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1. Changing the Past

Peter van Inwagen

There are two kinds of time-travel: travel to the past and travel to the future. Travel to the future raises no conceptual problems. A ''time-machine'' for travel to the future need do no more than uniformly slow down the physical processes that go on inside it relative to physical processes external to the machine. If all you want of a time-machine is that it be capable of taking you to the future, a spaceship that can reach speeds near the speed of light will suit your purposes very well. To ''travel to 2071'' in your spaceship/time-machine, simply leave the Earth, keep the throttle open till you have reached a speed near the speed of light, travel at that speed for a while (relative to the stellar background), and then decelerate in such a way that you come to rest (relative to your point of arrival) in 2071 (you will, of course, have had to travel in a big loop[1]—you will have had to follow a trajectory that ended at the point on the surface of the earth at which you wanted to ''arrive in 2071''). If you follow the right schedule of acceleration and deceleration—a very demanding one, to be sure—, the trip will take only half an hour (as measured by onboard clocks—either the digital display on the control panel or the clock constituted by your own metabolic processes). I suppose that even the chair I am sitting on can be regarded as a limiting case of a machine for travel to the future: if I sit on it long enough, shall find myself in 2071.

Travel to the past is another story, and it is the story I am interested in. Accordingly, in the sequel I shall use 'time-travel' to mean 'travel to the past', unless otherwise noted.

[1] If you ''depart for 2071'' in 2010, the loop will be sixty-one light-years in length (assuming that you reach your ''cruising speed''—very near the speed of light relative to the stellar background—pretty quickly and subject yourself to the necessary fierce episode of deceleration only for a short period at the end of the trip). Since you will be traveling in a loop, you will be constantly changing your direction, and thus be subject to ferocious g-forces even when your speed is constant relative to the stellar background.

I have no idea whether the (actual) laws of physics permit time-travel. My best layman's guess is that it will turn out that time-travel is physically impossible for extended objects with an internal structure (such as a human being or a machine). I am much less confident, however, that it will turn out that it is physically impossible to send electrons or photons into the past—one at a time, one after the other. (The best bet for time-travel is a wormhole, and it is far more likely that we shall one day open or discover a zero-width wormhole whose ''other end'' is in, say, 1920—an electron or photon might pass through a zero-width wormhole—than one so wide that a proton or a cat could pass through it and retain its internal structure.) If a sequence of electrons or photons can be sent into the past, then information about the present can be sent into the past[2], and the possibility of sending information into the past creates the same paradoxes (whether they are real paradoxes or only apparent ones) as the possibility of sending macroscopic physical objects like human beings or Terminators into the past. (Tim sends information into the past in the hope that this information will convince the recipient to kill his, Tim's, grandfather . . . .)

I am going to assume that ''extended physical object'' time-travel is physically possible—but if time-travel of that sort is physically impossible, and it is nevertheless physically possible to send sequences of individual elementary particles (and hence information) into the past, what I shall say can be easily adapted to the philosophical problems raised by that case (for the simple reason that the problems are essentially the same in both cases).

Travel to the past is (like time-travel *simpliciter*) of two kinds. I will call them Ludovician and non-Ludovician time-travel.[3] Ludovician time-travel does not involve changing the past. Consider the following story. Tim the time-traveler enters a time-machine in 2020

[2] I am thinking of something like Morse Code. But even a single particle sent into the past could carry information if a proper ''code'' had been agreed on: ''Observe the particle detector at noon the day before election day, 2020. On noon the day after the election I shall send an electron forty-eight hours into the past if Blenkinsop wins and a muon if Entwhistle wins.''

[3] In honor of David Lewis. See his ''The Paradoxes of Time Travel,'' *American Philosophical Quarterly* (1976), pp. 145–52. Reprinted in David Lewis, *Philosophical Papers, Volume II* (New York: Oxford University Press, 1986), pp. 67–80, and in Peter van Inwagen and Dean W. Zimmerman, eds., *Metaphysics: The Big Questions*, 2nd. edn. (Oxford: Blackwell, 2008), pp. 224–35.

and travels to 1920; he spends a month in 1920, during which month he has a series of adventures; then he returns to 2020. For this story to be a story of *Ludovician* time-travel, the events related in the following story must have been a part of the historical record, a part of the one true history of the world, at every moment from the moment of Tim's arrival in 1920 to the moment at which he entered the time-machine to travel to 1920—and at every moment thereafter to boot[4]:

> At a certain moment in 1920 a marvelous machine popped into existence[5]—apparently *ex nihilo*—and a man who said his name was Tim disembarked from it and had a certain series of adventures; a month later, this fellow Tim once more entered his ''time-machine''—that is how he referred to it—and he and the machine vanished like a soap bubble.

My topic is non-Ludovician time-travel: time-travel that involves changing the past. An episode of time-travel is non-Ludovician if it is *not* a part of the historical record at the moment the time-traveler entered the time-machine for a trip to the past that he or she arrived in the past—*not* a part of the record that a marvelous machine with (very nearly) the same intrinsic properties as the ''departing'' machine popped into existence at the ''target date''—and so on. Note that non-Ludovician time-travelers change the past by the mere fact of their *arrival* in the past—however careful they may be thereafter ''not to do anything to change the past.'' (I see no reason to suppose that a world in which there were episodes of non-Ludovician time-travel would have to be a world in which there were no episodes of Ludovician time-travel: it might be that while certain rogue time-travelers—''time bandits''—engaged in non-Ludovician time-travel, responsible, professional time-travelers were careful to travel to the past only if they could first find a

[4] The historical record as God knows it: human historians, whose knowledge of the past is of course fragmentary, may or may not have been aware at any time during this interval that history contained events of this description.

[5] In the illustrative stories I shall be telling I shall assume that the time-machine is a ''Wellsian vehicle'': the time-traveler travels to the past *in* it. In some time-travel stories, the time-machine is more like a projectile launcher than a vehicle: it ''sends'' the traveler to the past, but does not itself travel to the past. No point of principle is affected by supposing that the time-machine is a vehicle as opposed to a launcher.

trustworthy historical record of ''their visit to the past.'' I will not discuss the possibility of a ''mixed'' time-travel world.)

