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Temporal Passage: A Shape-Dynamic Account

1. INTRODUCTION

Time passes: one of the many banal facts about time which turns out to be extremely unfriendly to philosophical analysis. Time passes, but what that comes to, no one can say. And why time passes, that's even harder.

I'll do three things in this essay. First, I'll try to shed some light on what the passage of time *is* (which should not be confused with the project of spelling out what the expression 'time passes' *means*; I don't know what the expression means, but I have a favorite theory about what underlying reality makes true our talk about temporal passage). Second, I want to say something about *why* time passes: how the passage of time works. Here I'll draw on recent work by Julian Barbour on shape-dynamic approaches to general relativity. And third, I want to briefly examine J.J.C. Smart's well-known objection to the idea of temporal passage from the perspective afforded by my theory.

A disclaimer: these are tall aims for a short essay. What temporal passage is, why it happens, etc.: these are topics for a book or two. How to say something substantive about them in the space of an essay? By painting in broad strokes, being somewhat impressionistic. That's what I propose to do here: to sketch out in a broad, impressionistic way how to think about these things, leaving the task of filling in the details for another time.

2. TEMPORAL PASSAGE: WHAT IT IS

Everyone believes in temporal passage: it's a datum; one of those features of experience every temporal ontology has to account for. There's a divide among temporal ontologies as to how to characterize it. Those committed to the so-called A-theory—sometimes also called the dynamic view of time—hold that temporal passage is in some sense fundamental, incapable of explanation in more basic terms. Those committed to the so-called B-theory—sometimes called static views of time—hold that temporal passage is not fundamental, that it is explainable in more basic terms that make no mention of any sort of temporal passage.

That's a rough way of characterizing the divide, anyway. Characterizing the divide less roughly turns out to be extremely difficult, as Dean Zimmerman showed in his, "The A-Theory of Time, the B-Theory of Time, and 'Taking Tense Seriously'" (2005). You might have thought you could characterize the difference between the views in terms of tense: the A-theorists are those who "take tense seriously" and the B-theorists don't. But if by that you mean that the A-theorists are those who think that the objects of propositional attitudes—the propositions—are things that change their truth value over time and are governed by the logic of a Prior-style tense logic, and the B-theorists are those who deny this, holding that all propositions have their truth values eternally, you've this problem: David Lewis held the former view, but he most certainly wouldn't be one you would associate with an A-theory of time.

Some try to characterize the difference in terms of a special property of presentness, a property which is both fundamental—perfectly natural, "carving at the joints"—and also moves successively through the B-series, where its passage across the series comprises temporal passage. A-theorists are those who think there is such a property as this fundamental presentness; B-theorists think not. The trouble with this way of carving the territory is two-fold.

First, as Zimmerman shows, B-theorists à la Lewis can accept the existence of a primitive property that is very difficult to distinguish from the A-theorist's presentness. The property *being self-simultaneous*—the property had by something *x* iff *x* is simultaneous with itself—the B-theorist might argue, is both fundamental, and such that only one time has, in the present tensed sense of 'has', the property. A-theorists fond of characterizing their theory in terms of fundamental presentness will likely object that presentness is *not* the same thing as self-simultaneity, but saying exactly what the difference comes to turns out to be extremely difficult.

Second, the view I'll endorse below eschews any appeal to fundamental presentness; I don't believe in such a property. But, since, so I think, my view deserves the label 'A-theoretic' as well as any, characterizing the A-/B-theory divide in terms of fundamental presentness is an infelicitous way of characterizing the divide.

Zimmerman thinks the best way of characterizing the A-/B-theory distinction is in terms of the notion of truth *simpliciter*. A-theorists are those who think that what is true *simpliciter* changes over time; B-theorists deny this: though some—the serious tensing B-theorists—hold that the objects of our propositional attitudes change truth value over time, they'll analyze this in terms of dyadic truth-at-a-time, a two-term connection between proposition and time. My belief that I am standing, they'll say, expresses a proposition that is true relative to some times but not to others, where this is a matter of bearing the truth-at relation to some times but not others. Not so, says the A-theorist: my belief that I am standing expresses a proposition that is true *simpliciter—that I am standing* is true relative to various times, to be sure, but is also true *simpliciter*, true period, true full stop. Since it was false *simpliciter*, it's an example of a proposition which is true *simpliciter* but not immutably so. Such, then, is the difference between A- and B-theorists: the former accept and the latter deny that what is true *simpliciter* varies over time.

