Troubles with Time Travel

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I. Introduction:

> Tim stepped into the time machine on January 1, 2000, set the destination time for January 1, 1920, and pressed the start button precisely at noon. The machine moved off smoothly into the past. Through the porthole Tim watched people moving quickly backwards without hesitation or mishap. On the ground a rotting apple rapidly undecomposed while leaves fluttered up and attached themselves to trees. Suddenly the apple bounced several times and leapt up and snapped itself onto a twig ...

This sort of narrative provides a popular theme for both metaphysicians and writers of science fiction and is familiar to *aficionados* of time travel fables in each of these genres.[1] Talk about travelling in time is nevertheless puzzling, even if it isn't obviously contradictory.[2] The story of Tim *appears* to be perfectly coherent.[3] Philosophical opinion however is notoriously divided about whether time travel involves empirical paradox, or some deeper logical or metaphysical incoherence.

II. Heraclitus and Parmenides

Underlying the polarised views about time travel are two fundamentally opposed conceptions of the world in time. On the one

[1] For a comprehensive and instructive collection of extracts, arguments and reflections about time travel see Paul J. Nahin, *Time Machines: Time Travel in Physics, Metaphysics, and Science Fiction* (New York: American Institute of Physics, 1993).

[2] Time travel is understood as departure from a place and time which is followed (from the traveller's point of view) by arrival at the same place at an earlier time from a sedentary observer's point of view. Subjective discrepancies about temporal duration are thus ruled out, as are relativistic durational discrepancies in which the timelike ordering of events remains invariant.

[3] This sort of B-movie scenario in fact is ruled out by currently accepted physical theory, which holds that the arrow of time can flow in only one direction at any particular place. But although physical theory may rule out time travel as a local phenomenon there are scenarios which exploit global features of general relativity spacetime topology which appear to admit 'closed timelike curves'. However there are good reasons (as I will argue) to be leery about closed causal loops.

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hand there are the followers of the Greek philosopher Heraclitus for whom the world is perpetual flux. On the other hand there are the metaphysical heirs of Parmenides who hold that truth and reality are stable and eternal. These opposing metaphysical conceptions were sharply focused in McTaggart, whose argument for the unreality of time has become a customary point of departure for discussions about its nature.[4] Only the Parmenidean view—according to which past, present and future are as real as the present—can accommodate time travel.

There are a number of problems which must be faced when attempting to make sense of stories about time travel. The requirements for a coherent account of time travel are certainly at odds with fundamental assumptions which we ordinarily take for granted. That of course is not a serious, let alone decisive, objection to time travel. However the implications of time travel are more radical and disturbing than its proponents tend to suppose. It may be that the absurdities of which time travel is guilty are less spectacular than the absurdity of self-contradiction.

The narrative sketched in the opening paragraph seems to show that time travel is *conceivable*. It certainly does not follow from this that time travel is *possible*. Conceivability is a notoriously unreliable test for possibility. The geometers who strove to square the circle or to trisect the angle conceived these tasks clearly enough without, unfortunately, realizing their impossibility.

It is sometimes suggested that the fact that we are not inundated with tourists from the future is sufficient to rule out time travel. Again while many find this persuasive, it is certainly not decisive. Perhaps our epoch is one which the tourists of the future happen to find unappealing. At most this constitutes an objection to the actuality, not the possibility of time travel.

III. 'No destination' objections

A fundamental requirement for the possibility of time travel is the existence of the destination of the journey. That is, a journey into the past or the future would have to presuppose that the past or future were somehow real. But on one popular metaphysical conception only the present is real, and to suppose that the past or future is also real is to suppose that the past and the future are also present—and that embodies confusion if not contradiction.

[4] J. M. E. McTaggart, 'The Unreality of Time', *Mind* 18 (1908), 457–84. Reprinted and revised in *The Nature of Existence, Vol. II* (Cambridge University Press, 1927), Ch. 33.