I want to present a ''model'' that permits non-Ludovician time-travel without paradox.[6] The model I will present presupposes the ''growing-block'' theory of time. I take no stand on the question whether the growing-block theory is metaphysically possible, on the question whether it is consistent with present-day physics, or even on the question whether it is meaningful (whether there *is* such a theory). I will assume—for the sake of argument, as it were—that the growing-block theory is at least meaningful. I will not develop

[6] There are other ''models'' that may have this feature than the one I shall present in the text. Here is a very simple one. When the ''depart'' button in the time-machine is pressed, the machine and its passengers leave our physical universe (perhaps for some region of spacetime unconnected with the spacetime of the physical universe). The machine ''leaves behind'' in our physical universe a perfect atom-for-atom duplicate of itself and its passengers (maybe it borrows the mass-energy contained in the duplicate from the quantum vacuum or some such jargon). Then the direction of the momentum of every particle in the physical universe is reversed, and every particle moves ''backward'' along its historical trajectory (each of the particles that compose the newly created duplicate of the time-machine moves backward along the historical trajectory of the particle which it replaces) until the physical universe has returned to the state it was in in, say, 1920. Then the time-machine and its passengers return to the physical universe (managing somehow to push the matter at their arrival point out of the way) and ''everything goes forward again.'' A ''return to the future'' is accomplished by the same means as in the model presented in the text. Episodes of this kind are episodes of non-Ludovician time-travel (without paradox)—provided they are episodes of time-travel at all. The only defect in this model is that it is not entirely plausible to suppose that it really does involve ''traveling to the past,'' that it provides the reality, and not merely the appearance, of time-travel. (Note the occurrence of phrases like 'has *returned*' and 'the state it *was* in' and 'everything goes forward *again*' in the description of the alleged episodes of time-travel.) A different sort of complaint can be brought against ''branching histories'' models of changing the past: although such models involve real time-travel, it is not entirely plausible to suppose that they really represent the past as being *changed*. It is plausible to say that, on a branching-histories model, when Tim murders grandfather, the ''original past,'' the past in which grandfather eventually dies, full of years and wickedness, is still ''there.'' It is plausible to say that what Tim's action has accomplished, according to a branching-histories model, is the creation of a ''new past'' in which he cuts his grandfather's career short, a past that somehow runs parallel to the original past—and which is ''no less real'' than the new past. Or to put the matter another way. Suppose I know that you plan to travel to the past and, as you put it, ''murder van Inwagen when he was twenty.'' If the successful accomplishment of the undertaking you have so described would really be a case of ''changing the past,'' I ought to be worried. But, on the branching-histories picture of ''murdering van Inwagen when he was twenty,'' *I* have nothing to worry about: you will get into your time-machine and vanish, never to be seen again, and *my* life will go on much as before.

this theory in the detail that would be necessary if my interest in it were other than instrumental—if I were interested in the theory ''for its own sake,'' as a theory of the nature of time. I have relegated many nice points—ones I could not resist making—to the notes. The reader should feel free to skip the notes to the following section of the chapter.

1. THE GROWING-BLOCK THEORY

The following statement of the growing-block theory is my own. It differs from the statements of Broad and other writers[7] in detail, but not, I think, in any essential way.[8] For the sake of simplicity, the ''time'' of which this theory treats will be supposed to be Newtonian: I will assume the existence of absolute or observer-invariant simultaneity. And—also for the sake of simplicity—I will suppose that the past and future are infinite. (It might be thought that, since 'The future is infinite' implies that there are future times, it contradicts the growing-block theory. We shall see that this is not so.) The theory comprises the following eight theses.

(1) Timeless or tenseless or ''pure'' predication is possible. (And timeless predication that applies to ''temporal'' subjects like horses

[7] See Broad's ''The General Problem of Time and Change'' in C. D. Broad *Scientific Thought* (London: Routledge & Kegan Paul, 1923). An excerpt from this paper is printed in van Inwagen and Zimmerman, *Metaphysics: The Big Questions*, 2nd. edn., pp. 141–59. There has been extensive discussion of the growing-block model in the recent philosophical literature. See Michael Tooley, *Time, Tense, and Causation* (Oxford: Oxford University Press, 1997), esp. ch. 6, ''Tensed Accounts of the Nature of Time''; Craig Bourne, ''When am I?'', *Australasian Journal of Philosophy* 2002, pp. 359–71; David Braddon-Mitchell, ''How Do We Know it is Now Now?'', *Analysis* 2004, pp. 199–203; Peter Forrest, ''The Real but Dead Past: A Reply to Braddon-Mitchell,'' *Analysis* 2004, pp. 358–62; Trenton Merricks, ''Good-Bye Growing Block,'' in Dean Zimmerman (ed.) *Oxford Studies in Metaphysics* (Oxford: Oxford University Press, 2006).

[8] Many recent critics of the growing-block theory contend that growing-block theorists should be skeptics about whether it is now the present time. More exactly, that adherents of the growing-block theory are committed to a skepticism of the sort that would be expressed by the utterance of sentence-tokens of the following types: ''For all I know, this utterance occurs in the remote past. For all I know, the present moment is a moment approximately thirty-seven thousand years after the moment at which this utterance occurs.'' (See the essays by Bourne, Braddon-Mitchell, Forrest, and Merricks cited in the previous note.) I will not address this criticism of the growing-block theory.

and explosions and not only to timeless things like numbers and attributes and the God of the Philosophers.) There is a sense of 'is' in which the sentence 'Bucephalus is a horse' expresses a truth, even though Bucephalus does not now exist. And there is a sense of 'are' in which the sentence 'Bucephalus and Street Smart are horses' expresses a truth, despite the fact that there is no time at which both horses exist. For the sake of simplicity, we shall consider timeless predication only of ''full career'' predicates like 'is a horse' (in the sense of 'horse' in which the word applies to foals as well as to adult horses). That is, predicates that apply to things over the whole span of their existence if they apply to them at all.

(2) Timeless or tenseless quantification—over temporal things—is possible. I should like to explain what this means, but I find that I cannot offer an explanation of timeless quantification that is consistent with another aspect, an essential aspect, of the growing-block theory. I will explain my difficulty presently (in note 13), after that ''aspect'' has been introduced. Timeless quantification will therefore be taken as an unexplained notion in this statement of the growing-block theory. The predications in the open sentences bound by timeless quantifiers will, at least in most cases, be tenseless predications: If one says 'There is, timelessly, a horse' one almost certainly does not mean 'There is, timelessly, a thing that is-at-present a horse'. In this statement of the growing-block theory, we shall consider timeless quantification only on open sentences like '*x* is a horse'; that is, on open sentences that instances of full-career predicates.

(3) Physical reality (hereafter, Reality) is to be thought of as comprising physical events (hereafter, events).[9] Events, *pace* Chisholm, are concrete particulars, not universals: events cannot ''recur,'' and we make no distinction between an event's happening at a time and its existing at that time.[10] Reality is the ''grand event,'' the mereological sum of all events—where 'all' is a timeless quantifier.

[9] Dualists may wish to replace my phrase 'physical reality' with 'temporal reality'.

[10] It will be observed that we quantify not only over events but also over the times at which events occur. These ''times'' *are* to be understood as abstract objects of some sort, but I do not much care exactly what abstract objects they are. Here is one example of what they might be. Pick some ''benchmark'' event to serve as a ''reference point''—the first Olympic games, the founding of Rome, the birth of Christ (if past time is infinite, any choice of a benchmark will be arbitrary). Call it B.

(We assume that just any events have a unique sum. The sum of the Battle of Waterloo and the Battle of Stalingrad, for example, existed and is [timeless predication] a gappy event, an event—it would not be right to call it a *battle*—that happened or existed partly in 1815 and partly in 1942: at just those times at which one battle or the other was being fought.) In saying this, we do not deny the existence of physical substances or continuants. Nor do we deny that at least some events ''involve'' continuants (Caesar's death presumably has Caesar as a constituent in some sense of 'constituent', and could not exist if Caesar did not exist). The present statement is no more than a stipulation that establishes the way we shall use '(physical) reality'.

