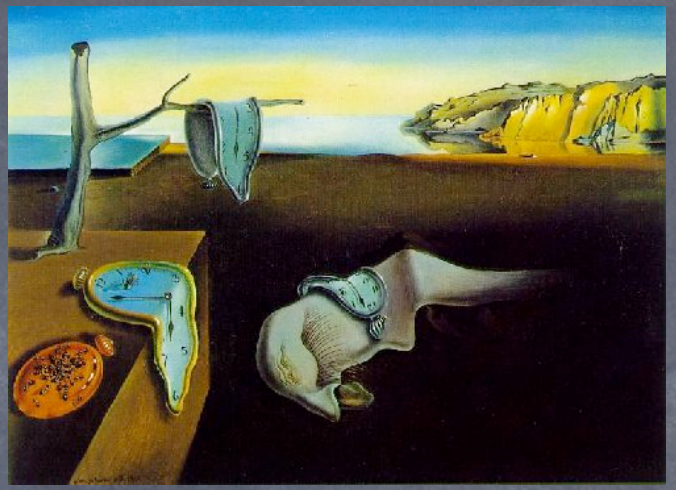
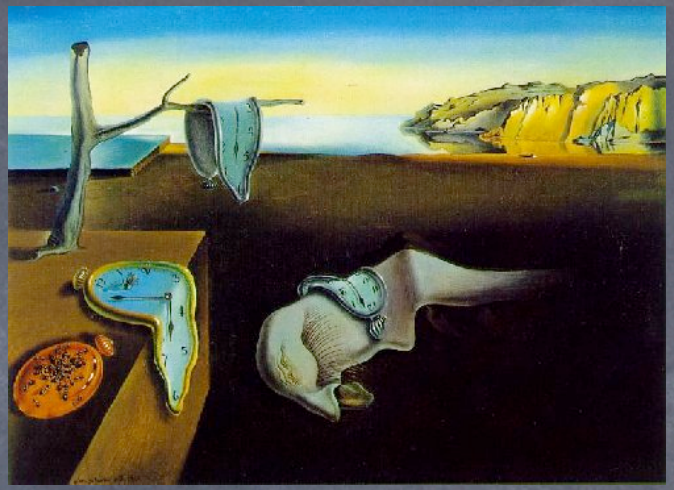


Five Objections to Becoming Dissipated



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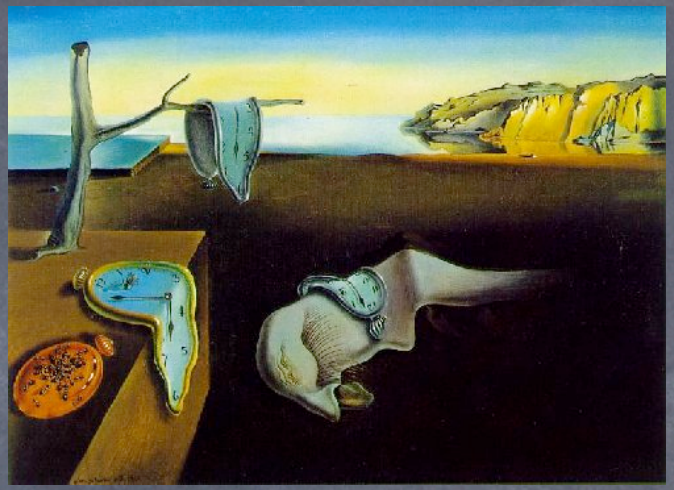

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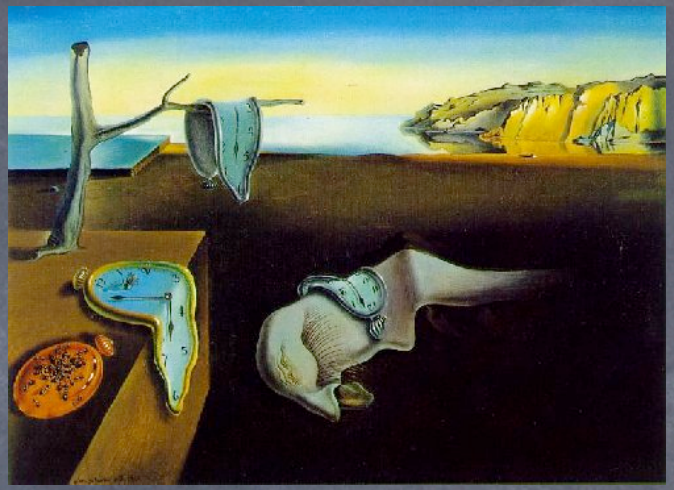