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According to this Heraclitean metaphysical conception, the future is genuinely open: there *is* no realm of determinate future fact, no denizens of the future to identify or talk about, though of course—in the fullness of time—there will be. Travel to the future on this view would be ruled out because there is simply nowhere to go.[5]

The past, on the other hand, is ordinarily taken to be fixed and determinate and not subject to change. Travel into the past would appear to make it accessible in a way that would enable the traveller to effect changes—that is, to change things that are fixed and determinate and so not subject to change. Aristotle endorsed this popular view when he said that changing the past is beyond even the power of God. It was for this reason, Aristotle said, that 'no one deliberates about the past, but about what is future and capable of being otherwise'.[6]

We can label the denial of the existence of future times and accessible past times as 'no destination' objections to time travel. This view rejects travel to the future because there is just nowhere (or 'nowhen') to which such a journey could be undertaken, while travel to the past is ruled out because its already too late for a traveller to gain causal access to it.

IV. Travel: spatial and temporal

To travel is to change position with time. Travel through space is the successive occupancy of *spatial* positions. Time travel apparently requires the successive occupancy of *temporal* positions. But that seems to amount to either the trivial claim that each successive moment is occupied at the moment at which it is occupied, or the contradictory claim that there are some instants which might be followed not by the succeeding moment, but a quite different moment altogether. In Tim's case, 12 noon on 1 January 2000 was not succeeded by the next moment on that day, but by another moment 80

[5] It has been suggested that this Heraclitean 'no destination' objection to time travel is worthless because the time traveller is 'transported' to a past or future time, when of course, that time is real. This retort involves the dubiously coherent notion of 'travel' between places, one of which ceases to exist while the other starts to exist in the course of (or as a result of) the 'travel'. Time 'travel' is clearly grounded on a spatial metaphor, and spatial relations (like any relations) clearly require existing relata. We are certainly owed an account of how travel to non-existent destinations can be made intelligible.

[6] Aristotle. *Nichomachean Ethics*, 1139b6 (trans) W. D. Ross. In *The Basic Works of Aristotle* (ed.) Richard McKeon (New York: Random House, 1941).

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years earlier. That seems to involve either assigning the same moment in 1920 two distinct places in the time series, or assigning it the contradictory properties of both preceding and succeeding a moment in 2000. As Ayer has noted: 'To assign to one and the same event two different places in the same time order is self-contradictory'.[7]

A requirement for the possibility of time travel is that two successive events may be separated by unequal amounts of time. We need some explanation of the chronological discrepancy which this involves. While such an explanation need *not* involve a second time dimension, it will involve an additional time series that provides an alternative way of ordering events.

It is well known that chronological discrepancies arise in connection with the special and general theories of relativity, quite independently of the question of time travel. But relativistic chronological discrepancies are benign in a way that time travel discrepancies are not. I will say more about these chronological discrepancies below.

What would count as a case of travelling into the past? We can conceive that after a certain time we might have experiences which are *exactly like* those of 1920. It is just this kind of thought experiment that makes time travel *conceivable*. But we would not be compelled to treat such experiences as decisive evidence of having travelled into the past. They might be taken as evidence of serious cognitive disorder, for example.

V. The Lewis defence

David Lewis has provided the most detailed and comprehensive defence of the coherence of time travel stories and it is instructive to examine his defence of the possibility of time travel. Lewis rejects the metaphysical conception which denies the reality of the future and the past. The world we live in, according to Lewis, is a Parmenidean world: 'a four-dimensional manifold of events' and the occupants of the world are four-dimensional aggregates of stages—'timelike streaks'.[8] However a time traveller is not like other aggregates; 'if he travels towards the past he is a zig-zag streak'.[9] There might also be stretched out streaks which are travellers into

[7] A. J. Ayer, *The Problem of Knowledge* (Harmondsworth: Penguin, 1956), 158.

[8] David Lewis, 'The Paradoxes of Time Travel', *American Philosophical Quarterly* 13 (1976), 145.

[9] Ibid., 146.

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the future. This Parmenidean ontology of temporal stages at once removes the 'no destination' objection to time travel. Four-dimensional geometry provides the means of recording a time traveller's career.

