Paradoxes and Hypodoxes of Time Travel
© Peter Eldridge-Smith 2007
Philosophy, Australian National University
peter.eldridge-smith@anu.edu.au

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Paradoxes and Hypodoxes of Time Travel

Peter Eldridge-Smith

Time, yet another final frontier, poses some paradoxical challenges and opportunities for science fantasy and science fiction.

Consider Tig, a misguided time-travelling assassin, who (unwittingly) kills his own grandmother at a time prior to her conceiving the prospective parent. The sequence of causal events leading up to Tig's birth would be broken and Tig's birth would be, in a sense, *ungrounded.* The events of one's grandmother conceiving one's parent and of the same grandmother's prior demise are mutually exclusive.[1] Yet, given time travellers, it seems both events could happen. This is a *paradox.*[2] The paradoxes of time travel are often used to entertain, surprise or confound the reader, and are a distinct feature of science *fantasy.*

Consider next the story of the time traveller who goes back seeking some clarification from Shakespeare. Shakespeare, startled by the visitor appearing in his home wearing funny clothes and speaking in such an affected manner, has him arrested for home invasion. Shakespeare was struggling up to this point, but picks up the book the stranger left behind and begins copying out the plays word for word. Things soon pick up generally. The sequence of events leading up to Shakespeare's authoring his plays forms a loop in time. This sequence of events is logically consistent and therefore possible, even though it is historically *ungrounded.* I term this a *hypodox.*[3] (It is similar to "This sentence is true" — known to logicians as *the Truth-teller.*) Hypodoxes, I hope to demonstrate, belong more to the genre *of science fiction.*

In this article, I will distinguish between paradoxes and hypodoxes of time travel and suggest that these can be a useful guide to discriminating between science fantasy and science fiction.[4] I will also briefly discuss David Lewis's resolution of the paradoxes of time travel.

But clearly, time travel is fraught with difficulties. No-one should time-travel without a good guidebook. Don't leave the present without one! So first I have some definitional work to do.

Background

> *Time goes, you say? Ah no!*
> *Alas, time stays, we go?*

It is we who travel, not time. (I assume time is a dimension.) Talk of time "flying", "flowing" or "moving" is loose talk, as is, in an opposite way, talk about a "ray of light" — rays don't move but light does. If time moves, Jack Smart asks rhetorically, what then is the rate of time, "seconds per ------- ?".[6]

There are, I acknowledge, philosophers who believe time does move. In such a metaphysical view, time travel is impossible, because, as Heraclitus said, "You cannot step into the same river twice": no double-dipping into the flow of time is allowed. However, even if we do live in such a Heraclitean world, other non-Heraclitean worlds are possible; and, given this, one might say that science fiction about time travel assumes an alternative possible universe in which time travel is not only possible, it is the norm.

Normal time travel, one might say, is the movement through time we are all now making.[7] What we shall mean here by *time travel,* however, is some other movement through time into *the future* or *the past.* It seems reasonable to believe there is just one past; and unless a science

fiction writer takes special care to indicate that time itself can have more than one dimension, as Isaac Asimov does in *The End of Eternity,* we assume there has been just one way the world was.[8] So, given a fixed past, time travel is concerned with whether it is possible to be *present* in the past or future.

It seems that time travel "involves the possibility of alternative successors to the present moment".[9] I am unsure whether this is true in the same sense for objects as it is for subjects. A Tardis time machine leaving the present and arriving in the past does not have issues about how it will act. Dr Who, arriving in his Tardis, does. Deciding how to act is predicated on being in the present. If there is only *one* present, which seems reasonable given only one past, then how can Dr Who act in the past? David Lewis distinguishes the "personal" time of the time traveller from the "external" time of the world.[10] Time travel is relative to an external frame of reference: the Tardis and its occupants have moved some moments forward in time relative to their own past, while they have gone back a hundred years relative to the rest of the world. This seems to adequately address the issue for the Tardis as an object, but for its occupants, how can they be in their own *present,* with all its possibilities to act, while in the world's fixed past? It appears they must be in the past as it was then *present.*

In talking about *the* future, we may need to be more circumspect. Does the future presently *exist,* and if so, are future possibilities alternative future realities, or is there just one way our world will be? On the Heraclitean view, the answer is — and it's one that I suggest is too simple — that the future doesn't exist. To put it more rhetorically:

> According to [the] 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."

