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Five Features of Multiverse Time Travel: How Past Paradoxes Can Be Avoided in the Future

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Abstract: The aim of this paper is to help construct coherent time travel narratives by establishing five features of multiverse time travel. To this end, multiverse time travel will be contrasted to fixed-universe time travel, and both versions related to various cases - where each case is designed to illustrate a key feature of multiverse time travel.

Keywords: time travel; multiverse; fixed universe; narratives; paradoxes

1.0 - Introduction

Although there has been growing philosophical treatment of multiverse time travel (Abbruzzese, 2001; Effingham, 2012), no work has been solely dedicated to a formulation of the key features of this type of time travel. This paper aims to redress this vacuum by establishing five key features of multiverse time travel. These features are established to help the construction of more coherent multiverse time travel narratives. That is, it is hoped that if fictional worlds are constructed with these features in mind, they will avoid inconsistencies common to such worlds. To this end, multiverse time travel will be contrasted to fixed-universe time travel, and both versions related to various cases - where each case is designed to introduce one, or more, key features of multiverse time travel.

To help illustrate why identifying such features might be important to creators, consumers, and scholars of time travel narratives, consider the following simple, and typical, example of time travel from the popular 1978 film Superman. In this film Lois Lane (with whom Superman is in love) is killed. Consequently, Superman goes back in time and saves her.[1] Despite its simplicity, there are problems this narrative; problems that render it impossible for Superman to save Lois under either multiverse or fixed-universe time travel. These problems will be made clear in the next section, after both theories of time travel are introduced. It is these types of problems that writers may wish to avoid, consumers may wish to spot, and scholars may wish to study; this paper aims to help us in these respects. However, just as importantly, this paper also aims to encourage discussion on some interesting, and subtle, distinctions between different types of multiverse time travel that have not yet been given adequate attention.

We begin with a brief overview of a well-known time travel paradox, the grandfather paradox. We shall use this paradox to introduce and contrast fixed-universe and multiverse time travel. We shall also discover why Superman's efforts to save Lois Lane are thwarted under both theories of time travel.

2.0 – The grandfather paradox

The grandfather paradox can be presented as follows:

> If you could travel into the past then you could kill your own grandfather at a time before your father's conception, so preventing your own birth, which would prevent you from traveling into the past, and so prevent you from killing your grandfather before your father's conception.

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This case highlights the notion that backwards time travel seems paradoxical - it appears to both allow and deny the same event (the killing of your grandfather). It is because of this apparent paradox that some have argued against the possibility of time travel (Mellor, 1998, p. 135; Hawking, 1992, p. 604). The simplest form of this argument can be presented as follows,

1. If backwards time travel is possible, then a paradox is possible.

2. It is not the case that a paradox is possible.

So,

3. It is not the case that backwards time travel is possible.

Most analytic philosophers take the truth of Premise 2 for granted.[2] So, on the assumption that backwards time travel could occur (or one wishes to construct a coherent time travel narrative), one must reject Premise 1 of this argument.

A common objection to Premise 1 is that it is not traveling back in time itself that gives rise potential paradoxes. It is altering the past that does so. As a consequence a number of different versions of time travel have arisen that allows one to travel backwards in time, but not alter the past. In this paper, we will focus on two of these: fixed-universe time travel and multiverse time travel. Let us begin with fixed-universe time travel.

Although the focus of this paper is not on fixed-universe time travel, a very brief introduction to this version of time travel may help, as a counterpoint, to better illustrate multiverse time travel. According to fixed-universe time travel, all past events are fixed in time (Dwyer, 1975; Lewis, 1976; Brown, 1992; Vihvelin, 1996). So if an event occurs, it is set in stone. The past is unalterable. (In some versions it is not only the past that is fixed, but all present and future events also.)