So far, we have seen Zimmerman's preferred way of characterizing the A-/B-theory divide. Two potential costs for this way of characterizing it, the first of which Zimmerman mentions: First, if you're attracted to a deflationary view of truth, you won't much like this way of characterizing the divide. If there is no such property as truth *simpliciter*, this way of spelling it out is a non-starter. Second, if you're skeptical, as I am, about the existence of propositions—abstract pieces of information encoded or expressed by beliefs, sentences, etc.—then, here again, you won't much like the proposal.

A related suggestion which gets around these two worries postulates the existence of events or states of affairs of the Armstrong/later-Chisholm sort. On this view, necessarily, for any *x* and *y* and relation *R*, *x* bears *R* to *y* iff there is the event (or in Armstrong's language, "state affairs", but I'll stick with event talk for concision) *x*-bearing-*R*-to-*y*, a non-mereological fusion of *x*, *y* and *R*, whose existence depends on the existence of *x* and *y* and the instantiation of *R* by *x* and *y*.

That there are such things as these events is contentious. A reason for thinking there are, alongside the usual ones put forward by Armstrong, Chisholm *et al.* is their usefulness in characterizing the dispute between A- and B-theorists of time, a dispute which intuitively makes sense but is extremely difficult to characterize without adverting to events.

With events in hand, though, the dispute is easily described. Above we saw the A-theorist holding that what is true *simpliciter* changes over time. Here is a variation on that theme: what exists changes over time. More exactly: which events exist changes over time. Or, in terms of quantifiers and tense operators—reading the quantifiers here as unrestricted, ranging over everything whatsoever, ignoring nothing—we may understand A-theorists as those committed to this:

> *Thesis of Temporal Passage*: It is always the case that, for some event *x*, either WAS(for every *y*, *y* is, was and will be numerically distinct from *x*) or WILL(for every event *y*, *y* is, was and will be numerically distinct from *x*).

B-theorists deny the Thesis of Temporal Passage. They'll think it always the case that, for any event *x* you pick, WAS(something will be identical with *x*), or WILL(something was identical with *x*).

So the distinction between A- and B-theories of time may be thought of thus: the A-theorist accepts whereas the B-theorist denies the thesis of temporal passage. Since commitment one way or the other on the Thesis of Temporal Passage is compatible with any number of views about truth and propositions, we have a way, then, of characterizing the A-/B-theory divide that swings free of deflationism about truth and propositions.

All to the good. We've also a way, then, of answering our question: what temporal passage is. At least, we have a way of answering that question from the perspective of the A-theory, which is the perspective I shall presuppose in this essay.

What is temporal passage, then? It is the coming into being or ceasing to be of events. (It's something like C.D. Broad's *becoming* (e.g., 1923: 66-67), though not exactly that since he thought of the passage of time as involving the coming into being of events, not the ceasing to exist of any events.) In terms of quantifiers and tense operators, taking our quantifiers as unrestricted, temporal passage is a matter of there being some event *x* such that WAS(for no *y* is it the case that *y* is, was or will be identical with *x*) or WILL(for no *y* is it the case that *y* is, was or will be identical with *x*).

3. TEMPORAL PASSAGE: HOW IT WORKS

Next I want to consider the question how temporal passage works. Why does it happen? Why do events come into being and cease to be?

Here is an attractive, if uninformative, picture.

Things have powers. A bit of copper has the power to expand when heated, a stick of dynamite has the power to explode when put into the right conditions, and so forth.

It is an attractive thesis, so I think, that to have a power is to stand in a fundamental, multigrade relation of things to universals. So suppose we have some object *o* with the power to instantiate a property *A* on the condition that it instantiate the property *B*. This, I propose, is a matter of *o*'s bearing a fundamental power relation to the universals *A* and *B*. Using a property abstraction operator similar to those deployed variously by George Bealer (e.g. 1982), we can put it like this: *o*'s having the power to instantiate *A* on the condition that it instantiate *B* is a matter of its being the case that $[Bx \Rightarrow Ax]o$, where we read this as '*o* is an *x* such that *x* has the power to instantiate *A* on the condition that it instantiates *B*, and '[__⇒__]__' expresses our fundamental power relation. (Why complicate things thus with property abstraction? It'll aid concision below.)