Notwithstanding this alternative philosophy of time, I will assume there is *a* future accessible to time travel and, for present purposes, that it is *the* future. So I will avoid debating the question whether there is presently *an already existent future* to visit, as that would be tangential to our subject.

"Time travel" can be given a slightly more precise philosophical definition. Philosophers, following J. M. E. McTaggart, distinguish an A and a B series in time. Our concept of time seems to relate both to an A-series of past, present and future, and a B-series of earlier and later. There are paradoxes and conundrums which arise in trying to reconcile these two series, but these are paradoxes of the concept of time, not the paradoxes of time travel with which we are presently concerned.[12] It may nevertheless be helpful to distinguish time travel in terms of the A and B series.

One form of time travel is along the A-series but not along the B-series. The protagonist's present focus moves (along the A-series) into the future or the past without altering the (B-series) events of his or her life. In Kurt Vonnegut's *Slaughterhouse-Five,* Billy Pilgrim's present (on the A-series) moves back and forth to earlier and later experiences in his life (on the B-series).[13] This is time travel of a sort, but not the sort with which science fiction is usually concerned. Call this A-series time travel. Science fiction is usually concerned with B-series time travel.

Time travel *for present* purposes is movement along the B-series. B-series time travel involves physical movement through time. In B-

series time travel, the time traveller actually physically moves through time, back into the past or forward into the future (still excluding *normal time travel*). B-series time travel may also result in A-series time travel for subjective beings (human beings, dogs, cats or mice, perhaps not mushrooms) — if the experience doesn't kill them. If Algernon physically travels back to earlier times (on the B-series), his focus on what is happening *now* is shifted back into the past (on the A-series). Notice this doesn't happen to a block of cheese. One may send some limburger back one hundred and twenty-five years, but it cannot enjoy the experience. (I dare say it will not savour the moment.) From this point on, I will use "time travel" to refer to B-series time travel, and conflate travelling to earlier times on the B-series with travelling into the past and travelling into later times on the B-series with travelling into the future. If time is one dimension of our world, some constraints on time travel logically follow and these are also relevant to science fiction.

In fiction, the world we are talking about may be more or less similar to our own. Nevertheless, science fiction involving time travel respects logical constraints on time travel and what is conceivably possible according to the laws of physics (or at least the physics of the day). Principles of charity may apply to how physics is extended in the story. My so-called "logical constraints" are not derived purely from logic alone. As mentioned, they follow from the assumption that time is one-dimensional. An author might discount this assumption. With this exception, contravention of a logical constraint on time travel is not science fiction, but science fantasy.

Before proceeding, it would be useful to have a definition of paradox, so here is an example from a dictionary of literary criticism:

> [P]aradox: A statement which, though it appears self-contradictory, contains the basis of truth that reconciles the seeming opposites.[4]

But this definition is more appropriate to the paradoxes used by the metaphysical poets. It doesn't cover paradoxes of time travel as they are used in science fiction or fantasy. As alluded to in the beginning of this paper, it is more enlightening to draw analogies between paradoxes of time travel and logical paradoxes. So I will provide a brief theory of semantic paradox and hypodox, in particular, the Liar and the Truth-teller (both self-referential statements). The Liar statement says of itself that it is false. The Truth-teller statement says of itself that it is true. Here are the two statements in question:

> Liar: "This statement is false".
>
> Truth-teller: "This statement is true".

Consider the way in which we settle the truth of the following statements:

> Jack says: "What Jane says is true".
>
> Jane says: "What Phil says is false".
>
> Phil says: "What Bruce says is false".
>
> Bruce says: "Ariadne taught Theseus a dance".

Say we want to know whether what Jack says is true. Well, what Jack says is true if Jane's statement is true, and that's true if Phil's is not. Phil's statement is not true if Bruce's is true. Assuming we can settle whether or not Ariadne taught Theseus a dance, we can settle whether Bruce's statement is true, and we will then be able to settle whether Jack spoke truly or not. Bruce's statement can be considered a base statement upon which all the others are *grounded,* so to speak. Jack's, Jane's, Phil's and Bruce's statements form a referential chain of statements ending with

Bruce's. The truth or falsity of the earlier statements in the chain can only be settled if the truth of Bruce s statement can be settled. The Liar refers to itself in a circular chain of reference. So the truth-value of the Liar can be settled if the truth-value of the Liar can be settled. What is more, the truth or falsity of the Liar can *only* be settled if the truth-value of the Liar can be settled. The Truth-teller refers to itself, and the same sorts of considerations apply. So both the Liar and the Truth-teller are *ungrounded.*[15] There are no base statements like Bruce's on which they are grounded. The difference between the two is that the Liar is paradoxical because we cannot consistently allocate any truth-value to it, whereas the Truth-teller is hypodoxical because it might consistently take either truth-value but we have no basis for determining which.