Time travel requires that two events are separated by unequal amounts of time. One way that our experience of time may not correspond to physical time is because it may be intermittent. This type of discrepancy between objective time and psychological time provides a sense in which time travel into the future is unproblematic. These 'Rip van Winkle' cases illustrate that experience may not coincide with elapsed time measured by clocks. The time travel envisaged by Lewis however involves the possibility of travel to the past—going causally upstream, so to speak—and that raises serious difficulties. The essential feature of paradox-generating time travel stories is that the departure from a particular place and time is followed (from the point of view of the time traveller) by arrival at the same place at an earlier time from the point of view of a 'sedentary' observer.

Lewis believes that denying the reality of past and future events is as parochial as denying the reality of distant places. Pastness, presentness and futurity are not objective features of reality but reflect only the perspective on the facts which is the standpoint of the experiencing subject. The experience of a changing present does not reflect a change in facts at all, but only a change of chronological perspective, just as a change in spatial location effects a change in spatial perspective.

On this view the temporal modalities of past, present and future do not mark any metaphysically significant distinction, whatever their importance may be for knowledge and practice. The commonly held conviction that there is a significant distinction between the past and the future is closely tied to the idea that cause cannot succeed its effect. The future *seems* to be causally accessible while the past is not. That indeed is one of the platitudes about what distinguishes the past and the future. It is no accident that those (like Lewis) who defend the possibility of time travel are leery about any deep metaphysical asymmetry between past and future. If we accept this metaphysical framework it may seem, as Lewis suggests, the problems raised by time travel are oddities rather than absurdities.

Having explained the consistency of time travel with his four-dimensional ontology, Lewis goes on to elucidate how the sequence of stages from which an individual is composed could be reversed in time. This involves reverse causation—a discrepancy between the direction of cause and the direction of time. Finally he provides a heroic attempt to defuse the threat of empirical paradox which arises

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because it *seems* that time travel would involve (or raise the possibility of) changing the past. There are also some related subsidiary problems which Lewis addresses, such as a puzzle about closed causal loops. Lewis believes that none of these difficulties are fatal to a coherent account of time travel.

VI. Temporal parts

Time travel requires more than the possibility of successive events being separated by unequal amounts of time. It also requires a Parmenidean world which is extended in time analogously to the way that it is extended in space. Although the dispute about whether the world is ultimately composed of persisting substance individuals or individuals which are aggregates of temporal stages is important, I will examine the plausibility of time travel stories mainly from *within* the Parmenidean four-dimensionalist metaphysical framework. While I believe that an ontology of individuals extended in time as well as in space is defective, that will not be a primary focus of concern in what follows.

Let us grant that the world is a four-dimensional manifold of events and that we are aggregates of stages or streaks extended in time as well as in space. Could the aggregates of person stages from which we are constituted be zig-zagged or stretched in the way that Lewis says time travel requires?

VII. The double occupancy problem

One difficulty for zig-zag aggregates, not widely remarked upon, is what may be called the double occupancy problem.[10] Tim, we supposed, stepped into the time machine on 1 January 2000, adjusted the dial, and precisely at noon set off into the past. For observers outside it seems that the machine simply vanishes when Tim presses the button. But how can the 'movement' into the past possibly get started? We know that at times later than noon there is no machine present, since it has disappeared into the past. But what of the moments just before noon? At those times there seem to be not one

[10] The risk to time travellers of catastrophic collision with objects occupying the spatiotemporal destination is a problem raised (in chapter 3) in one of the earliest time travel stories, H. G. Wells *The Time Machine* (London: William Heinemann, 1895). The difficulty of *avoiding* such a collision was first drawn to my attention by my former student Stephen Langman.

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but *two* machines—one going backwards and the other forwards—each apparently occupying (or attempting to occupy) the same location! That is, it seems that as the machine sets out into the past it will collide with itself, or on a four-dimensionalist view the Tim-at-noon stage has earlier *and* later stages at the same space-time location.