(4) As the previous statement suggests, we are assuming that at least some events *have* proper parts and that all events (other than Reality) *are* proper parts. We in fact assume that only events are parts of events, and that events are parts only of events. Every part of an event is a ''sub-event'' of that event: the event ''the Battle of Stalingrad'' was a part of the event ''the Second World War.'' (Again, we do not deny that there are physical substances or continuants, but we so use 'part' that no continuant is, in the strict and philosophical sense, a part of an event: no German tank or Russian soldier was—strictly speaking—a part of the Battle

Let ''times'' be such *properties* as ''is an event that is one year later than B,'' ''is an event that is one billion years earlier than B'', and so on. Such ''times'' have an obvious ordering, and there is an obvious measure of the ''interval'' between two times. For an event to ''happen at'' a time is for it to *have* (the property that is) that time. Given a robust platonism about properties, it follows that for any temporal interval and any event E, there is a time ''that long before'' E and a time ''that long after'' E. In the text, we have assumed for the sake of convenience that the past is infinite (we have assumed there was no Big Bang or other ''downwhen terminus''—to borrow a term from a novel by Isaac Asimov), but I should point out that there is a good sense in which this conception of times does not *imply* an infinite past. True, this conception of times implies that if there was a Big Bang there are ''times'' earlier than the time at which that event occurred. But those times are times at which nothing happened. If ''times'' are the properties with which I tentatively identified them above (if the founding of Rome is our benchmark event, they would be properties like ''is an event twenty billion years earlier than the founding of Rome''), the times earlier than the time of the Big Bang are *uninstantiated* properties: on the ''property'' conception of times, times at which nothing happens are uninstantiated properties. To say that the past is finite is not to say that there is a time such that there is no earlier time; it is rather to say there is a time such that there is no earlier time *at which anything happened*.

of Stalingrad. And if Caesar was in some sense a constituent of Caesar's death, he was nevertheless not a *part* of that event. But we assume that if substances or continuants exist at a time, then events exist or happen at that time—changes or ''unchanges'' in the substances that then exist, if no other events.) Reality, then, is (the predication is timeless) the event of which all (timeless quantifier) events are parts (and all of whose parts overlap some event—but it is not necessary to add this customary clause, owing to our stipulations concerning the ''parts'' of events).

(5) There are, timelessly, events that have happened and there are events that are happening, but there are (timelessly) no events that have not happened yet[11] but will happen.[12] If Jones died

[11] The qualification 'have not happened yet' is not idle, at least on one conception of the identity of events across time. Consider, for example, the longish event ''my life.'' According to the growing-block theory, there is, timelessly, such an event. And this event will still be happening—at least I hope so—ten minutes from now. In a sense, therefore, the growing-block theory implies that there can be, timelessly, events that will happen in the future—it implies, at any rate, there can be events that *will be happening* at various future times. Understand the words 'events that have not yet happened yet' in the text in this sense: 'events that are not happening now and were not happening at any times in the past (but which will be happening at some times in the future)'. For some points related to the ''dating'' of events and the use of the ''ongoing aspect'' of the verb 'to happen', see the note that follows. (There is another way to solve the problem to which this note is addressed, a very simple and elegant way: the event I now call 'my life' is not the event that admiring historians of philosophy after my death will call 'van Inwagen's life': the event I now call 'my life' will be only a proper part of any event that historians refer to *post mortem meam*—unless they should happen to use phrases like 'the part of van Inwagen's life that occurred before 6:10 p.m., GMT, 14 August 2008'.)

[12] We shall say that an event is or was happening at a time if any part of it is or was happening at that time. This statement is not a definition of 'is or was happening at *t*'—for, if it were a definition, it would be circular. The point of the statement is this. I assume that some events are of such short duration that it is unproblematical to say that those events happen at a particular time. (Only event-slices, events of zero duration, could, strictly speaking, have this feature if a ''time'' is an instant.) What the statement comes to is a stipulation. And the stipulation is this: If such an ''unproblematical'' event happens or happened at a time, any ''longer'' event of which it is—timeless predication—a sub-event will be said also to be or to have been ''happening'' at that time. Thus the event ''my life'' is happening now and the Second World War was happening on 21 September 1942. If, moreover, there *will be* unproblematical sub-events of a ''current event'' that (will) happen at a future time *t*, that current event will (still) be happening at *t*. My life, for example, will—I hope—still be happening ten minutes from now, despite the fact that it is now true that there are, timelessly, no unproblematical sub-events of my life that will happen ten minutes from now.

yesterday, there is (timelessly) such a thing as Jones's death. But if (it is now inevitable that) Smith will die tomorrow, there is nevertheless (timelessly) no such event as Smith's death. Now these three sentences contain indexical elements (if that is what tenses are; at any rate, the verb-phases 'will happen' and 'died' and 'will die' are tensed). And these three indexical, or at any rate tensed, sentences would express truths whenever they were uttered or written. But the point I wish to make has nothing to do with indexicality or tense. To convey the point I really wish to make, I must ask you, the reader of these words, now—at the moment you are reading them—to perform the following two linguistic acts: first, give the moment you now call 'the present moment' the proper name 'Nunc'; then, having done that, utter the sentence, 'There are (timelessly) no events that happen later than Nunc'. Have you done those things? You have? Good. In so speaking, you expressed a truth.[13] And so would anyone who performed those two linguistic acts (*mutatis mutandis*) at any time.

(6) One might have supposed that timeless quantifications could not have different truth-values at different times—that either truth-values can be ascribed to such propositions only ''timelessly,'' or at any rate, that every such proposition is either unalterably true or unalterably false. But statement (5) implies that this is not the

[13] It is this ''aspect'' of the growing-block theory—the aspect presented in statement (5)—that has forced me to conclude that the growing-block theory must treat timeless quantification as primitive. The *obvious* definition of 'There is, timelessly, an F' (in terms of temporal or tensed quantification) would treat this schema as equivalent to the following schema: 'Either there has been an F or there is at present an F or there will be an F'. (The disjunction, of course, is inclusive. The quantifications are understood to be over temporal objects, and F is understood to represent a full-career predicate.) This, I say, is the obvious definition—and I can see no other. If the definition is obvious, however, it is equally obvious that it cannot be accepted by the growing-block theorist. Suppose, for example, that the earth will one day be sterilized by a supernova. Let us express this baleful supposition in these words: a ''sterilization event'' will one day occur. (Suppose, for good measure, that it is now causally inevitable that a sterilization event will occur.) But this implies that there *will be* a sterilization event (although there never has been one). The proposed definition of timeless quantification obviously implies that, in the circumstances imagined, there is, timelessly, a sterilization event. But the growing-block theory implies that there is, timelessly, no sterilization event. I myself doubt whether there is any *possible* sense of 'There is, timelessly', such that a statement of the form 'There is, timelessly, no F', understood in that sense, is consistent with the corresponding statement of the form 'There will be an F'. But, of course, a doubt is not an argument.

case. Timeless quantifications over events—even ones expressed by sentences that contain no indexical element whatever—*can* change their truth-values. The most important case of this phenomenon is this: Timeless existential quantifications over events that have been false can become true. (But existential quantifications over events obey the rule, ''Once true, always true.'') For example, the proposition that there is (timelessly) such a thing as the death of Caesar was once false, but it became true at a certain moment in the Ides of March, 44 BC (and it was thereafter unalterably true).[14] It follows that timeless universal quantifications over events can be true and later become false, and that they obey the rule, ''Once false, always false.''[15] For example, the proposition expressed by the ''Nunc'' sentence that—obedient reader that you are—you uttered a moment ago was true at the moment you uttered that sentence and immediately thereafter became false and is destined to be forever false.