Richard T. W. Arthur,
McMaster University

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- I take it to be implicit in this characterization that processes are *asymmetric*: if b comes to be out of a, then a does not come to be out of b. (Here I am talking about individual processes, process *tokens*, if you like, and not *types* of process. If a type of process is reversible, this means that the laws (or *de facto* circumstances) governing it are time-symmetric, and are instanced by tokens going from a_1 to b_1 as well as tokens going from b_2 to a_2. But more on this below.)

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Illustration: Russell on Zeno's Arrow Paradox:

"Weierstraß, by strictly banishing from mathematics the use of infinitesimals, has at last shown that we live in an unchanging world, and that the arrow in its flight is truly at rest... People used to think that when a thing changes, it must be in a state of change, and that when a thing moves, it is in a state of motion. This is now known to be a mistake. ... Motion consists merely in the fact that bodies are sometimes in one place and sometimes in another, and that they are at intermediate places at intermediate times. Only those who have waded through the quagmire of philosophic speculation of this subject can realize what a liberation from antique prejudices is involved in this simple and straightforward commonplace."

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You can be as Weierstraßian as you like about the continuum, yet you can still define a function which assigns a value for the velocity of the arrow at each instant: this will be zero for the arrow at rest at every instant of the motion, and

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> The banishment of the infinitesimal has all sorts of odd consequences, to which one has to become gradually accustomed. For example, there is no such thing as the next moment. The interval between one moment and the next would have to be infinitesimal, since, if we take two moments with a finite interval between them, there are always other moments in the interval. Thus if there are to be no infinitesimals, ... there must be an infinite number of moments between any two; because if there were a finite number one would be nearest the first of the two moments and therefore next to it. (83)

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- It is false that "Weierstraß banished the use of infinitesimals from mathematics". As Philip Ehrlich has shown, although they disappeared from the calculus, they did not disappear from mathematics, but were systematically developed between the early 1870s and 1961 in the context of studies of the rate of growth of real functions, differential geometry, and number theory.

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Granting this, there does not appear to be anything valid in Russell's "Weierstraßian" attack on becoming: for in the same way that one may perfectly well claim that, even though there is no motion in an instant, there is still motion over an interval of time, one can claim that, even though there is no becoming in an instant, there is still becoming over an interval of time. To claim otherwise in either case is simply a fallacy of composition.

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As Smart points out, since motion is already represented in the spacetime manifold, it is illegitimate to speak of it as "static". To require some superadded motion to represent change or becoming is a paralogism. Similarly, Williams writes: "There is passage, but it is nothing extra. It is the mere happening of things..." One cannot begin, as does McTaggart, by assuming as if it is uncontentious that events already exist and then ask what it is about them that changes as they come to be. They do not exist (although we may of course represent them) prior to their becoming.

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Let us say it *exists* atemporally, as for instance one might say a temporal relation such as O's being earlier than M *exists*. This implies nothing about permanence, or eternalism, if this term is used temporally. McTaggart makes this kind of error:

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To return to spacetime, that it *exists* does not entitle any claims about its existing at all times. It does not exist at any time. That events exist when they occur does not entitle any claim that they exist at any other times than those at which they occur, so that there is no pre-existence that makes redundant their coming-to-be.

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One might also add that it seems awkward for becoming existent to depend on an *inertial* frame: what is so special about the class of inertial frames that makes them constitutive of coming into existence?