This is a difficulty which is glossed over in Lewis's account—though in fairness it should be added that it is glossed over in other accounts as well. All individuals, for Lewis, are aggregates of the temporal parts (or stages) of which they are composed. But a traveller into the past is a topological anomaly unlike other aggregates. It sounds as though the time travelling individual is a perfectly orderly, if unusually oriented, aggregate of stages. But it is quite mysterious how some stage of an individual can have an earlier *and* a later stage at the same space-time location.

This problem can be avoided by locating the successor stage of Tim-at-noon somewhere else, but then this stage will be discontinuous with Tim's earlier stages. Time reversal would then involve discontinuity. And as Lewis notes: 'The problem of personal identity is especially acute if he is the sort of time traveller whose journeys are instantaneous, a broken streak consisting of several unconnected segments'.[11] The advantage of spatio-temporal continuity for individual identity is that it is a one-one relation. Discontinuity threatens to compromise identity by raising the possibility of one-many relations.

This discontinuity is concealed in the account because Lewis explicates the zig-zag with the help of a spatial analogy of a railway doubling back on itself. In that case the doubling back is unproblematic because there is more than one dimension for the railway track to follow. But although Lewis does not rule out two-dimensional time altogether, he explicitly excludes it from the discussion and identifies his concern with travel in one-dimensional time.[12] In one-dimensional time it is quite unclear how there could be an aggregate of stages which doubles back without discontinuity.[13]

There are parallels sometimes drawn from physics, such as Feynman's famous conjecture that positrons are electrons travelling backwards in time, but they are of no help here. Evaluating

[11] Lewis, op. cit., 147.

[12] Ibid., 145.

[13] 'No world-line starting from Here-Now can ever reach the region of Elsewhere; a fortiori none can be bent backwards to reach the rearward causal cone of the past...' M. Capek, 'Time in Relativity Theory: Arguments for a Philosophy of Becoming', in J. T. Fraser (ed.) *The Voices of Time* (New York: G. Brasiller, 1966), p. 448.

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Feynman's proposal would take us too far afield, but it should be noted that the supposed positron-electron aggregate is not a smooth and continuous 'world-line' of a single particle, but at best distinct particle stages punctuated by violent events. The problems concerning the identity of quantum particles however are notoriously intractable and I will say no more about them.[14]

VIII. Personal time

To make the story about Tim coherent we have to introduce another time series. There must be more than one chronological separation between two events. Time travel, Lewis says, 'involves a discrepancy between time and time'.[15] That is, time travel requires that the temporal interval separating successive events is not necessarily unique: successive events may be separated by distinct temporal intervals. Since a temporal interval may be identified with a uniform causal process which occurs during that interval—that is to say, with a clock—this amounts to the claim that successive events can be separated by different networks of causal links. The so-called 'twin paradox' proposed by Paul Langevin, concerning the possibility of differential ageing implied by the general theory of relativity, is a famous illustration of the possibility of a plurality of chronological metrics.

The networks of causal separation required for time travel involve something much more radical than the time dilation sanctioned by physics, though it may be that the chronological pluralism of relativity softens us up for the sort of time travel story told by Lewis. Although the same interval of duration may be recorded by distinct, non-equivalent temporal metrics, these discrepant metrics are topologically contemporaneous.

Thus in the relativistic 'twin paradox', one twin may return having aged less, but there are important theoretical constraints on the permissible deviation in the alternative chronologies. In particular he cannot return younger than when he departed, or arrive back before he departed. Time may be dilated but not contracted; and in particular because the separation between distant events can never be reduced to zero it follows that it can never be reversed. A clock in another inertial frame can appear to be running slow, and in an accelerated inertial frame will actually run slow. But it won't stop, and *a fortiori* it won't run backwards.

[14] For further discussion of these issues see D. Deutsch and Michael Lockwood, 'The quantum physics of time travel', *Scientific American*, March, 1994, 50–56.

[15] Lewis, op. cit., 145.