Or: Suppose *o* has the power to instantiate *A* on the condition that it instantiate *B* and *C*. This iff $[Bx \,\&\, Cx \Rightarrow Ax]o$.

Or: Suppose o_1 and o_2 jointly have the power to instantiate a relation *A* on the condition that they instantiate the relation *B*. This iff $[Bxy \Rightarrow Axy]o_1,o_2$. And so forth.

This, I say, is an attractive if uninformative picture. It's attractive because it construes power talk as fundamental, as carving at nature's joints. It's uninformative for the same reason: explanation of the fundamental is perforce limited.

Grant me the picture and let us see what it suggests about temporal passage. Suppose there is an *x* such that (a) *x* lacks the property *A*, (b) *x* has the power to instantiate *A* on the condition that it instantiate *B*, and (c) *x* instantiates *B*. Then by dint of its having this power and being in what we might call the "triggering condition" of the power, *x* will exercise its power and jump to a state in which it instantiates *A*. Likewise with relational powers: Suppose there is an *x* and *y* such that (a) *x* does not bear *A* to *y*, (b) $[Bxy \Rightarrow Axy]x,y$, and (c) *x* bears *B* to *y*. Then by dint of *x* and *y* jointly possessing this power and being in the power's triggering condition, *x* and *y* will exercise their power and jump to a state in which *x* bears *A* to *y*.

When *x* exercises a power and jumps to a state in which it comes to possess a property *A* it didn't previously possess, a new event, *x*-being-*A*, comes into existence. When that happens, there is an event *x*-being-*A* such that, it was the case that, quantifying unrestrictedly, nothing is, was or will be identical with *x*-being-*A*. When that happens, time passes.

When *x* and *y* jointly exercise their power to jump to a state in which *x* bears *A* to *y*, a relation they didn't previously bear to one another, a new event, *x*-bearing-*A*-to-*y*, comes into existence. When that happens, there is an event *x*-bearing-*A*-to-*y* such that, it was the case that, quantifying unrestrictedly, for no *y* is it the case that *y* is, was or will be identical with *x*-bearing-*A*-to-*y*. When that happens, time passes.

So we get this picture of time's passage: at present, reality comprises a large number of particulars, universals, and the events they constitute. Many, many of the particulars comprising reality have powers to jump to new states and are in states sufficient to trigger those powers. As those powers are triggered, the particulars possessing those powers jump to new states, thereby bringing into being new events. At this point, new powers are triggered, resulting in a jump to new states yet, which give rise to further triggering of powers, and so on. Such jumping of things from state to state, thereby successively bringing into being new events, followed by further new events, and so forth, all driven by the exercise of the powers of things, we call the flow or passage of time.

It's a helpful bit of picture thinking to conceive of the phenomenon of temporal passage as something akin to the popping of popcorn. The popcorn kernels each have the power to pop at thus-and-such triggering temperature. A kernel hits its triggering temperature, exercises its power to pop, and jumps to a new state. Another hits its triggering temperature, exercises its power, and jumps to a new state. Another, and another, and another, ... Such is the flow of time: the constant popping of things (points of space, perhaps, or their point-sized matter/energy constituents) from one state to another as power after power is triggered.

So far, then, a powers account of temporal passage, painting in very broad strokes. Let me next try to fill the picture in some by describing a way of thinking about relativistic physics that fits nicely with the picture.

4. TEMPORAL PASSAGE AND "SHAPE DYNAMICS"

Julian Barbour and collaborators have been working on a Machian view of particle and geometry dynamics for the last decade or so. Ernst Mach was famously suspicious of Newton's absolute space and time on epistemological grounds: they can't be observed, so we have no good reason to postulate them. A major difficulty in realizing Mach's empiricist scruples in our physical theorizing was that it turned out to be extremely difficult to recast Newtonian particle dynamics in a form that makes no appeal to absolute space and time. Newtonian dynamics was eventually superseded by general relativistic dynamics, much of it inspired by Machian ideals, but even here, Einstein ends up postulating an unobservable background space (spacetime) and a fundamental temporal metric (proper time along timelike trajectories), neither of which fits well with Machian scruples.