Assuming the Liar is true, then it is true that it is false. Assuming the Liar is false, then it is false that it is false, therefore it is true. If the Truth-teller is true, it is true. If the Truth-teller is false, it is false that it is true, therefore it is false. When "This statement is false" is said of another statement, we can determine its truth value by determining the truth value of the statement referred to. If that statement refers to another, we follow the referential chain until there is no need to consider further statements. Such statements are *grounded.* Liar paradoxes involve statements that refer to themselves or other statements in a loop (or in such a way that the referential chain always requires consideration of further statements). Truth-tellers also involve such circular or *ungrounded* reference. I will extend the concept of *ungroundedness* by analogy to paradoxes and hypodoxes of time travel. There is an analogy with causal chains involving *loops.*[16] The causal chains of events resulting in paradoxes and hypodoxes of time travel *loop* in ways that result in causally *ungrounded* events. In the paradoxical cases, some of these events are mutually exclusive with other events in the past or future.

Paradoxes and hypodoxes of time travel

Time travel stories provide many examples of paradox and hypodox. For instance, there is a story in which scientists from New Damascus time-travel back in history to just prior to when the Moors overran Europe. The time travellers save someone from being assassinated. In the following battle, the Moors now lose, they don't overrun Europe, they don't go on to found New Damascus and the history leading up to the scientists inventing their time machine becomes *ungrounded.*[17] This scenario involves mutually exclusive events occurring in the past. This scenario is paradoxical.

It seems reasonable to assume that, like the first space travel, the "first" time travel will be unmanned. More likely still, data will be sent time-travelling first. If I knew how, I'd be sending information back. Perhaps some future people are, but we don't know how to receive it or even recognize it yet. Following Nicholas J. J. Smith on this matter, one could suppose that a previously uncontacted, primitive tribe might refer to passing aeroplanes as "noisy nuisance birds" while still having a vigorous debate about whether people will ever fly.

There is a scientific theory that sub-atomic particles have attributes for Charge, Parity and Time.[18] So, here is a design for a time machine. Just devise a device to reverse the time direction of the sub-atomic particles that make up the device itself and its contents. Send it back with a "timer switch" to reset the time direction to forward when it gets *here* in time. Indeed, if I have anything to do with it, I will be hoping to receive something from the future before finishing this article. And if I succeed I intend to send a photograph of the painting that wins the next Archibald prize (as well as share price futures, philosophical breakthroughs and ... some personal information). I will contact the painter to agree on terms for him or her to paint the picture from the

photograph. In this way, the creation of the art will involve a causal loop from the future.[19] The scenario is similar to the one about the origin of Shakespeare's plays, when a future anthropoid travels back with a copy of *The Complete Works of Shakespeare* and Shakespeare copies his own plays word for word. There is nothing paradoxical about these scenarios. No mutually exclusive events occur. No contradiction makes these scenarios impossible. Nevertheless, the chain of events that leads to the creation of the painting or Shakespeare's plays goes round in a loop in time, from the point of view of the rest of the world.

Not all paradoxes of time travel are about the past. An episode of the cartoon *Catdog* involved time travel into the future. Experiments were being performed in the present that would genetically modify a rat, but *meanwhile* Catdog time-travelled to the future and discovered that the descendants of this genetically-modified rat would take over the Earth; so Catdog returned to current time and had the experiments stopped. Thus *the future* that Catdog *had* visited, in which the rat's genetically-modified descendants took over the Earth, *became* ungrounded. Moreover, unless we admit the *reality* of multiple futures, there is only one *future* Catdog could have really visited, and it is one in which the rat has and does not have genetically-modified descendents. This scenario is paradoxical.