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The time travel discussed by Lewis however involves more than a different chronological perspective on the same stretch of duration. Lewis introduces the notion of 'personal' time which may diverge from 'external' time.[16] Five minutes of personal time might correspond to 100 years of external time. Lewis envisages however that personal time can run backwards with respect to external time. During the course of the journey the time traveller could observe external time clocks running in reverse. Backwards chronologies however are without any empirical (theoretical or experiential) support. We can of course imagine sequences of events running in reverse, but that is very different from the actual reversal of physical processes.

Time travel into the past requires more than chronological discrepancy, which is in any case a relativistic feature of our world. As Lewis says it 'necessarily involves reverse causation',[17] and Lewis analyses causation in terms of counterfactual dependence. Time travel therefore involves events which are related so that an earlier event depends on a later event, for its occurrence. Local causal reversal however generates the possibility of empirical paradox and is, I suggest, at odds with some deep convictions about human agency. I will come back to this when we consider Lewis's discussion of whether Tim can kill his grandfather.

Trouble in fact arises, as we shall see, even if we suppose that it is not individuals but information signals which are sent into the past. These problems are bound up with a metaphysical conviction that while the future may be hostage to contingency the past cannot be.

IX. Reverse causation

It is not *a priori* or necessary that causal priority is the same as temporal priority. Temporal priority concerns the totality of events; causal priority is concerned with particular sequences of related events. It may be that a particular causal sequence could run temporally 'upstream', as it were. While this may not be contradictory it is certainly problematic in the extreme.

We know quite generally that once an effect has occurred then its cause must have occurred. But if the cause were later than the effect, then once the effect has occurred then its cause would have to be unstoppable. However we also believe, in general, that we are able to intervene in the world to bring about or to prevent contin-

[16] Ibid., 146.
[17] Ibid., 148.

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gent happenings. If the cause of some event is located in the future then such interventions are subject to clear constraints, and in some cases will turn out to be impossible.

It is a familiar feature of our experience that something that already exists can bring into being something which did not exist before. But, as Ayer has argued, it quite unclear how something which does not yet exist could now exert a causal influence.[18] We are causally dependent on our ancestors, but not on our descendants. (I will consider below a problem which arises from supposing that some individuals might be their own ancestors.)

A problem which arises in connection with reverse causation is the possibility of causal loops, that is 'closed causal chains in which some of the causal links are normal in direction and others reversed'.[19] These are queer customers, but Lewis rejects that as an objection on the grounds that an infinite past or the decay of radioactive elements are just as inexplicable as closed causal loops. However the situation with closed causal loops, I suggest, is worse. Whereas spontaneous radioactive decay appears to leave something mysteriously unexplained without the possibility of appealing to something further, the case of closed causal loops raises the possibility of empirical contradiction.

The fundamental difficulty of reverse causation is making sense of how what has not yet happened could affect what is happening now. On the one hand we believe that if something has not happened yet then maybe it will not. Perhaps something will derail the causal train. But if what has not yet happened is necessary for what has already happened then happen it must. We are all fatalists about the past, but reverse causation extends the same considerations to the future. Lewis notes the close parallel with fatalism in his discussion of whether it is possible for Tim to act to change the past and it is to this issue that we shall now turn.[20]

X. Changing the past and empirical paradox

It is often said that time travel is impossible because it would enable the traveller to change the past. But time travel stories need not commit this metaphysical solecism. Lewis suggests that we can avoid it by supposing that if Tim's journey to the past occurs then it is always true that it occurred. That is, we suppose that there is a timeless and eternal ordering of the manifold of events which con-

[18] Ayer, op. cit., 171.
[19] Lewis, op. cit., 148.
[20] Ibid., 151.

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stitutes world history. Tim's journey need not involve changing the past. For on this view we can no more change the past than we can change the future: as Smart puts it: 'it no more makes sense to talk of altering the future than it does to talk of altering the past'.[21] The past is just what has happened and the future is just what is going to happen. Both what has happened and what is going to happen cannot be changed. It is a mistake to suppose that we can change *either*.