According to fixed-universe time travel, if you were to travel back in time intent on killing your grandfather before your father's conception, you would fail. Although killing your grandfather may be something well within your power to accomplish, you will not. The facts are determined to stop you. For example, although you could travel back in time, locate your grandfather, and line up a lethal shot with your rifle, the rifle would jam, or you would have a heart attack, or you would slip on a banana peel, and so on; and these defeating factors will continue to pop up for as long as you keep attempting the feat (Goddu, 2007). (It is because you are completely unable to kill your grandfather that Deutsh and Lockwood (1994) have argued that fixed-universe time travel invalidates the Feature of Autonomy. According to this feature it should be "possible to create in our immediate environment any configuration of matter that the laws of physics permit locally, without reference to what the rest of the universe may be doing" (p. 71))

In short, nothing a backwards time traveller does in the past can alter it. This is what it means for a universe to be fixed – all the events are fixed, that is, unalterable. Or, put another way, everything a backwards time traveller does in the past has already occurred that way. This is why narratives that involve changing the past cannot occur under fixed-universe time travel. So, although Superman might be permitted to travel back in time, under fixed-universe time-travel he would be unable (contrary to the film) to save Lois Lane. Narratives that operate under fixed-universe time travel will be more akin the 1995 film *Twelve Monkeys*, where the actions of the protagonist James Cole (portrayed by Bruce Willis) fail to cause any deviation from a future that must come to pass.

Fixed-universe time travel denies the truth of Premise 1 of the argument against time travel by providing the conditions under which time travel is possible, but a paradox is not. That is, traveling back in time is not possibly paradoxical, providing the past is not altered. Let us now contrast this version of time travel to multiverse time travel.

An alternative version of backwards time travel is multiverse time travel. It, too, rejects Premise 1 of the argument against backwards time travel by asserting that altering the past (i.e. one's own past) is impossible. However, it still allows for the possibility that one might cause events that did not occur in one's own past, to occur in a past qualitatively identical to your own, up until the moment you change it.

According to multiverse time travel, when a time traveller travels back in time, they don't arrive in the past of their universe (that is, the universe from which they came). Rather, the act of their travelling back locates them in a child universe. This child universe is qualitatively identical to the parent universe the time traveller departed from, up until the moment they arrive, and from then on it is different. For example, if a time traveller goes back in time one hour, say from 2:00pm to 1:00pm, they depart the parent universe at 2:00pm and arrive in the child universe at 1:00pm, where both parent and child universes are qualitatively identical up until 1:00pm.

Like fixed-universe time travel, if you were to decide to go back in time to kill your grandfather before your father's conception, you would, again fail (Gribbin, 1992, p. 202; Davis, 1995; Green, 2004, pp. 455-458). But this time, you fail for a different reason: your grandfather is safe and sound in the parent universe. The best you could hope to achieve is the killing someone qualitatively identical to your grandfather within the child universe, and thus preventing the birth of your own doppelganger.

Likewise, under multiverse time travel, Superman might have been able to travel to a different universe and save a Lois, but his efforts to save his Lois (the one he saw die) are in vain (in addition, he also now has a rival for Lois' affection to contend with – his doppelganger in this universe).

The grandfather paradox was introduced to help illustrate some important features of multiverse time travel.[3] The three key features introduced by this example are as follows.

Multiverse time travel: If, at time (t), x time travels to some prior instant (t-y), then:

> (a) x departs from Universe A at t, and arrives in Universe B at t-y;
>
> (b) Universes A and B are qualitatively identical up until t-y;
>
> (c) at t-y, the only difference between Universes A and B is that x is present in B, but not in A.

In order to help us flesh out further key features of multiverse time travel, we shall now examine some further cases. The next case is the bootstrap paradox.

3.0 – The bootstrap paradox

Consider the following case:

> An older version of yourself arrives from the future and gives you the plans to build a time machine and then disappears. It takes you years to build the machine, but you eventually succeed. In due course you also go back to the exact time and place that the older you appeared to the younger you. You then give the plans to the younger version of yourself in the exact same manner they were given to you.