I have provided sufficient definitions and examples to now give a brief analysis of paradoxes and hypodoxes of time travel. Talking about *contradictions* may not be the best way to analyse paradoxes of time travel. Although logicians have analysed time travel paradoxes using this terminology, it seems to me to be a carry-over from analysing paradoxes about statements. Time travel involves unusual causal chains of events. Events, not statements, are the basic units of time travel. It is better to say some events are *mutually exclusive,* rather than

contradictory. (Mutually exclusive events need not be equivalent to each other's complement.) A causal chain of events is a sequence of events such that each is a cause of its successor, apart from the last event in the chain. Causal chains normally go in the same direction through time without any *loops or jumps* relative to the B-series. Events involved in causal chains without *loops are grounded.* Events resulting from unusual causal chains with *loops* are *ungrounded.*

Notice the analogy with ungrounded statements that form referential loops. I have extended the concept of ungroundedness based on this analogy. In such causal loops in time, some consequent event in a causal chain has a causally antecedent event that occurs later in B-series time. Not all *ungrounded* events are paradoxical or hypodoxical. Hypodoxes are loops in a causal chain, not just loops in time. If Doc Brown in *Back to the Future* had not only travelled a hundred years backwards in time but also far enough West that no consequential event of his actions in the past affected the locality from which he departed for a hundred and fifty years, no paradox or hypodox would arise. An unusual causal chain would result in paradox if it would bring about an *ungrounded event* that is *mutually exclusive* (in relation to the B-series) with some other event in the chain. Tom's death in 1870 is *mutually exclusive* with his assassination in 1851.

A science fiction writer may attempt to address certain issues about time travel: how it might be possible, how to reverse time, how to speed up or jump from one moment to another — discontinuous — moment, how to stop once one starts. H. G. Wells, for example, has some discussion about whether the time traveller can be seen and the hazards of stopping when one is embedded in a concrete wall. Wells doesn't say much about how time travel is possible.[20] His description of the machine reminds me of the crystal cave in Mary Stewart's novel

of the same name, and seems more like fantasy than science fiction. In a story that is neither paradoxical nor hypodoxical, Wells' time traveller moves forward in time, returns home for dinner, and goes back to the future. However, in the most recent movie adaptation of this story, the time traveller attempts to change the future's future — thus engendering paradox.

David Lewis's resolution of the paradoxes of time travel

Now, what can a philosopher really say about time travel? Isn't it the domain of science? Well, David Lewis, one of the most influential analytic philosophers of the last quarter of the last century has already said a lot. Philosophers analyse time travel from the point of view of what is possible. For example, the *Time Cop* movies, in which Jean Claude van Damme and Jason Lee are sent back as time police to prevent an evil mastermind from altering the course of history, are illogical. Whatever has happened in the past is past, and therefore already includes whatever the time traveller did in the past. An evil mastermind may travel back to the past and do whatever he or she did there, and the present will be just the same.

The makers of *Terminator* knew better. A neural-networked computer linked up across the globe becomes conscious and decides to wipe out human beings. It sends a machine back in time to terminate the mother of the future leader of the human resistance. Anticipating the reality TV genre, the terminator is hopelessly foiled by a string of increasingly improbable events, and only succeeds in bringing about the future it sought to avoid.

Lewis's view of *laissez faire* time travel is that time guardians are not required. The past (at least) is fixed and contingencies are sufficient to both allow for time travel and prevent time travellers doing anything

other than what they already did in the past. As our history isn't full of strangers failing to assassinate Hitler, we may conclude that either there is not much time-travelling going on in our world, or that our future time travellers have even more sense than a self-aware computer with a brain the size of the planet, and are not attempting the impossible.

In *Terminator 2,* any sense of reality went by the wayside, as it tends to do with cash-in sequels. Similarly, the *Back to the Future* movies, in which photographs register changes in the then future *present* and characters scurry through scenes to correct the alterations they have made to what the *present* will be like, are — as you'd expect — just fantasy. Even trivial changes to the past are impossible. Ray Bradbury's *A Sound of Thunder,* in which a time traveller alters history by treading on a butterfly, is equally unrealistic.[21] As Sorensen recounts Lewis as saying: "Time travellers cannot alter the past because they are already part of the past".[22] There is no need at all for *time guardians* to prevent time travellers causing any change in the past. Lewis comments that:

> Not all science fiction writers are clear-headed, to be sure, and inconsistent time travel stories have often been written. But some writers have thought the problems through with great care, and their stories are perfectly consistent.[23]

Lewis's restriction on what time travellers can and cannot do is contingent. If something did not happen in 1921, then no time traveller can go back and make it happen; they may travel back, but they will only succeed in doing what is already in the past. By extension, as in the Catdog example, the present is the future's past, and we cannot go to the future and come back and make the present different from the way it is.