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Becoming is local: *processes lie along worldlines, and proper time* —which is path-dependent — *measures the lapse of time along a worldline*. But there is no necessity for the measures of how much time has elapsed along different worldlines emanating from the same source to match up when the lines intersect at a later event (twin paradox).

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There are no planes of synchronous becoming (except approximately), but this is no objection to becoming. Becoming, as process, is *local* not global.

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4. arguments based on the incoherency of the moving “now” or *nunc fluens*, which presuppose that becoming must be described in terms of such a notion.

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There are two aspects to this criticism: (i) that (according to relativity theory) there is no global, invariant “now” which could move; (ii) that it makes no sense in any case to talk of any motion or rate of flow of time, since any such notion of rate must be taken with respect to time. (i) we have already ceded, but, as just argued, the lack of a global plane of becoming is not an objection to the existence of a local, process-bound notion of becoming: it is what processes do. So let us turn to (ii).

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Jack Smart correctly points out various of the things said above about the illegitimacy of talking of movement along a line on a spacetime diagram. In BSaP (256) he writes: "There is clearly no room in the space-time picture for movement *through spacetime*." He continues: "Since movement is change of space with respect to time, what would movement through time be? Change of time with respect to what?"

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As Paul Davies observes, Smart's criticism is "brilliantly encapsulated" in his "arresting question: 'How fast does time flow?' We all know the answer: one second per second. The muddle in the metaphor manifests itself immediately." (*About Time*, 254)

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Price: "A rate of seconds per second is not a rate at all in physical terms. It is a dimensionless quantity..." (13)

time flow (cont.)

This certainly has the appearance of a knock-down argument against the flow of time. But let's dig a little, to try to understand what would motivate a conception that appears so incoherent.

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In promoting the flux of time and its constancy, Gassendi stressed that this is a metaphor. What is the point? Well, there is an order of succession, but such a succession could be quicker or slower for any given thing.

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Barrow adopted Gassendi's notion of "time flowing at an even tenor", but observed that in comparing rates of processes, all one ever did was to compare processes whose flow is assumed to be constant: perhaps the periodicity of an hourglass is a better bet than the periodicity of the moons of Jupiter. Why then retain the notion of flow? Barrow was adamant that one had to distinguish the Quantum of time from its Quantity, the latter being given by empirical measures.

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Newton was not happy with Barrow's having simply assumed the constancy of certain empirical measures of the flow of time: by his lights it is possible to calculate mathematically which processes flow equably by a suitable calculation of forces, and thereby accurately to determine the "equation of time" —read, how to render an equable flow of time from perceived periodic processes (such as the periodicity of the maximum elevation of the sun (i.e. noon) on successive days).

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time flow (cont.)

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So, granting that there may exist no empirical measure of time flow that is in fact equable, we can nonetheless calculate one; or, more precisely, assuming the equable flow of absolute time, and a correct theory of the cosmos and the forces acting therein, we can account for all observed irregularities in a coherent way. Newton, of course, took the notion of flow quite literally: the relative times identified by Barrow are *fluxions*, and for certain purposes one may take such a measure instead of time, so that $x^{\circ} = dx/dt = 1$, so that $y^{\circ} = dy/dt = dy/dx$.

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The bottom line is that the "Newtonians" (lumping Gassendi and Barrow in with their successors) appeal to time flow in order to try to capture successive quantity: recall Clarke/Newton's objection to Leibniz that

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> The order of things succeeding each other in time is not time itself, for they may succeed each other faster or slower in the same order of succession, but not in the same time. (Clarke to Leibniz, IV, §41)

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Implicit in this classical conception of time flow (shared by Leibniz, however unsatisfactory one might find his attempts to account for it) is the idea that the "rate" of succession is global, a kind of pulse of the universe: events occur on a hyperplane of simultaneity, so that becoming is always "in step". (This is, of course, a different sense of absoluteness than the substantivalist one.)

time flow (cont.)

The twins will not experience any alarming dislocation when they meet up again, even though, objectively and invariantly, different times will have elapsed for them. (There will be alarming consequences if closed timelike curves are allowed; but

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Let us now see how things lie in the relativistic context. Here there is no global plane of becoming. But, as I have argued, the rate at which processes occur is measured along their worldlines by the proper time.