This case involves a causal loop. The older you giving the plans to the younger you causes (transitively) the same event (i.e. the older you giving the plans to the younger you). Some people object to the weirdness of such a loop. Why? Because the plans seem to have no ultimate origin (the events seem to 'pull themselves up by their own bootstraps'). It's as if they are woven into the very fabric of reality – a brute fact of the universe.[4] The question we will be considering here is: could this loop occur according to fixed-universe and multiverse time travel?

Providing we allow for the weirdness of such brute facts (i.e. the plans having no ultimate origin), there is no problem with such loops occurring under fixed-universe time travel. For if you were given the plans by your older self, then this event is fixed and (despite you perhaps trying to do otherwise) you will travel back when you are older and do the same. However, things aren't so straightforward under multiverse time travel.

Once a time traveller has gone back in time they arrive in a different universe; what is more, they are never able to return to any universe they have left. Why? Because the act of travelling backwards in time places them in a duplicate of the universe they have left (identical to the parent universe up to the time they arrive), and its duplicates all the way down – at first a duplicate, then a duplicate of a duplicate, then a duplicate of a duplicate of a duplicate, and so on. One can never return from a child universe to a parent universe. So true causal loops are impossible.

So, any narrative wishing to feature this paradox cannot avail themselves of multiverse time travel. For example, in the 2014 film Time Lapse, a group of friends find a series of photos of themselves, each of which is from 24 hours into the future (it is the photos that travel back in time here, not the people). The friends then end up doing the things the photos show them doing – sometimes because of the fact they viewed them; in such instances the bootstrap "paradox" is in effect. Such narratives cannot occur under multiverse time travel. Although there is nothing in multi-universe time travel to suggest that the future of a parent universe cannot be similar to the future of a child universe, it does not necessitate this like an actual causal loop would.

The bootstrapping paradox is designed to illustrate the point that once a time traveller goes back in time they are unable to return to the universe they departed from, hence the impossibility of causal loops of this kind. Consequently, we can add (d) to the key features,

Multiverse time travel: If, at time t, x time travels to some prior instant, t-y, then:

> (a) x departs from Universe A at t, and arrives in Universe B at t-y;
>
> (b) Universes A and B are qualitatively identical up until t-y;
>
> (c) at t-y, the only difference between Universes A and B is that x is present in B, but not in A;
>
> (d) x cannot return to Universe A.

With this feature established we shall move to the case of the time travellers' reunion.

4.0 – The time travellers' reunion

Consider the following case:

> Your wife creates two time machines. She uses the first to go back in time to see the Beatles play at the Cavern Club. After a week of waiting for her to return you decide to use the second time machine to also attend the gig to see if you can find her.

The question to consider here is: could such a reunion occur under fixed-universe and multiverse time travel?

There is no problem with such a reunion occurring under fixed-universe time travel. In theory, if your wife is at the club, then you are able to travel back to the same time and place and meet up with her. However, again things aren't so straight forward under multiverse time travel.

Reconsider feature (b) of multiverse time travel:

> (b) Universes A and B are qualitatively identical up until t-y.

Given this feature and that neither you nor your wife attended the Cavern Club when the Beatles first played in the parent universe, it follows that when you travel back in time, your wife can't be there waiting for you - if she was already there, the parent and child universes would not be qualitatively identical up until the moment you arrive back in time. Likewise, when your wife initially traveled back in time, you can't be waiting for her for the same reason. Therefore, you can't arrive before your wife, and she can't arrive before you.

But what if you set your time machine to arrive at the exact same time you wife arrived in the past – could a reunion occur in this manner? No, because the possibility of you both arriving at the exact same time is denied by feature (c):

> (c) at t-y, the only difference between Universes A and B is that x is present in B, but not in A.

x identifies the thing that travels back in a singular instance of time travel. However, the case of the time travellers' reunion involves two instances of time travel (your wife travelling back, and then you travelling back later on). So x can pick out either your arrival at t-y, or your wife's arrival, but not both. If x picks out your wife's arrival at t-y, then you cannot also arrive at this time in the same child universe that your wife travelled to. This is because this would then involve an additional difference between the parent and child universes than just the presence of x, your wife. In other words, your wife's arrival would not be the only difference as feature (c) dictates. The same goes for if x picks out your arrival at t-y. So, you are unable to arrive at the same time.