Barbour (together with his collaborator, Bruno Bertotti) has the distinction of being the first in the history of physics to show how to reconstrue Newtonian particle dynamics in fully Machian form: no appeal to an invisible Newtonian container space (to define inertial motion) or invisibly flowing Newtonian time (to define a temporal metric) (1982). The temporal metric postulated as primitive in Newton's dynamics turns out on Barbour and Bertotti's dynamics to be definable from more fundamental quantities in the theory, as a measure of change in those quantities over time (a useful measure of that change, it turns out, because it yields the simplest mathematical description of the dynamics of that change). Time, in Aristotle's famous phrase, is just a measure of change.

In more recent papers (e.g., 2010), Barbour and collaborators show how to extend the approach to General Relativity (GR). On the standard formulation of GR, the basic equations of the theory are Einstein's field equations, which describe the distribution of metric and matter fields across a four-dimensional spacetime. A non-standard way of thinking of GR is "geometrodynamics", where this is a matter of reconstruing GR as a dynamical theory describing the evolution of three-dimensional geometry over time.

Barbour *et al.* develop a version of geometrodynamics on which the fundamental law governing the evolution of 3-space over time is an action principle determining geodesics through a configuration space, each point of which corresponds to a possible conformal 3-geometry of a closed 3-space, and geodesics through the configuration space corresponds to dynamically possible histories of an evolving 3-space. The resulting theory corresponds closely to General Relativity (but isn't General Relativity: possible histories in Barbour's theory correspond to only the CMC-foliable models of GR, a subset of the full set of general relativistic spacetime models). So far anyway, it corresponds closely enough to General Relativity as to satisfy all current experimental verifications of GR.

It's an extremely interesting theory of gravity, for several reasons. First, local Lorentz invariance of non-gravitational interactions turns out to be a consequence of the action principle at the heart of the theory (as opposed to the usual approach to GR, according to which the validity of special relativity in local inertial frames is an independent assumption). Second, as with Barbour's Machian Newtonian dynamics, temporal metric (in this case, infinitely many local temporal metrics along timelike trajectories) turns out to be non-fundamental, definable from more fundamental quantities in the theory. And third, spatial metric—the measure of spatial distance—also turns out to be non-fundamental, definable from the dynamics of the theory. (The fundamental geometrical facts, on the theory, are conformal: facts having to do with angles between trajectories in space. It's a theory, then, about the evolution of conformal 3-geometry over time. Hence the name he gives it: shape dynamics.)

There's much to like about the theory in terms of unity and economy: for minimal cost in ontology (no primitive temporal or spatial metric), you get local Lorentz invariance and all known experimental consequences of general relativity. It's a neat theory.

Assume for discussion that it's true and let us consider what it suggests about the picture of temporal passage I have been sketching. The picture, again: The many, many particulars comprising reality have powers to jump to new states and are in states sufficient to trigger those powers. As those powers are triggered, the particulars possessing those powers jump to new states. At this point, new powers are triggered, resulting in a jump to new states yet, which gives rise to further triggering of powers, and on and on. Such constant change—such constant jumping from state to state owing to the exercises of the powers of things—we call the flow or passage of time.

Reflection on Barbour's shape dynamics suggests an interesting development of the account. At the heart of Barbour's shape dynamics is an action principle describing dynamically possible histories of an evolving 3-space. Now, proponents of powers theories of causation will sometimes say that laws of nature should be thought of as descriptions of powers. Let me suggest that that's how we think of the action principle at the heart of Barbour's shape dynamics: as a compendious mathematical description of the powers possessed by Space and its constituent points. (Space: the three-dimensional, enduring container of all mass/energy, whose constituent points are linked by spatial distance relations, whose geometry is variably curved depending on the distribution of mass/energy, and whose geometry changes over time as it lapses through successive jumps in state. I am assuming, notice, a three-dimensional, as opposed to a four-dimensional, view of the spatiotemporal world. I assume that *all* mass/energy, quantifying unrestrictedly, is housed in an enduring 3-manifold structured by relations of spatial distance as opposed to the usual 4-manifold structured by the spacetime interval. In a word, I assume presentism. See, e.g., my 2003 for further explanation and defense of presentism.)

Perhaps it works like this. Let the *x*s be all and only the points of Space. Then perhaps the *x*s jointly instantiate various power relations: $[R_1xs \Rightarrow R_2xs]xs$, $[R_2xs \Rightarrow R_3xs]xs$, $[R_3xs \Rightarrow R_4xs]xs$, and so forth, where R_1, R_2, ..., we may suppose, are conformal geometrical properties like those described by Barbour's theory. These powers specify that when the *x*s comprising Space are such that R_1xs, they'll jump to a state in which R_2xs, and that when in that state, they'll jump to a state in which R_3xs, and so forth, with the upshot that these powers specify that Space will traverse some one of the extremal curves through a configuration space of Shape Dynamics. Barbour's action principle is just a handy mathematical description of how Space behaves under the action of these powers.