(7) An event is or was *past* at a time *t* if it is or was true at *t* that there are (timelessly) events that occur after it.[16] An event is or was *present* at a time *t* if it is or was false at *t* that there are (timelessly) events that occur after it.[17] Thus, it is true at every time that every event—timeless quantification—is either past or present. If, at any time, an event is then a future event if it is then neither past nor present, it follows from these definitions that it is true at every time that there are (timelessly) no future events. But our having

[14] Suppose that in 45 BC, Brutus had said—using tensed language—that it was then false but would eventually be true that there was such an event as Caesar's death—or would eventually be true that there was an event that was a death of Caesar. Was the proposition that he expressed true at the time he spoke? Was it true timelessly but false at the time he spoke? Was it false, both timelessly and at the time he spoke? Did it perhaps have no truth-value of either sort, although it was destined to become timelessly false? A proponent of the growing-block theory will have to answer questions of this sort. I am content to leave them open.

[15] Ted Sider has pointed out to me that the two rules, ''once true, always true'' and ''once false, always false'' require some sort of restriction. Consider, for example, 'There is a sunrise that is followed by no sunset'. This is true at the moment at which I write (according to the growing-block theory), but it will become false this evening when the sun sets. I have no idea how to formulate the appropriate restriction.

[16] ''Is or was'?'' Well, the Battle of Waterloo is past now and was past in 1915.

[17] My writing the words you have just read *is* present at 1:02 p.m., Eastern Daylight Saving Time, 4 August, 2008—so I say at 1:02 p.m., Eastern Daylight Saving Time, 4 August, 2008. *You* would say that it *was* present at that time.

offered definitions of 'past' and 'present' and 'future' that have this consequence should not be regarded as an attempt to make the substantive thesis (5) above true by definition. It should rather be said that we have offered a definitions of 'past' and 'present' and 'future' that presuppose the truth of the substantive thesis. We say, moreover, that an event is present (without qualification) if it is now present. It follows that an event is present if and only if it exists now—as opposed to 'it is now true that it exists timelessly'. And it follows that an event is past if and only if it (exists timelessly but) does not exist now. A *time* is present (or is *the* present time, for all present events are simultaneous) if and only if some event that happens at that time is present.[18] A time is *past* if and only if it is earlier than the present time, and a time is *future* if and only if it is later than the present time. (Every future time is such that the proposition that there are, timelessly, events that will happen at that time is now false. Our supposition that the future is infinite could be expressed this way. Every future time t has this property: the currently false proposition that there are, timelessly, events that happen at t will become—unalterably—true at t. If there were—contrary to what we are supposing—a ''beginning of time,'' then some past time would be such that it and every earlier time had this property: the proposition that there are, timelessly, no events that happen at that time is and always has been unalterably true.)

(8) Define 'x exists timelessly at t' as follows: 'the proposition that there is, timelessly, something identical with x is true at t'. Then:

For any times t_1 and t_2 (t_2 later than t_1), every event that exists timelessly at t_1 exists timelessly at t_2, and some events that exist timelessly at t_2 do not exist timelessly at t_1.[19]

[18] If times are understood as in n. 10, we may say that t is the present time just in the case that an event that has the property t is present.

[19] There are confusions of tense in this statement. I let the statement stand in the text because a careful statement of the intended thesis is so complicated as to be, to say the least, hard to take in at a glance. Strictly speaking, we should regard 'x exists timelessly at t' as a present-tense statement, and go on to define 'x *existed* timelessly at t' as 'the proposition that there is, timelessly, something identical with x *was* true at t' (and similarly for 'x *will* exist timelessly at t'). Thus, the Battle of Waterloo exists timelessly now, existed timelessly in 1915, did not exist timelessly in 1715, and will exist timelessly in 2115. The carelessly stated thesis may now be carefully stated as the following tensed statement:

These eight statements comprise the growing-block theory. And that name is appropriate, for there is an obvious intuitive sense in which the theory represents Reality as a ''growing block.'' It is a ''block'' because the B-relations among its parts are (once established) unalterable. It is growing, because, if we think of the temporal axis as a dimension, then Reality is, as we might say, growing along the temporal dimension: at every time it contains—timelessly—all the parts it contained at earlier times and other parts as well. (Of course, if past time is infinite, Reality is growing only in the sense in which a railway that is infinitely long in one direction is ''growing'' as new track is laid. We need not worry about the question whether Reality is ''really the same object'' from moment to moment—a question raised by the fact that, at any two moments, the word 'Reality' denotes the mereological sum of different sets of events at those moments.)

Some philosophers have supposed that if Reality is indeed a growing block, there must be a ''second sort of time'' in which it does its growing. Other philosophers have denied this. Let *us* suppose that whether or not the existence of this second sort of time follows from or is essential to the growing-block theory, this other time—hyper-time, I shall call it—does exist. (In my view, for what it is worth, the existence of hyper-time does not follow from the growing-block theory; not, at any rate, from the theory as I have stated it. But, if the concept of hyper-time is meaningful at all, the existence of hyper-time does seem to be *consistent* with the theory.)

Let us provide this hyper-time with an intuitive representation by imagining that there is an immaterial rational being, an

> (a) If t_1 is a past time and t_2 is a later past time, all the events that existed timelessly at t_1 existed timelessly at t_2; and some events that existed timelessly at t_2 did not exist timelessly at t_1. (b) If t is a past time, all the events that existed timelessly at t exist timelessly at the present time; and some events that exist timelessly at the present time did not exist timelessly at t. (c) If t_1 is a past time and t_2 is a future time, all the events that existed timelessly at t_1 will exist timelessly at t_2; and some events that will exist timelessly at t_2 did not exist timelessly at t_1. (d) If t is a future time, all the events that exist timelessly at present will exist timelessly at t; and there will be events that exist timelessly at t that do not exist timelessly at present. (e) If t_1 is a future time and t_2 is a later future time, there will be no events that exist timelessly at t_1 and will not exist timelessly at t_2 and there will be events that exist timelessly at t_2 that will not exist timelessly at t_1.