Consequently, it follows from features (b) and (c) of multiverse time travel that once your wife travels back in time you will be unable to reunite with her. You could, of course, travel back in time and create another child universe of the same parent universe from which you both departed, but it would not be the same child universe to which that your wife travelled - it would instead be sibling universe not containing your wife, thus forever separating you both.

So, many narratives that involve someone traveling back in time to pursue another time traveller (such as the 1989 film *Back to the Future Part II*, or the 1994 film *Timecop*) make no sense under either fixed-universe or multiverse time travel. Why? Consider *Timecop*: the protagonist, Max Walker (brilliantly portrayed by Jean-Claude Van Damme) is a cop who travels back in time to stop other time travelers from doing things they shouldn't in the past. This would be a futile effort under multiverse time travel because when someone travels back in time, another individual cannot follow the first traveller – thus, Max will be unable to stop the people he is following back. Likewise, in *Back to the Future Part II*, the protagonist, Marty McFly (less brilliantly portrayed by Michael J. Fox) travels back in time to stop Biff from altering the past (and so the future). Under fixed-universe time travel, this is impossible, as past events can't be altered, which means Biff couldn't have changed them in the first place.

This case illustrates that once a time traveller goes back in time, nothing from their parent universe is able to follow them. Given this, we may add (e) to our key features:

Multiverse time travel: If, at time t, x time travels to some prior instant, t-y, then:

> (a) x departs from Universe A at t, and arrives in Universe B at t-y;
>
> (b) Universes A and B are qualitatively identical up until t-y;
>
> (c) at t-y the only difference between Universes A and B is that x is present in B, but not in A;

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(d) x cannot return to Universe A;

(e) nothing else from universe A can arrive in Universe B.

With this feature established we shall move to the case of meeting time travellers past.

5.0 – Meeting time travellers past

Although it is impossible under multiverse time travel to meet up with time travellers from a universe you have departed, it is worth considering how it might be possible to meet up with other time travellers. Consider the following case:

> Your father tells you that when he was a boy, a time traveller from the future turned up one day and gave him a great betting tip. Inspired by the story, you go on to build a time machine yourself and then travel back to that day from your father's childhood to meet a fellow time traveller.

Let us begin by considering the question: could you travel back in time to meet such a fellow time traveller under multiverse and fixed-universe time travel?

Again, there is no problem with such a meeting occurring under fixed-universe time travel, for if you did meet up with the fellow time traveller in the past, then you will do so (and conversely, if you didn't, you won't). However, again things are not so straightforward under multiverse time travel.

Since there was a time traveller in the past of your original universe, then, according to multiverse time travel, the universe you start out in will be a child of another--which makes the universe you arrive in by travelling back in time the grandchild of the universe from which the first time traveller departed. To make things a little easier for ourselves, let us give each of these particular universes a number.[5]

- Universe 1: the universe from which the first time traveller came.
- Universe 2: the universe from which you originated.
- Universe 3: the universe you travel to by virtue of travelling back in time.

Although the time traveller you plan to meet up with came from Universe 1, the time traveller you meet in Universe 3 may not have arrived from Universe 1. To understand why, we need to consider whether child universes are parallel to their parent universe, or whether they branch off of their parent universe.

Consider again key feature (b):

(b) Universes A and B are qualitatively identical up until t-y;

The term 'qualitatively identical' is to be contrasted here with 'numerically identical'. If x and y have the same qualities (or properties), then they are qualitatively identical. For example, two different red billiard balls might be (by and large) qualitatively identical as they (mostly) have the same properties. If x and y are the same one thing, then they are numerically identical. For example, Clark Kent and Superman might thought to be the numerically identical because they are both the same person. With this distinction in mind, it is worth noting that feature (b) is compatible with the two following possibilities:

(b.1 - with parallel multiverse time travel) Universes A and B are qualitatively, but not numerically, identical, up to until t-y;

(b.2 - with branching multiverse time travel) Universes A and B are qualitatively, and numerically identical, up until t-y.