Suppose so. Then two interesting consequences. First, as Space jumps from state to state under the guiding influence of these powers, it successively lapses along a geodesic of a configuration space of Shape Dynamics, and thus successively lapses along a CMC-slicing of some general relativistic spacetime model. All that to say: as Space and its contents lapse from state to state, they behave just as General Relativity predicts: clocks move slower near massive objects; clocks move at different rates in relative motion; massive objects curve the Space around them; gravity waves propagate through Space; and so forth.

Secondly, as Space lapses from state to state under the guiding influence of these powers, there is no fundamental temporal metric measuring its lapse. General relativity's local proper time emerges from more fundamental quantities in the theory as a useful measure of changes in the conformal geometry of Space over time, useful because it yields the simplest mathematical description of that change. But the trajectory-relative temporal metrics of General Relativity aren't fundamental: they don't carve nature at its joints. They're one among infinitely ways to parameterize changes in Space over time, distinguished only in that they enable us to formulate the laws governing the evolution of Space over time more simply than alternatives.

Other ways of parameterizing are, from the standpoint of metaphysics and its attempt to describe fundamental structure, just as correct—and more useful in everyday life to boot. So there's measuring change by solar time, assigning a measure of one solar day to the quantity of change transpiring in some system per rotation of the earth around its axis. There's measuring change over time by ephemeris time, where this is the timescale such that the laws of motion describing the sun and planets in our solar system are approximately those given by Newton. There's reference-frame dependent timescales: time as measured by a cesium-133 clock in thus-and-such state of motion. All are equally correct ways of measuring cosmic and local change over time. None is fundamental; none carves at the joints. Some make for simpler mathematical description of the change of physical quantities over time, but all are simply measures of change.

5. SUMMARIZING

Taking Barbour's shape dynamics on board, then, here, I want to suggest, is an attractive account of temporal passage:

(1) Individual objects have powers to jump to new states when in certain monadic triggering conditions. Multiple objects jointly have powers to jump to new states in certain polyadic triggering conditions.
(2) Having such monadic and polyadic powers is a matter of entering into a fundamental, multigrade power relation between things and universals.
(3) Things exercise their powers in their triggering conditions, thereby jumping to new states and bringing into being new events: events such that, quantifying unrestrictedly, it was the case that nothing was identical with that event. These new events put their subjects into new triggering conditions, which gives rise to further exercise of powers, which brings into being further new events, which puts their subjects into new triggering conditions, yields further exercise of powers, further new events, and so forth. We call this successive coming into being of events, resulting from successive exercise of powers, the flow or passage of time.
(4) There is such a thing as Space—the manifold of points-at-a-time in which all matter/energy is housed. It is an enduring, three-dimensional space whose curvature varies with distribution of mass/energy and over time. The totality of its constituent points are linked by polyadic power relations which specify certain conformal geometric properties as triggering and manifestation conditions. These power relations are elegantly described by the action principle at the heart of Barbour's shape dynamics.
(5) As the points of Space jointly exercise these powers, they lapse successively through the configuration space of shape dynamics, which corresponds to a CMC-slicing of some general relativistic spacetime model. Wherefore matter and energy behave in accord with the dynamics predicted by general relativity: local Lorentz invariance, gravitational time and length dilation, bending of light, etc.
(6) There is no fundamental temporal measure of this lapse. The usual, trajectory-dependent, relativistic temporal metric emerges from more fundamental quantities in shape dynamics as the simplest way of representing its laws.

Such, in short, is my shape-dynamical account of temporal passage. I close with a brief discussion of its bearing on a classic objection to A-theoretic accounts of temporal passage.