Intelligence, that exists outside ''our sort of time,'' and whose conscious experience comprises the successive awareness of events in the order in which they occur in hyper-time. Let us imagine that the Intelligence can actually *watch* Reality (physical reality) hyper-become temporally longer as hypertime passes—in a sense analogous to the sense in which human beings can watch a railway become spatially longer as new track is laid. Reality, therefore, not only grows with the passage of time (at a rate of so many standard events per second[20]), but hyper-grows with the hyper-passage of hyper-time (at a rate of so many seconds per hyper-second).[21]

2. THE MODEL

Hyper-time is the key to our model of non-Ludovician time-travel. That is to say, the model presupposes a version of the growing-block theory that includes hyper-time. Unless the growing-block theory actually entails the existence of hyper-time (I have said that I do not think it does) postulating its existence does nothing for the theory *as a theory of time*. If we were interested in the growing-block theory only as a theory of time, hyper-time would be an otiose postulate.

But suppose that there in fact are episodes of time-travel. What does the Intelligence see when it examines Reality at a hyper-time at which it contains (timelessly) one of these episodes? If the episode is Ludovician, something of the following sort. (I shall tell two stories about what the Intelligence sees as it examines the hyper-growing-block that is Reality.[22] In these stories, the

[20] A ''standard event'' would be something like a single vibration of a cesium atom. If the number of cesium atoms is always the same—let us suppose this to simplify the example—, then, for some n, n standard events become ''new parts'' of Reality every second, and we may say that Reality grows at a rate of n standard events per second.

[21] The Intelligence could use Reality as a hyper-clock. It might in fact use Reality as the ''standard'' hyper-clock and, for some m, *define* a hyper-second as the amount of hyper-time in which m standard events (see the previous note) are added to Reality. If this m is equal to the n of the previous note, then Reality hyper-grows at a rate of one second per hyper-second. If $m = 2n$, then Reality hyper-grows at a rate of two seconds per hyper-second, and so on. In the text, I will assume that Reality grows at the rate of one second per hyper-second.

[22] From our point of view, Reality is a growing block: it is constantly gaining new parts and never loses any parts. From the point of view of the Intelligence, it is a hyper-growing-block: it is a certain number of seconds ''longer'' every hyper-second.

apparent tenses of verbs are really hyper-tenses. If you like, when I tell these stories, I am imagining the words of a speaker of hyper-English—another inhabitant of hyper-time—who is telling the story of the observations of the Intelligence. I will, however, scatter a few 'hyper-'s around in the stories, more or less at random, simply to keep the sort of stories they are before the reader's mind. My stories have the following defect. The block the Intelligence is watching *is* a block: apart from its hyper-growth, it is entirely hyper-static. But I represent the stories as being in large part records of things happening. The first story, for example, contains the words 'The human beings then left the machine'. My only excuse is that it is not possible for me to tell the story in any other way.)

> When the block had grown to the point at which its internal calendars read '1920', an object (a machine with human beings inside it) having the set of intrinsic properties F appeared, thrusting aside the matter that had occupied the region of space that it, the machine, now occupied; this event had no temporal causal antecedents. The human beings then left the machine. As hyper-time passed and the block grew a certain number of seconds longer, there came a point at which those human beings got back into the machine. At that moment, the machine-cum-passengers composite had the set of intrinsic properties G; it promptly disappeared, leaving no physical residue whatever. When the block had grown another hundred years and its internal calendars read '2020', an object having (approximately) the set of intrinsic properties F disappeared without leaving a trace. A few moments later, an object having (approximately) the set of intrinsic properties G appeared in a manner similar to the way in which the object with the set of properties F appeared in 1920.

It should be clear that postulating the existence of hyper-time contributes nothing to our understanding of Ludovician time-travel. Our hyper-temporal—the strictly correct word would be 'hyper-chronic'—observer does no work toward that end. (A long-lived and omnisicent Intelligence who was, like ourselves, an inhabitant of time, would have described this episode in almost the same words. To turn the story above into the story such an observer would tell is a purely mechanical task.)

But suppose we try to imagine a hyper-temporal Intelligence watching an episode of *non*-Ludovician time-travel. What would it see? No doubt this is an open question, but, on the model of non-Ludovician time-travel I propose, the answer is as follows.

> The Intelligence sees the block grow beyond the 1921-New-Year's point with no apparently *ex nihilo* appearance of any sort of machine having been included in the block. After the block has grown about a century longer, the Intelligence sees one of its inhabitants, Tim, enter an elaborate machine. At the moment t, Tim presses a button (at t, the machine-Tim composite has the set of intrinsic properties F)—and suddenly, all in a hyper-instant, the futuremost century-long part of the block vanishes. The events that hyper-now constitute the ''leading face'' of the block occur at a moment t_0 in 1920. But those events are hyper-now a bit different from the way the t_0-events hyper-were before the block lost its century-long terminal segment, for the leading face hyper-now contains the appearance of a machine-Tim composite with (approximately) the set of intrinsic properties F. (The matter that had, just before t_0, occupied the region of space the composite now occupies has been somehow thrust aside into the space surrounding that region.) Thereafter, the block grows at the same rate (so many seconds per hyper-second) it hyper-always has. But it does not grow in quite the same *way* it did following the previous hyper-occasion on which it passed the point t_0—not even if the laws of physics that govern the ''ordinary'' evolution of the block are deterministic. It grows in a different way because conditions at t_0 are hyper-now different from what they were the previous hyper-time the block reached t_0: on *this* hyper-occasion, the leading face contains the appearance of the machine-Tim composite. A month later, Tim re-enters the time-machine and presses a button. At that moment, the machine-Tim composite has the set of intrinsic properties G. The physical processes inside the time-machine then slow down, relative to external physical processes—almost, but not quite, to a standstill—till the block has grown a bit past the moment t, and then the composite begins once more to ''age'' at the normal rate. (Let us suppose that when the machine is in its ''slow'' state

> it has essentially no causal interaction with the rest of the world; it is, for all practical purposes, at least, undetectable.) At that moment, the composite has (approximately) the set of intrinsic properties G.[23]

This is part of the story. But, we may well ask, what happens *then*? How should the story be continued? This is a matter of conjecture—even if the ''ordinary'' growth of the block is deterministic. I am inclined to think that the world is sufficiently chaotic—*you* know: butterfly wing-flaps and hurricanes two weeks later—that Tim will find that he ''has never been born,'' that ''no one knows who he is,'' that there is no record of anyone who bears his name and looks like him and shares his DNA and has the same set of great-grandparents. And I suspect that he would find that the same thing was true, *mutatis mutandis*, with respect to ''everyone he ever knew or knew of'': that there was no one who corresponded to the friends and relations and public figures that he (would think he) remembered.[24] He may well, in fact, discover that time-travel ''has never been invented.'' Non-Ludovician time-travel entails changing the past; if the world is chaotic, a very small change, even the arrival of a time-machine in an isolated area and its ''departure'' a fraction of a second later, might well lead to *immense* changes in

[23] Does this story represent Tim as a mass-murderer? In a way, it does. But only, I think, in virtue of being a story in which a century-long segment of the past is changed. ''Mass-murder'' in this sense would seem to be, of logical necessity, a feature of any story in which the past is changed to that extent: If Tim changes the past in the way I have imagined, he will have to be a ''mass-murderer'' according to *any* theory or model of changing the past.