While it arguably makes no sense to speak of changing the past or changing the future we can nevertheless consider *affecting* the past, and *affecting* the future, in the sense of bringing about by our actions that the past and the future are different to what they would otherwise have been. That is, our choices can be efficacious in bringing about one state of affairs rather than another. If time travel were possible, then our choices could also be efficacious in bringing about what has happened. Ordinarily causes are earlier than their effects, but there is no reason, Lewis thinks, to suppose that this has to be the case.

I cannot change the past. So given that I was not at the Great Exhibition of 1851 it is not possible for a time machine to take me there. Or so I suppose. Lewis might reply: given that I *was* at the Great Exhibition in 1851, it is not possible for a time machine to *fail* to take me there.

Our attitude to the future is nevertheless very different from our attitude to the past. We feel that future times contain genuine alternatives which past times lack. But on Lewis's view there is no genuine alternative outcome to the present. Future possibility is just present ignorance. The fatalism which everyone accepts about the past applies equally to the future.

We can attempt to defuse this objection to fatalism by saying that the absence of real alternatives in no way entails the existence of coercion or inexorable compulsion to act in a particular way. Alternativeness is an epistemic illusion. 'What will be will be' reports the truism that the future is no more subject to change than the past.

On a Heraclitean conception however 'what will be will be' is ambiguous. It might mean 'what will later be the case will later be the case'. But it might also mean 'what will later come to be the case need not be destined (causally, divinely, or any other way) to be the case and nor need it be determinately the case now'. Lewis of course explicitly rejects any such indeterminacy about the future, believing, for example, that 'it was true already in the year 1548 that I was not going to vote Republican 428 years later'.[22] For Lewis because

[21] J. J. C. Smart, 'The Reality of the Future', *Philosophia* 10 (1981), 149.
[22] Lewis, op. cit., 151.

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truth is timeless 'what will be will be' is a straightforward univocal tautology.

Consider Lewis's discussion of what Tim can and cannot do when he embarks on his murderous mission to 1920 to kill his detestable grandfather who in fact died in 1957.[23] Can Tim kill his grandfather? Lewis says it depends. Yes he can on a narrow delineation of the facts. But no he can't if we delineate the facts widely, for we know that the wider delineation includes the fact grandfather died in 1957. The evaluation of counterfactuals always takes place against a background of fact. The general rule is to hold the background as constant as possible. It may seem that we have a lot of leeway with respect to the future, but that is only a product of our comparative ignorance. We have much less leeway with respect to the past because we know a lot more about what actually happened than about what will happen.

Lewis is certainly right that the known death of grandfather in 1957 is not compatible with his being killed in 1920. But the problem is to make sense of the story given the wide delineation of the facts. The contingent facts themselves seem to constitute a *de facto* chaperone in Lewis's story which mysteriously prevents Tim from acting efficaciously. Perhaps this example involving human choice does not focus the issues as clearly as they might be. For we know that human action is hostage to variety of failures. Best laid plans gang aft agley.

The facts of the story however do not square with is the belief that we *can* choose efficaciously. That is, that our choices bring about states of affairs which are other than they would have been had we not so chosen. The problem is that Tim can *choose* to shoot grandfather, and that this choice (we know on the wide delineation of the facts) cannot succeed.

Consider another case. We have already noted that travel into the past necessarily involves reverse causation. So if reverse causation generates contradictions, then that will rule out time travel. In fact we don't need Tim and his ordnance to travel back into the past: all we require is the possibility of sending a signal. The basic difficulty arises with reverse causation alone.

Suppose that Tim constructs a device which can send a signal back into the past. The signal can be used to detonate an explosive. Tim then wires up the device so that when the button is pressed the signal will blow up the device, together with the button, one hour earlier. It is clear that a necessary condition for the button to be pressed is that it not be pressed, for otherwise it (the button) will have been destroyed before it is pressed. So Tim cannot press the

[23] Ibid., 149–152.