6. SMART ON THE RIVER OF TIME

A classic objection to A-theoretic ways of thinking about temporal passage was first introduced into the philosophical literature by C.D. broad, and was famously defended by J.J.C. smart in his 1949 paper, "The River of Time." The heart of the argument is contained in this passage:

> If time is a flowing river we must think of events taking time to float down this stream, and if we say 'time has flowed faster to-day than yesterday' we are saying that the stream flowed a greater distance to-day than it did in the same time yesterday. That is, we are postulating a second time-scale with respect to which the flow of events along the first time-dimension is measured. 'To-day', 'to-morrow', 'yesterday', become systematically ambiguous. They may represent positions in the first time-dimension, as in 'to-day I played cricket and to-morrow I shall do so again', or they may represent positions in the second time-dimension, as in 'to-day time flowed faster than it did yesterday'. Nor will it help matters to say that time always flows at the same rate. Furthermore, just as we thought of the first time-dimension as a stream, so will we want to think of the second time-dimension as a stream also; now the speed of flow of the second stream is a rate of change with respect to a third time-dimension, and so we can go on indefinitely postulating fresh streams without being any better satisfied. (1949: 484)

How shall we think about this argument? how does it go exactly?
I think the idea is something like this. a river flows through a given area, you might think, only if there is some rate at which the water of the river is passing. Likewise, Smart seems to be thinking, with time: if it flows or passes, there must be some rate at which it flows or passes. As a first premise for the argument, then, we have something like

(1) Time flows or passes only if there is some rate at which it flows or passes.

Suppose this is so; suppose time passes only if there is some rate at which it passes. What rate might that be? At what rate would time pass? Ordinarily, we think of rate as the ratio between some bit of change and a period of time over which that change occurs. So there is the ratio between the change in someone's heart over a period of time (measured in number of beats, say) to some period of time over which that change occurs (measured in minutes, say), arriving at a heart rate of *x* beats per minute. Or, there is the ratio between the change in someone's position over a period of time (measured in meters, say) to the period of time over which that change occurs (measured in seconds, say), arriving at a rate of *x* meters per second.

The rate at which time passes, then, would be a ratio between the change in time over some period of time to the period of time over which that change occurs. Here one begins to see the problem, for the change in time over a period of one second, say, is one second, and the period over which that change takes place is, well, one second, arriving at a rate of change for time of one second per second. There is something odd about that rate, to be sure. At the very least, it's uninformative to be told that time advances at a rate of one second per second. Smart seems to be thinking there is something nonsensical about it, something incoherent:

> A connected point is this: with respect to motion in space it is always possible to ask 'how fast is it?' An express train, for example, may be moving at 88 feet per second. The question, 'How fast is it moving?' is a sensible question with a definite answer: '88 feet per second'. We may not in fact know the answer, but we do at any rate know what sort of answer is required. Contrast the pseudo-question 'How fast am I advancing through time?' or 'How fast did time flow yesterday?' We do not know how we ought to set about answering it. What sort of measurements ought we to make? We do not even know the sort of units in which our answer should be expressed. 'I am advancing through time at how many seconds per ____?' we might begin, and then we should have to stop. What could possibly fill in the blank? Not 'seconds' surely. In that case the most we could hope for would be the not very illuminating remark that there is just one second in every second. (1949: 485)

Smart is thinking, then, that there is something unhappy about the suggestion that time passes at a rate of one second per second: it's a "not very illuminating" answer to the "pseudo-question" 'How fast does time pass?'.

Well, to be sure, it's not a terribly illuminating answer to this question, but why is that a strike against it? What's wrong with the answer (and with the question)? I'm not sure. Peter van Inwagen (2009) and Eric Olson (2009) have argued that what's wrong with it is that one second per second is not a genuine rate, since one second divided by one second is just one, which isn't a rate. I'm not sure this argument works, but grant it for now; as we'll see, not much hangs on it.

Supposing, then, that it is somehow objectionable to think of time as passing at a rate of a second per second, if you're committed to the idea that time passes and to (1), the idea that it passes only if there is some rate at which it passes, you might think the only coherent way to talk about the rate at which time passes is to postulate some second time scale in terms of which one can describe change in time as featured in the original scale. Were there some such second time scale, one could say that the rate at which time passes is the ratio between the amount of first-time-scale time over some period to the amount of second-time-scale time over that same period. If you thought all this made sense, you might accept something like

> (2) There is a rate at which time flows or passes only if there is a second time scale (distinct from the first time scale we normally use), in terms of which the rate of time measured by the first scale can be described.

Next, Smart suggests that if we think of some period of temporal passage as measured by our newly introduced second time-scale, the question arises afresh: how fast did that period of second-time-scale time pass? There'll be some rate at which it passed. So:

> (3) If there is a second time scale measuring temporal passage, then there is some rate at which periods of time as measured by our second time scale pass.