[24] It is a commonplace that time-travel, even Ludovician time-travel, creates difficult problems of personal identity. In the end, these problems cannot be evaded, since—for one thing—if it is not Tim the time-traveler who ''arrives'' in 1920, the same Tim who (timelessly speaking) departs for 1920 in 2020, then we do not really have a case of a time-traveler. (But if the person who pops into existence in 1920 is not Tim but is a qualitative duplicate of Tim—as he hyper-was at the moment he pressed the ''depart'' button—we should still have a case of sending information into the past, and thus the same problems with ''the paradoxes of time-travel.'') For example, if Tim travels one hour into the past and meets himself (or meets his earlier self, as some writers like to say)—well, what do we say about that? Is he then bi-located—or what? Would not bi-location imply a violation of Leibniz's Law? I am not going to try to ''talk round'' all those difficult problems, since my project is to deal with the paradoxes of time-travel (which are raised simply by sending information into the past) and not with *all* philosophical problems raised by time-travel.

the course of history—the history of the human *Lebenswelt*, that is: no doubt the Earth's orbit and the shapes of the continents would remain the same—within a few years or even a few months.[25] But the ''what happens then?'' question, interesting as it is, is not really relevant to our central problem, the paradoxes of time-travel, for if there are such paradoxes, they should have shown up by the time (that is narrative time) the story has got to this point.

3. CHANGING THE PAST WITHOUT PARADOX

Our model represents the growing block as having a ''hyperhistory.'' Normally it grows at a steady rate, but hyper-occasionally it instantly ''shrinks'' (loses a terminal segment) and then begins to grow again, and grow in a different way from the way it grew the previous hyper-time. The hyper-history of the block comprises all the episodes of normal growth and sudden ''snappings-back'' that have hyper-ever occurred. Describing the hyper-history of the growing block by adopting, in our imaginations, the point of view of an imaginary hyper-temporal Intelligence has its intuitive and expositional advantages. But we are going to examine a very complex episode in hyper-history, and the story of what the Intelligence observed in the course of that episode would be very hard to follow indeed. Since one picture is worth a thousand words, I will use a different descriptive device. I will use what I shall call ''hyper-temporal diagrams.'' (One might think of them as notes that the Intelligence uses to record its observations of the growing block.) A hyper-temporal diagram is a diagram that has the following features. (The reader is advised first to skim through this list of features and then to consult it frequently while working through the examples—diagrammatic representations of episodes of time-travel—that follow the list.)

—Each hyper-temporal diagram ('diagram' for short) consists of a vertical sequence of horizontal lines. Each line is a ''time-line'' of

[25] If the world is *both* indeterministic (if its ''normal evolution'' is indeterministic) and chaotic, the vanishing of a ''terminal'' segment of the block even *without* the ''arrival'' of a time-machine at its hyper-new leading face might well lead to immense changes in the course of history in a short time. The arrival of a time-machine in such a world would, to a near certainty, magnify these changes.

the familiar kind used to display the order of events in history or in a narrative. Each point on each line represents both a time and the events that are occurring or have occurred or hyper-have occurred at that time. (If a vertical line is drawn through a diagram, each of the points it intersects represents the same time. Recall that ''times'' are abstract objects of some sort, and that the existence and identity of a time are therefore unaffected by the changes the growing block hyper-undergoes.)

—The top line of a diagram represents the growing block as it was (in hyper-time) just before (in hyper-time) the first-ever (in hyper-time) episode of time-travel.[26] The events belonging to a world in which there were no episodes of time-travel would be represented by a ''unit diagram''—a diagram that consisted of a single line. And so would a world that contained only Ludovician episodes. A ''purely Ludovician'' diagram is distinguishable from a ''no time-travel'' diagram only in that some of the events represented in the former will have rather bizarre causal properties (machines pop into existence and these sudden apparitions are in principle causally inexplicable by any appeal to the prior state of the world; machines vanish into thin air leaving no trace of themselves behind).[27]

—The number of lines in a diagram equals the number of episodes of time-travel there hyper-have been plus 1. (The number of episodes of time-travel there hyper-have been should not be confused with the number of episodes of time-travel there have been. For one thing, if an ''episode'' of time-travel has both a departure and an arrival as sub-events, there never have been any episodes of time-travel because there never have been any departures. But even the number of *arrivals* that there hyper-have been is not necessarily

[26] I will assume—once more, for the sake of simplicity—that there hyper-was a hyper-first episode of time-travel (despite the fact that this is of 0 probability if the past is infinite and the large-scale features of the physical world have always been much as they are now). There would be no fundamental difficulty in extending the notion of a hyper-temporal diagram to include diagrams in which every line has a line above it. They would be hard to draw, of course.

[27] The single line that represents the sequence of events in no-time-travel and Ludovician-time-travel worlds terminates in a moving point, the present; that is to say, a normal sort of time-line requires continual revision as new things happen. Only the bottom line of a non-Ludovician diagram has this feature: all the other lines terminate in a (hyper-) fixed point, the moment at which a time-traveler departed for the past.

identical with the number of arrivals that there have been. For it might be, for example, that there has been only one arrival (B), but there hyper-have been two arrivals, A and B—owing to the fact that B changed the past in such a way that the hyper-earlier arrival A never occurred. That is: A was contained in the segment of the block that vanished when B occurred.

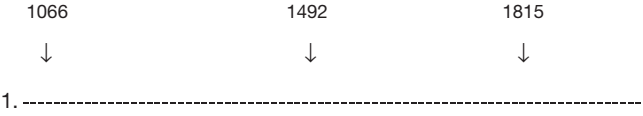
—The lowest line represents the past and present (all the events that are occurring or have ever occurred), the present being its endpoint. That is, the lowest line represents the hyper-latest history of the growing block: by 'the past and present' we mean the past and present as they are at hyper-present. The second line from the bottom represents the hyper-previous history of the block, the line above that represents the history hyper-previous to that one, and so on. The diagram as a whole represents the *hyper-history* of the block: the entire hyper-temporal sequence of histories that it hyper-has had.

—Each line but the top one displays at least one time-machine arrival. If line 16 displayed seven time-machine arrivals, and if the ''new'' (in hyper-time) arrival displayed in line 17 is after four of them (in time), line 17 will display five time-machine arrivals: the first four that were displayed in line 16, and the new one—the last three arrivals displayed in line 16 having been in the segment of the block universe that was annihilated by the new arrival.[28]

—The events represented in line n to the left of (before—in time) the latest time-machine arrival are numerically identical with the events before that time in line $n - 1$; the events represented by the two lines after that time are numerically distinct (if a time-machine arrived ten minutes ago, no event happening now is represented in any line but the last), and, as we have seen, qualitatively or descriptively different to at least some extent—probably to a very great extent.