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But when we compare the rates of the same type of processes (such as, aging) for the two twins, we are presented with the scenario where, relative to one another, the twins do age differentially. Generalizing,

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So there is nothing incoherent after all in the notion that orders of succession may occur at different rates.A global plane of synchrony is not a necessary condition for the objectivity of becoming.

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My last point can be seen as the obverse of Huw Price's, the tails to his heads. He "takes it for granted that there is no objective flow of time," saying that he will "not explore the suggestion that flow gives direction to time, for

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In order to determine whether a process is time-reversible, instanced by tokens going from a_1 to b_1 as well as tokens going from b_2 to a_2, as I had it above, it would be enough to have a *conventionally imposed asymmetry*. The analogy is with the case of space, where one can see whether a one-dimensional object is symmetrical about a point on a line without presupposing an objective asymmetry. It is enough to *conventionally impose* such an asymmetry: left will correspond to my left, and so forth.

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Unlike the case of space, the direction given by the order of succession is not conventional, as left and right are relative to the orientation of the observer. The left-right asymmetry is extrinsic to the ordering of points on a line in the sense that it arises from a relation of the line to an "observer" who is free to orient herself at will with respect to the line. But in the case of time there is no such freedom of orientation, and nothing extrinsic about the asymmetry of the temporal ordering. The illusion that you can orient yourself "in either direction" in time with respect to a process, trades precisely on the illicit interpretation of time reversal as a passive symmetry.

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I think this agrees with Richard's conclusion, but my way of putting it (in an unpublished paper) differs from his in details whose significance I have not yet worked out; it derives from John Earman's treatment in his (1967):

direction of time (cont.)

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Abstractly speaking, it is possible to treat any symmetry transformation from either a passive or an active point of view. To treat a transformation passively is to construe it as taking us from a description of a certain type of process viewed from one frame of reference to a description of the same process viewed from a transformed frame of reference. To treat it actively is to construe it as transforming the system itself, viewed from the same frame of reference.

The active point of view can always be maintained, since we can always transform the system or process and then check to see whether this transformed system or process does actually occur (or in the case of quantum symmetries, occur with the same probability as the original system or process). But the passive point of view cannot always be maintained, because we cannot always physically realize the transformed reference frame to see whether the original system or process occurs in it.

Suppose, for the sake of concreteness, our process is the evolution of a system from point M to point N. The state of the system at M is S_m, its state at N is S_n, their time inverses are $S_m^{®}$ and $S_n^{®}$, and the time reversal transformation takes S_m --> S_n into $S_n^{®}$ --> $S_m^{®}$. Invariance under the transformation of time reversal would then amount to the claim that if the process S_m --> S_n has a certain probability of occurrence with respect to the normal time-orientation, then $S_n^{®}$ --> $S_m^{®}$ will occur with equal probability with respect to the same orientation.

direction of time (cont.)

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But what about the passive interpretation of this transformation, in which it is the frame of reference that is transformed? This would involve changing from the given frame of reference in which the process evolves from M to N, to one in which it evolves from N to M with each of its states time-inverted with respect to this new frame. Invariance under time reversal transformation would then have to be interpreted in terms of an equivalence between these two descriptions, in the first of which the system is at M *before* it is at N, and in the second of which it is at M *after* it is at N.

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But, as Earman points out, such a transformation of frame is physically impossible (at least in all normal spacetimes, that is, time-orientable ones). Two points M and N that are causally connectible will remain causally connectible *in the same temporal order* in all physically possible frames of reference. And if one transforms the whole of spacetime and everything in it, one ends up with a situation that is indistinguishable from the original. A temporally inverted observer will interpret temporally inverted processes in a way indistinguishable from the original observer interpreting the original universe (Sudarshan's "re-interpretation principle.)

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Thus the passive interpretation of time reversal invariance is illegitimate just because temporal asymmetry is intrinsic to the notion of process or succession (and *vice versa*). It is an error to view the operation of time reversal as a reversal of the direction of time.