But if so, then, says Smart, we'll need some third time scale (distinct from the first- and second- time scales) in terms of which to describe that rate, which sets up a regress:

> (4) If there is a rate at which periods of time as measured by our second time scale pass, there is a third time scale in terms of which the rate of time measured by the second scale can be described, and a fourth in terms of which the rate of time measured by the third can be described, and so forth.

And finally, Smart thinks this regress vicious ("and so we can go on indefinitely postulating fresh streams without being any better satisfied"), suggesting as the final step in the argument something like

> (5) The regress in (4) is impossible,

and the conclusion that

> (6) It is not the case that time flows or passes.

Such, I think, is the gist of Smart's argument that time does not flow or pass. If it's right, my above-adumbrated account of temporal passage is wrong, since, says my account, time flows or passes. What's to say?

6.1 Smart's Argument Examined

To start with, as we have seen, Smart presupposes it nonsensical or incoherent to suppose that time flows at a rate of one second per second. But it's exceedingly difficult to see why that would be. Other than that it's trivial or uninformative, there is nothing incoherent or nonsensical about the suggestion that time flows at a rate of one second per second, as has been nicely argued in a recent paper on this point by Hud Hudson, Ned Markosian, Ryan Wasserman and Dennis Whitcomb (2009). That being so, one could resist Smart's argument by rejecting premise (2) on grounds that we needn't appeal to multiple time scales to make sense of the idea that there is rate at which time flows.

But I'm inclined to accept premise (2), much as I agree with Hudson *et al.* that there is nothing problematic about time's flowing at a rate of one second per second. According to my above-adumbrated account, recall, there is no fundamental temporal metric, no fundamental measure of temporal duration. Say I: there are as many measures of temporal duration as there are measures of change. There are measures of temporal duration associated with sidereal timekeeping; measures associated with ephemeris timekeeping; general relativistic, trajectory-dependent measures of duration; and infinitely more besides. No one way of measuring temporal duration is fundamental; all are equally correct.

That being so, premise (2)'s claim that there is a rate at which time passes only if there is a second time scale (distinct from the first-order time scale) in terms of which the rate of time's flow on the first scale may be measured is perfectly correct. Suppose Space evolves through a sequence of changes during which the earth turns on its axis by exactly 15°. Measured in terms of a sidereal timescale, we'd say that period of time lasted an hour. In terms of Newtonian time, that same sequence of changes will have lasted an ephemeris hour, something just shy of a sidereal hour (or just over; I'm not sure which). Temporal flow, during that period, would be moving, then, at a rate of 1 sidereal hour per 1.01 (let us suppose) ephemeris hours.

This will hold for any period of temporal evolution you pick: for any timescale t_1 you pick, you'll be able to find some distinct timescale t_2 such that temporal passage flows during that period at a rate of t_1 units of time per t_2 units of time. Premise (2) is correct.

Premise (3) looks good, too: True enough, if there is a second time scale measuring temporal passage, then there is some rate at which periods of time as measured by our second time scale pass.

Premise (4) likewise seems fine. Again:

> (4) If there is a rate at which periods of time as measured by our second time scale pass, there is a third time scale in terms of which the rate of time measured by the second scale can be described, and a fourth in terms of which the rate of time measured by the third can be described, and so forth.

This is plausible. A temporal metric, from our present perspective, is a conventional measure of change. Since there are infinitely many ways of measuring change, it's plausible that there'll be a well-ordering of temporal metrics of the sort envisaged by Smart. Take, for example, the metric you'd measure with a cesium-133 clock in orbit around the sun at a distance of 1 million miles, the metric you'd measure with a cesium-133 clock in orbit around the sun at a distance of 1 half million miles, the metric you'd measure with a cesium-133 clock in orbit around the sun at one-half that distance, and so forth. Given General Relativity (and shape dynamics too), these yield Smart's well-ordering.

So (1) through (4) of Smart's argument look pretty good. Not so with (5). (5) says that the regress suggested by (4) is vicious. But, manifestly, it isn't. The regress follows from the fact that duration is a conventional measure of change, of which there are infinitely many. Nothing vicious about that. And if so, Smart's argument, interesting and important as it is, makes no trouble for my suggested account of temporal passage.[1]

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