space and how it relates to causation, just as McTaggart changed our notion of the flow of time. In the philosophy of language, theories of meaning have shown how what *A*- and *B*-statements mean depends on what makes them true (Davidson 1967). Semantic theories of indexicals like 'now', 'here' and 'I' have shed new light on McTaggart and shown how *A*-truths can be made true by *B*-facts while differing from *B*-truths. While new theories of the mind (defining beliefs and desires by how they make us act (Smith, P. and Jones 1986 chs 10–13)) and of truth (as what makes the actions beliefs cause succeed) have combined to show why our *A*-beliefs are as indispensable as they are irreducible.

This is just some of the twentieth century work that has advanced our understanding of the aspects of time dealt with above. Then there are the many issues I have had no space to discuss: how the direction of time relates to cosmology, radiation, thermodynamics, statistical mechanics, quantum theory and decision making; whether spacetime is an entity or a set of spacetime relations; whether time must be linear; the source of spacetime's metric and whether it is intrinsic or conventional; whether spacetime is discrete, dense or continuous; Zeno's paradoxes of motion; whether time travel, backward causation or cyclical time is possible; modal and tense logic, and the sense in which the past is necessary and alternative futures are possible; how to understand time in fiction; time and eternity, and whether God or anything else can be outside time.

On these issues too much progress has been made, and there is clearly more to come, as the literature shows. For examples, besides works already referred to, see Friedman (1983), Flood and Lockwood (1986), Horwich (1987), Le Poidevin and Macbeath (1993), Price

(1996), Le Poidevin (1998) and Butterfield (2000), and 'Time', 'Continuants', 'Eternity', 'Zeno of Elea' and related articles in Craig (1998). [1]

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[1] This article has drawn on material in my (1998a) and (2001) by permission of the former's publisher and the latter's editor. If asked to justify my choice of topics, I can only say that I cannot, as Oscar Wilde once put it, 'accept all schools of art with the grand catholicity of an auctioneer', since I am not an auctioneer.

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