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button. But there may be many similar buttons in the room and it seems intolerable to suppose that there is just the one button which Tim can't press. Yet on Lewis's story he cannot succeed in pressing that particular button.

As long as the button is attached directly to the explosive device it seems that it cannot be pressed. But suppose that the button is not directly attached to the explosive device, but to a remote activator. As long as the button is attached to a remote activating device that won't be destroyed by the blast it looks as though it is possible to press it. But if we move the activating device closer to the explosive, so that it will be destroyed by the blast it then becomes impossible to press it. It is quite mystifying how mere proximity could be causally efficacious in this way.

XI. The problem parent

A popular theme in science fiction is the case of the traveller whose journey into the past is not merely possible but necessary—in order perhaps to secure some significant fact about the present, such as the time traveller's own existence. It may be that the traveller, for example, is one of his or her own ancestors. In the story devised by Jonathan Harrison the principal character, 'Dum', turns out to be his own parent.[24] In a more complicated story '—All You Zombies—' by Robert Heinlein the principal character (who undergoes a sex-change) turns out to be *both* of his own parents.[25]

There is a *prima facie* difficulty being one's own parent, or more generally one's own ancestor. It seems to involve an individual having incompatible degrees of genetic relatedness to him or herself. The genetic constitution of an individual remains constant over that individual's lifetime. But each parent provides their offspring with one half of their genetic complement. An individual who was both parent and offspring would therefore seem to be both genetically identical with *and* genetically distinct from him or herself, which is *prima facie* impossible.[26]

The genetic composition objection is not quite decisive however. For it is not actually contradictory to suppose that the second gamete, provided by the other parent at conception, should restore

[24] Jonathan Harrison, 'Analysis "Problem" No. 18', *Analysis* 39 (1979), 65–66.

[25] R. A. Heinlein, '—All You Zombies—'. In *The Unpleasant Profession of Jonathon Hoag*. (Gnome Press, 1960. Reprinted by Penguin, 1966).

[26] See William Godfrey-Smith, 'Travelling in Time', *Analysis* 40 (1980), 72–73.

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precisely the complement of genes discarded in the meiotic cell division in which the first gamete was generated. That is, it is not *impossible* that a sexually reproducing parent be genetically identical with their offspring—though the likelihood of this is the sort of probability that a kettle has of freezing on a hot stove. In such a case the offspring would be genetically a clone of its parent.

Self-parenting would be more straightforward if we lived in a world in which ontogenesis was Aristotelian, so that the genetic form was provided by just *one* parent. But in a world, such as ours, in which a Mendelian process of genetic blending takes place the possibility defies belief. In the case of Harrison's 'Dum', it was impossible (without gratuitously complicating the story) for him and Jocasta to have produced a daughter, for example, and that is simply incredible.

XII. Conclusion

The very idea of time travel is bizarre from a Heraclitean metaphysical perspective.[27] It apparently involves the possibility of alternative successors to the present moment. It is as though the time traveller is somehow able to move away from the present so that former contemporaries come to 'occupy' another epoch. But there is just nowhen else to go.

The whole notion of time travel rests on a unfortunate spatial analogy which leads to a denial that there is any significant asymmetry between past and future. Time however branches forward but not back. The past is the realm of determinate fact; the future is the realm of unrealized possibility. The past is fixed, the future is fluid. These are all expressions of the same Heraclitean metaphysical intuition that there is a fundamental asymmetry between past and future. On this intuition it is nonsensical to suppose that there could be *real* time reversal.

The so-called 'arrows' of time—the thermodynamic, cosmological and psychological—are sometimes thought to provide time with direction. As long as time is identified with one of the 'arrows' it seems that time reversal makes sense. But if temporal passage is the actualization of possibility, time reversal would involve the absurdity of 'repotentialization' of the past.[28] The past however is not a

[27] For a more detailed characterisation of the difference between a Heraclitean metaphysic of *flux* and the static Parmenidean metaphysic of *being* see William Grey, 'Time and Becoming', *Cogito* 11 (1997), 215–220.