While I think Lewis's *laissez faire* solution is correct, there are a few points that I want to add. Firstly, there are things that a time traveller *necessarily* cannot do. (This is not a purely logical *necessity,* as it draws on our conceptions of time and life.) A time traveller cannot go back and kill him or herself. It is more irrational for a time traveller to think he could go back and kill himself than for him to think he could go back and kill Hitler. We can conclude *a priori* that a time traveller just cannot have killed himself in the past. We can draw this conclusion independently of any empirical facts, given one-dimensional time: the fixedness of the past follows from one-dimensional time. Two mutually exclusive events cannot occur at the same time in the past. If the time traveller is alive now, whenever *now* is, then he or she was alive prior to now. Therefore, the time traveller did not terminate his or her own life prior to now.

Secondly, hypodoxical time travel, although also ungrounded, is possible. Lewis's argument against paradoxical time travel does not rule out hypodoxical time travel. Hypodoxical time travel does not cause any events that are mutually exclusive with other events, unlike the paradoxes of time travel. It does seem odd to me, as a logician, that philosophers are committed (as I have argued) to hypodoxical time travel being possible if they don't think hypodoxical statements like the Truth-teller make a real statement or have consequences. Yet the *no-statement* account of the Truth-teller is a common view.

I am pushing an analogy, but it seems to me there is an analogy and that the two types of hypodox are not treated even-handedly.[24] A story involving a time travel paradox is a story about the impossible, involving mutually exclusive events. A Liar paradox entails a contradiction; so a Liar statement is *naively* both true and false, and often dismissed by theoreticians as neither true nor false. Truth-teller hypodoxes are

sometimes also said to be neither true nor false. In contrast, it would be incoherent to say of a time travel paradox, hypodox or any *ungrounded* event that it is neither possible nor impossible. Paradoxes of time travel are simply impossible; hypodoxes are possible. The bivalence of being either possible or impossible seems compelling, even more so than being true or not true. In the case of time travel, its paradoxes and hypodoxes are among the sorts of chains of events that are either impossible or possible.

Epistemic variations on time travel paradoxes

Whether he or she intends to or not, the time traveller cannot change the past. Nevertheless, there is a distinction to be made. If the time-travelling limburger goes back a hundred and twenty-five years, lands on a casket of guns on a train in winter and ruins the lives of the occupants of that sealed and heated carriage, then it already did so.[25] Likewise, a subjective being cannot do anything in the past that they haven't already done, nor can they undo anything they've already done. In this respect, they are in the same situation as the limburger, and any apparent paradox is non-epistemic. The paradoxes of time travel that I have been analysing involve mutually exclusive events. With respect to these paradoxes, events involving Dr Who or the limburger are subject to the same constraint: that mutually exclusive events are impossible. The difference for a subjective being is that he or she may intend to do or undo something in the past. The same constraint prevents them, but there are also paradoxes at an epistemic level: if one can time travel back into the past, one can intend to go back there to do something that one *can* do, in that one has all the capability and opportunity. However, if it is something one did not already do, one *cannot* do it. The intentions of a rational being ought

to be guided by beliefs. If one intends to do something in the past, one ought to believe one can. If one is rational, one knows that one cannot alter the past (even given the capability and opportunity to time travel). So it seems that a rational being ought not to intend to change the past.