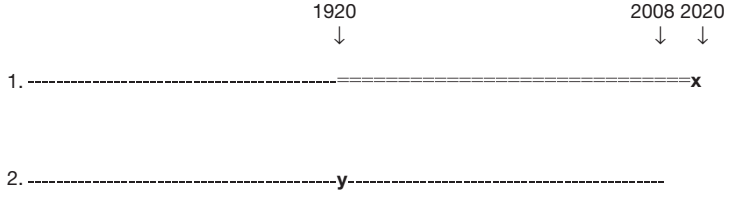
[28] If an ''episode'' of non-Ludovician time-travel is an event of which a departure and an arrival are both sub-events, it cannot be identified with any event displayed on any one of the lines in a hyper-temporal diagram. The arrival sub-event will be represented on one (or more) lines and the departure sub-event will be represented on the next line up—the line immediately above the highest line on which the arrival is represented.

Let us look at some examples of hyper-temporal diagrams. The simplest case is of course the diagram that represents a world in which there is no time-travel, or in which there are some episodes of Ludovician time-travel and no episodes of non-Ludovician time-travel. The diagram for such worlds is, as I have said, a single time-line of the sort one finds in history textbooks:



Now let us consider a very simple episode of non-Ludovician time-travel and see how it would be represented in a hyper-temporal diagram. Suppose that Tim presses the ''depart'' button in his time-machine in 2020 (he is then twenty-five years old), and that the machine ''then arrives'' in 1920, and that this is the only episode of time-travel there has ever been (the only one that there has ever been in hyper-time:). And let us suppose that subsequent to his arrival in 1920, eighty-eight years have passed and it is now, as I write this, 2008.

In the following diagram, **x** represents ''pressing the 'depart' button,'' and **y** represents the arrival of the time-machine.



(In the diagrams that follow, we omit the year-annotations.) The events to the left of point **y** in line 2 are the same as the events to the left of the same point in time (the moment in 1920) in line 1. But the events after **y** are different in the two lines, both numerically and descriptively—in all probability *very* different descriptively. (The ''double'' line represents the events contained in the part of the block that vanished: events that hyper-have occurred but have never occurred.)

Note that this is how we draw the diagram in 2008. If we had drawn it in 1920 (or if Tim had drawn it the moment he stepped out of the time-machine), it would have looked like this:

1. ----------=========**x**

2. ----------**y**

If it had been drawn in 1950, it would have looked like this:

1. ----------=========**x**

2. ----------**y**----------

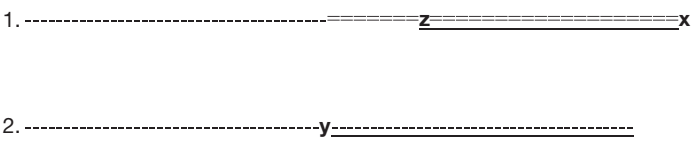
An episode of non-Ludovician time-travel annihilates the part of the block after the arrival[29]; then the block commences re-growth, but, as happens with starfish that re-grow a severed limb, the re-grown part will not be exactly like the original. (In the case of time-travel, however, this is of metaphysical necessity. In the present example, the ''new growth'' starts with the appearance, apparently *ex nihilo*, of a time-machine at a certain point in 2–1920 (that is, the second hyper-time the year was 1920: the point in line 2 that represents 1920), and no such event occurred in 1–1920.

Now let us suppose that very soon after Tim got out of the time-machine in (2–)1920, he killed his mother's paternal grandfather. (Tim's mother hyper-was born in 1–1960. In 2–1920, she was born sixty years ago in hyper-time; for, at the moment when Tim was

[29] What would happen if two people in different time-machines pressed their respective ''depart'' buttons simultaneously and had both set the same arrival date into their machines? Let us suppose that some factor—possibly mere chance—would have the following consequence: at most one would arrive; either both would find that nothing happened when the button was pressed, or one or both of them would be annihilated.

about to press the ''depart'' button, she was sixty years old.[30]) This creates no paradox. Tim simply continues to exist in the normal way after he kills great-grandpa. But why did he exist ''in the first place''? (Imagine that someone asks this question in 2–1920.) There's no answer to this question in *time* (he and the time-machine have recently popped into existence for no reason, no reason to be found in time.). There is, however, an answer in *hyper-time*: he was conceived and born in the normal sort of way twenty-five hyper-years ago—in 1–1995, in the part of the growing block that hyper-no-longer exists. And the time-machine exists for no reason to be found in time, but rather because Tim built it over the course of the last two hyper-years—between 1–2018 and 1–2020, in the part of the growing block that hyper-no-longer exists.[31]

We must therefore distinguish events that occurred *n* years ago in time and events that occurred *n* years ago in hyper-time. To find (in a diagram) the events that occurred *n* years ago in time, go back one hundred years from the present along the lowest line. To find the events that occurred *n* years ago in hyper-time go back one hundred years—but switch to the next line up at every time-machine arrival (in the present example, when you have reached point **y**, proceed ''directly'' to point **x**). Thus, the events that occurred one hundred years ago in hyper-time are represented by the point **z** in the following diagram:

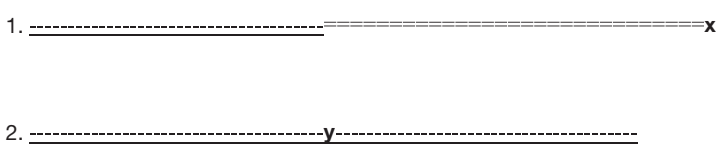


The underlining represents the last one hundred years of events in hyper-time—as opposed to the last one hundred years

[30] We assume that a year of time ''equals'' a year of hyper-time. That is, we assume that the block is hyper-growing at a rate of one year per hyper-year. More exactly, we assume that the hyper-temporals use the growing block as their standard hyperclock and have defined a hyper-year as the amount of hyper-time in which 3.16×10 exp $7 \times n$ standard events are added to the hyper-growing-block. (See n. 21.)

[31] These statements, of course, presuppose that causal relations can hold between events between which no temporal relations hold. But we had already supposed this: the departure of a time-machine is part of the cause of its arrival in the past, and any two such events are temporally unrelated.

of events in *time*, whose representations are underlined in this diagram:



(The events represented in line 1 to the left of the point above **y** are underlined because they are numerically identical with the events represented in line 2 by points to the left of **y**.[32]) Thus, if Tim is asked, immediately after his arrival in 1920, how long he has existed, there are two things he can say truly: 'I have existed for just a few minutes (in time)' and 'I have existed for twenty-five years (in hyper-time)'.