[28] See Milic Capek, *The Philosophical Impact of Contemporary Physics*. (New York: Van Nostrand, 1961).

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realm of potentiality like the future. That is not to say that future might be other than that which it is going to be, nor that it might be anything at all. It is to say that what it will be is not yet determinate. It is inchoate, unlike the past.[29]

Rather than developing these themes I have concentrated on some difficulties for time travel which arise from within a Parmenidean perspective. First, one of the requirements for time travel, the existence of alternative chronological orderings, designated 'personal' and 'external' time in Lewis's analysis, is not sanctioned by the alternative metrics of physics. Lewis's 'personal' time *happens to coincide with* the physical time order, although, were time travel to occur, it would diverge from it. It is a time order in which our experience is located but which *might* come apart from 'external' time. This temporal dualism between experiential time and physical time has a disturbing Cartesian resonance. Without further explanation—and justification which depends on more than its role to escape the contradictions which threaten the coherence of time travel—it is surely reasonable to suppose that there is only one time series, that of physical time, and that this is also the time of our experience.[30]

On the Lewis story there is only ever one stage of the traveller which is the causal successor of any antecedent stage. But the causal successor (for personal time) need not be the same as the temporal successor for other individuals (in external time). While external time provides us with an account of temporal succession we can define or make sense of another time series which is based on causal succession. This in turn was explained by Lewis's counterfactual analysis of causation.

I have not challenged that analysis directly, but noted that it has rebarbative consequences. Lewis says that zig-zag streaks have the

[29] Larry Dwyer (in 'Time Travel and Some Alleged Logical Asymmetries between Past and Future', *Canadian Journal of Philosophy* 8 (1978), 15–38) appeals to the logical possibility of time travel as a reason for rejecting claims about alleged logical asymmetries between past and future. In this paper I have attempted to avoid relying primarily on Heraclitean intuitions about temporal asymmetries, and concentrated on problems which arise from paradoxes implicitly in the idea of reverse causation, though these intuitions of course underlie the metaphysical view which I favour. I accept Dwyer's claim that the possibility of time travel requires rejecting and deep asymmetry between past and future, and conclude (naturally) that these asymmetries preclude time travel.

[30] Allowing of course for relativistic variation between observers of spacelike ordering of events. Time travel is problematic precisely because it implies that the timelike ordering of events is not invariant.

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same sort of mental continuity and connectedness that unite any other aggregate of person stages.[31] But the problems raised by reverse causation make it difficult to suppose that the present could be dependent on the future in the way that it is dependent on the past.

For the time traveller, something anomalous happens. It seems that nothing in our experience rules out the possibility of psychological time continuing in reverse. In that sense backwards experience seems to be perfectly coherent. There is no obvious contradiction, for example, in the description of Tim's experience at the beginning of this paper. It therefore seems that our conscious experience (the psychological arrow of time) just *happens* to align with objective physical time but that it *need not*. But this is not easy to make sense of at all. To make good sense of it we would need to provide an account of causal interactions at the boundary of a backwards travelling (or time reversed) physical system. The problems that this raises are quite intractable. The double occupancy problem is one of the difficulties which illustrates that it is very difficult to make sense of continuous zig-zag streaks in space-time.

Travel to the past requires reverse causation. Reverse causation raises the possibility of causal loops and the attendant problems that arise, for instance, if someone were to be one of their ancestors. Although this may not be self-contradictory it does lead to intolerable restrictions on the range of possibility, and the range of efficacious choice available to an agent. Dum and Jocasta in Harrison's story, for example, cannot have a daughter. Tim cannot shoot his grandfather or press a button, though he can shoot grandfather's twin and press a physically indistinguishable button which is *not* wired up to send a detonating signal into the past. These empirical paradoxes arise as soon as reverse causation is allowed because reverse causation makes past times causally accessible. They are some of the intolerable consequences of seriously countenancing time travel.[32]

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[31] Lewis, op. cit., 148.

[32] My thanks to Graham Nerlich for helpful suggestions and comments.

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