What *necessarily* prevents someone changing the past? How can a contingent event in the past be necessarily unchangeable for a time traveller who arrives there with intention, capability and opportunity? Tig sets off to kill Tom some years earlier, for no credit but because of a utilitarian miscalculation and paucity of principles. Tom is alive *now,* when Tig departs. Tig has the intent, wherewithal and opportunity in the past. Tom's surviving Tig's attack is a contingent event. How is it that Tig *necessarily* cannot kill Tom in the past? Lewis distinguishes what Tig can and cannot do relative to the information taken into account. If all that is given is that Tig has the intent, capability and opportunity, then Tig can kill Tom. However, if it is given that Tom is alive *now,* then he cannot have died earlier; so Tig cannot kill Tom in the past. In the past, Tig— the one from the future — had a good chance of killing Tom, but he slipped on a banana peel or something, and failed. All of Tig's descendants perpetuate the same utilitarian miscalculation and go back to the same year and attempt to kill Tom. Are there enough bananas in history to stop them?[26] Should Tom be paranoid, maintain a positive attitude or believe he lives a charmed life? After all, the best assassins from the future have failed to kill him up until now. Tom captures one of these assassins, who reveals Tom's whole life story under the influence of a powerful truth serum. Should Tom be a fatalist? The philosophical issues of time travel compound for subjective beings.

Actually, a rational being can intend to *change* the past, in the sense that a time traveller can affect the past. The only logical constraint is that one cannot do other than what one actually did. This rules out Tom being killed one year and alive the next. Because Tig— the one from the future — did not kill Tom, he cannot go back and succeed next time around. There is no second chance for Tig (or his descendants). For some misguided reason, he time-travelled back to kill Tom — attempting the impossible. It's impossible because Tig's attack on Tom had already failed, not because he did not have a chance at the time. No event on the B-series up to the time of Tig's attack prevented Tig from succeeding. After that event on the B-series, Tig never gets a second chance.

Conclusion

A more logical time traveller will attempt something possible, like sending oneself a picture of the painting that wins a coveted art prize in the future. However, if one was going to do that, one might know that one was going to do that as soon as one received the picture (and explanatory note) from the future. Such foreknowledge does seem strange. The most surprising thing about this though is still the possibility of some event in the present being caused by something in the future that is itself a causal consequent of the present event. I do not for a moment believe in the auto-genesis of Shakespeare's plays, but the story about their ungrounded production, copied out from a future edition of the *Complete Works of Shakespeare* is, surprisingly, logically possible.

In summary, time travel may involve causally ungrounded chains of events. If any of those events are mutually exclusive with the way the world was (or even *is,* as in the Catdog example), paradox ensues and such a story is science fantasy not science fiction, at least in this respect. Some of the time travel paradoxes are necessarily paradoxical, like

attempting to kill one's earlier self; most are contingently paradoxical.
Hypodoxical time travel scenarios are logically possible and appropriate
material for science fiction.

1   Unless, of course, Grandmother is a time traveller too.
2   It is not a classic literary paradox like Donne's "Death, thou shall die", but it is more in the vein of a logical paradox — like the Liar paradox, concerning the truth of "I am lying". While logicians and poets both delight in paradox, logicians are generally concerned to distinguish what is possible from what is paradoxical and insulate the former from the latter, whereas poetic authors put forward paradoxes as metaphysical truths. Antinomies have been an age-old source of metaphysical debate for philosophers too — ironically so, because there has always been lacking a logical analysis of the concept of paradox that supports their direct use or denial. Paradoxes have also marked some important junctures in the intellectual history of mathematics and science. Personally, I do believe a general theory of paradox is possible. Cf. Roy Sorensen, *A Brief History of the Paradox* (Oxford: OUP, 2003). For this article's purposes though, in both philosophy and literature, paradoxes and hypodoxes of time travel concern what is impossible and what is — surprisingly, perhaps — possible.
3   I coined and recommended "hypodox" as a general term for a Truth-teller-like expression in my paper "Paradoxes of Truth, Satisfaction and Membership", presented at the 2005 *Australasian Association of Philosophy Conference*. It is particularly useful to be able to form an adjective, "hypodoxical". The present article can be read independently. Nevertheless, I have produced it as part of a project to classify paradoxes. For those interested in this theoretical background: While "paradox" is generally interpreted as *beyond belief,* "para" also means *above* and "hypo" means *under.* In a prequel, "Relatives of the Liar Paradox and the Truth-teller including a New One", which I presented at the 2004 *Australasian Association of Philosophy Conference,* I conjectured that each paradoxical statement has a hypodoxical dual. I showed the semantic value of a Liar-like statement is *over-determined* just when the semantic value of a dual statement is *under-determined.* In my 2005 paper, I showed this duality is preserved by analogous paradoxes of satisfaction and paradoxes in naive set theory. For example, Russell's paradox *turns* on the set of all sets which are not members of themselves — is that set a member of itself or nor? The dual hypodox *turns* on the set of ah[1] sets that are members of themselves. Nothing seems to determine whether or not that set is or is not a member of itself. Against the background of my project to classify paradoxes (and hypodoxes), this article shows how some of the distinctions that can be made in classifying logical paradoxes can also be applied to the classification of paradoxes and hypodoxes of time travel.
4   For David Lewis's resolution, see his "The Paradoxes of Time Travel", in *American Philosophical Quarterly,* 13 (1976) 145-52; reprinted in his *Philosophical Papers,* Vol. II (Oxford: OUP, 1986) 67-80.
5   Austin Dobson, *The Paradox of Time,* cited on p. 30 in Martin Gardner, "Can Time go Backward?", in *Are Universes Thicker than Blackberries?* (New York: Norton, 2003) 29^45.
6   Martin Gardner "Can Time go Backward?", 30.
7   Cf. Phil Dowe, "The Case for Time Travel", *Philosophy,* 75 (2000) 441-51 "... one way to define time travel is via a *causal process.* The simplest case of a causal process is the trajectory of a particle through time ... The same can be said for the history of a person ... Time travel is where a causal process connects two times in a special way. Dr Who's body is a causal process, and when the Tardis takes him from 1976 to 1876 that causal process connects two times in a special way. I say 'special way' to distinguish time travel from the normal causal process, such as John's life, a causal process, connecting 1965 to 2005, the dates of his birth and death", 441.
8   Regarding this, David Lewis, in *The Paradox of Time,* p.68 footnote 2, mentions the initial chapters of Isaac Asimov's *The End of Eternity* (Garden City, N.Y.: Doubleday, 1955), but comments that the novel later seems to require some different conception of time.
9   William Grey "Troubles with Time Travel", *Philosophy* 74 (1999) 55-70; 68.