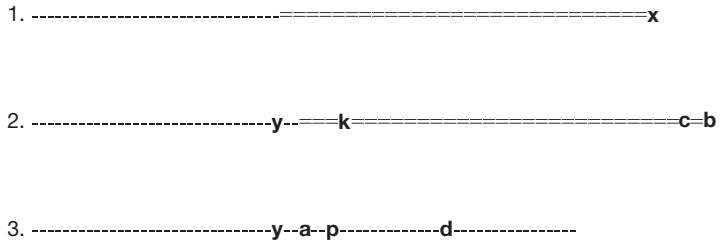
Now let us look at a world with a more complex hyper-history and draw a diagram that represents the events comprised in that hyper-history.

Tim has built a time-machine. He presses the ''depart'' button in (1–) 2020 (**x**), hyper-then arrives in 2–1950 (**y**), and soon thereafter **kills** his maternal grandfather (**k**); thereafter, he does no more time-traveling and continues to exist in the normal sort of way. Seventy-two years later, in 2-2022, he **confesses** this act to his young friend Teresa (**c**). (Of course, he is a very old man then—seventy-two years old in time, and ninety-seven years old in hyper-time—and thus ninety-seven years old ''physiologically.'') Teresa decides to undo Tim's temporal meddling—the murder at least. She, too, has built a time-machine. She enters it and presses the ''depart'' **button** (**b**). She **arrives** in 1950 very soon after Tim's arrival[33] but before he

[32] A hyper-temporal diagram might more perspicuously have been drawn in the form of a ''multi-branched Y,'' the fork occurring at the earliest temporal date on which an arrival has hyper-ever occurred. But such diagrams are hard to draw—and they might be somewhat misleading because they might suggest a ''branching history'' account of changing the past. (The resemblance would, however, be superficial since a hypertemporal diagram drawn in the contemplated style would have only one fork even if it represented the past as having been changed hundreds of hyper-times.)

[33] Let t_y be the date of point **y**. Hyper-after Teresa has arrived in 1920, shall we say that Tim arrived in the past at 2-t_y or at 3-t_y? The answer is 2-t_y. Remember that

has got round to murdering grandpa (**a**). (A simpler way to undo the murder would have been to arrive *before* Tim's arrival—for in that case Tim would, to a near certainty, never have existed.[34] But Teresa is fond of Tim.) She **prevents** the murder (**p**). Tim and Teresa continue to exist in the normal sort of way for fifty-eight years—no time-travelers arrive during that period—and it is 2008 (for the third hyper-time). Grandpa, who also continued to exist in the normal sort of way, **died** of natural causes in 1980 (**d**), but Tim and Teresa are still alive. Here is the diagram (some intervals are exaggerated):



Now let us ask this. How old are Tim and Teresa (now, in 2008)? Well, Teresa, who was twenty years old when she pressed the button, is fifty-eight years old and seventy-eight hyper-years old. No problem there, for 'seventy-eight' is what she would give as her ''true age,'' although she would concede that, strictly speaking, she had existed for only fifty-eight years. And Tim is also fifty-eight

3-t_y is short for 'the third hyper-time the time t_y has occurred'—and there is no such hyper-time (not hyper-yet, anyway), for t_y hyper-has occurred only twice: its first occurrence is displayed in line 1, and its second in both line 2 and line 3.

[34] In a non-Ludovician time-travel world, a person can have come into existence (in time) in one of two ways: by having been born or by having arrived by time-machine. If Teresa had traveled to, say, 1919, Tim would, to a near certainty, not have come into existence in either way. If Teresa had arrived in 1919 Tim *might* have been born: although vastly improbable, that *is* a possibility. And if Tim did somehow manage to be born (in 1995 or thereabouts) despite the disruption of history caused by Teresa's arrival in 1919, he *might* have gone on to travel to a point in the past subsequent to her arrival in 1919 and have encountered her in, say, 1920. But while Teresa would know that if she were to travel to 1919, she *might conceivably* encounter time-traveling Tim in 1920 or *might conceivably* encounter non-time-traveling Tim by living to be a *very* old woman and witnessing his birth, she would also know that if she were to travel to 1919, Tim's very existence, his being ''available'' for her to encounter in either way, would be a vastly improbable circumstance.

years old (he is a little older than Teresa, since his arrival in 1950 was earlier than hers). But his birth, which occurred at a point twenty-five years before the end of line 1 was 155 hyper-years ago. (Fifty-eight hyper-years of line 3, seventy-two hyper-years of line 2 and twenty-five hyper-years of line 1.) If **B** represents Tim's birth, here (underlined) are the points at which the events contained in his hyper-biography occurred:

1. ----------=========**B**========**x**

2. ----------**y**--===**k**==========**c**=**b**

3. ----------**y**--**a**--**p**----------**d**----------

And yet, Tim is physiologically in his early eighties, and if he had been carrying a chronometer that measured elapsed time since the moment of his birth it would register eighty-three years. (Let us use the readings displayed by such imaginary chronometers as the definition of the bearer's ''true age.'') We can, therefore, identify ''one's true age'' and ''the amount of hyper-time that has passed since one's birth'' only for the latest time-traveler (the time-traveler whose arrival is the latest in both time and hyper-time). Consider Tim, who, in our present example, is not the latest time-traveler. The underlining in the following diagram marks the set of events whose collective hyper-duration we must measure to determine Tim's true age:

1. ----------=========**B**==========**x**

2. ----------**y**--===**k**==========**c**=**b**

3. ----------**y**--**a**--**p**----------**d**----------

The ''personal biography'' of a time-traveler (for the sake of simplicity, we consider only ''one-trip'' time-travelers), therefore, should

be identified with the sum of the events contained in his or her hyper-latest post-arrival life and the events contained in his or her pre-departure life. The part of one's life between one's birth and one's departure will be displayed in the line immediately above the line that displays one's arrival only if one is the latest time-traveler.

This is what ''changing the past'' comes to on the ''growing block with hyper-time'' model. Note that the model does not grant to the non-Ludovician time-traveler all the powers in respect of changing the past that someone with an interest in changing the past might want a time-traveler to have. I am thinking of those time-travel stories in which a conscientious time-traveler changes the past in such a way that ''time-travel has never existed.'' It is certainly possible, on the growing-block model, to change the past in such a way that time-travel has never been *invented*[35]—that is, that its invention exists only in the hyper-past. But, on the growing-block model, once (hyper-once) an episode of non-Ludovician time-travel has occurred, there is no way to get rid of time-travel *altogether*, since the bottom line of a two-or-more-line hyper-temporal diagram must contain the arrival of a time-traveler.[36]

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[35] For example: It is now the year 2500. History records that in 2018, a Terminator popped into existence out of thin air and murdered Alice, a brilliant physicist, and burned her laboratory and all her notes. (Alice was working in secret, and no one else knew anything about her research.) The Terminator then destroyed itself, but left a note saying that it had been sent back in time from the year 2040 to prevent Alice from constructing the first time-machine (which, according to the note, she would have succeeded in doing in 2020)—owing to the fact that time-travel had turned out to have disastrous consequences. No one, in all the intervening centuries, has been able to construct a time-machine.

[36] I am grateful to Ted Sider for comments on a draft of this essay, which have led to changes that I hope he will regard as improvements.