10 David Lewis, *The Paradoxes of Time Travel,* 69-71.
11 Grey, "Troubles with Time Travel", 57.
12 See the chapter on "Time" in Brian Garrett, *What Is This Thing Called Metaphysics?* (London: Routledge, 2006) for further information on McTaggart, his A- and B-series, and paradox. Cf. the subsequent chapter "Time II" for discussion of the paradoxes of time travel.
13 Kurt Vonnegut, *Slaughterhouse-Five* (New York: Delacorte Press, 1969).
14 Karl Beckson & Arthur Ganz, *Literary Terms: A Dictionary,* 3rd edn (New York: The Noonday Press, 1989) 190.
15 The term *ungrounded* was introduced by Hans Herzberger in 1970, and is given a thorough treatment in Saul Kripke, "Outline of a Theory of Truth", *Journal of Philosophy, 72* (1975) 690-716.
16 This analogy with ungroundedness is suggested in Peter Eldridge-Smith, "The Cretan Liar Paradox", in Livio Dobrez *et at.,* eds, *An ABC of Lying* (Melbourne: Australian Scholarly Publishing, 2004) 72-92.
17 I've heard this story attributed to Anthony Burgess.
18 Gardner "Can Time go Backward?", 34.
19 This artistic scenario is based on a story, which Michael Dummett had read and related to Peter Roeper, wherein an artist receives a photo of a picture from the future, which he then draws.
20 H. G. Wells, *The Time Machine* (1895; London: Chancellor Press, 1983).
21 Cited in Sorensen, *A Brief History of the Paradox,* 118.
22 Sorensen, 119.
23 Lewis, 67. And he continues in a footnote: "I have particularly in mind two of the time travel stories of Robert A. Heinlein: "By His Bootstraps," in R. A. Heinlein, *The Menace from Earth* (Hicksville, N.Y., 1959), and "-All You Zombies—," in R. A. Heinlein, *The Unpleasant Profession of Jonathan Hoag* (Hicksville, N.Y., 1959)".
24 There are dissimilarities too. No causal chain seems to have any other *base-level grounding* other than the big bang. This cannot be assumed; whereas a statement is *grounded* in virtue of having a base set of statements sufficient to determine its truth-value.
25 For details of how some limburger cheese, time-travelling or otherwise, might do this, see Mark Twain's *The Invalid's Story.*
26 Cf. Nicholas J. J. Smith, "Bananas Enough for Time Travel", *British Journal of the Philosophy of Science,* 48 (1997) 363-89.