The version of (b) one employs may affect whether or not we can meet the time traveller that arrived from Universe 1. Let us consider why.

Consider first parallel multiverse time travel (b.1). This version of time travel holds that the universe you travel to is, up until the moment you arrive, an exact duplicate of the universe from which you departed. If this is the case, then there may be reason to think the time traveller you meet in Universe 3 did not arrive there from Universe 1. Why? Because although the time traveller you meet is a duplicate of the one your father met, the traveller is not the same person. The time traveller your father met arrived from Universe 1, but the time traveller you meet in Universe 3 may not have possessed the same origins. So, from where might the time traveller arrive? Perhaps from some other universe – or perhaps the traveller is simply a brute fact of this child universe; that is, something which has no explanation (a possibility we shall explore further in the next section).

Let us next consider branching multiverse time travel (b.2). The first thing to mention about this version of time travel (if only to set it aside) is that it assumes, quite controversially, that two things that are qualitatively different in the future can be numerically identical in the past. This may turn out to be impossible, in which case, we can dismiss this version of feature (b). However, presuming this will remain a moot point, let us see if you are able to meet a time traveller from Universe 1 with (b.2) in place.

If the branching multiverse interpretation of key feature (b) holds, then there is reason to think the time traveller you meet actually arrived from Universe 1. Why? Because the act of your travelling back in time does not land you in a duplicate of a universe, but rather in one branch of that universe. Like a river that splits in two, the act of backward time travel takes you from one subsidiary of the timeline of this universe and places you at the exact place where the other subsidiary splits off and forces you down this alternative stream.

Accordingly, although the time-traveller you meet in Universe 3 is different to the time-traveller your father met (for the time traveller your father met did not also meet you), both share the same history. So, as both versions of the time traveller travelled from the same place (in their shared history), the traveller you meet in Universe 3, like the time traveller your father met in Universe 2, also travelled from Universe 1.

The aim of this paper is not to rule in favor of either version of feature (b). Rather, this case was introduced only to draw out this distinction, which allows us to modify our list of features as follows.

Multiverse time travel: If, at time t, x time travels to some prior instant, t-y, then:

> (a) x departs from Universe A at t, and arrives in Universe B at t-y;
>
> (b) Universes A and B are qualitatively identical up until t-y;
>
> • (b.1 – with a parallel multiverse) but not numerically identical up to until t-y;
>
> • (b.2 – with a branching multiverse) and numerically identical, up until t-y.
>
> (c) at t-y the only difference between Universes A and B is that x is present in B, but not in A;
>
> (d) x cannot return to Universe A;
>
> (e) nothing else from Universe A can arrive in Universe B.

With this distinction established we shall move to our final case - that of spying on one's self.

6.0 – Spying on one's self

Many time travel narratives involve a person travelling back in time multiple times to the same time and place. For example, in the 2007 film *Los Cronocrímenes*, the protagonist Hector (portrayed by Karra Elejalde) travels back in time multiple times – interacting with himself on each occasion in an effort to save his wife. Such narratives raise an interesting question for multiverse time travel. To draw out this question let us consider the following simple case of such a narrative:

> At 5:00pm, in your laboratory, you get into your time machine and travel back one hour, to 4:00pm. You set your machine to arrive on the rooftop of a nearby shoe factory. From this vantage point, you are able to discreetly observe your duplicate in her lab as she prepares to make a similar journey. At 4:30pm you get back into your machine and travel back one hour again, to 3:30pm. This time, you arrive on the balcony of a nearby penthouse suite which discretely overlooks the rooftop of the shoe factory. You sit and wait until 4:00pm, observing the rooftop of the shoe factory.

The question to consider is: What will you observe upon the rooftop of the factory at 4:00pm from the penthouse balcony?

Again, we have no problem answering this question under fixed-universe time travel because, as you arrived on the factory rooftop at 4:00pm, you will most certainly observe this happening again from the penthouse balcony. However, once again, things aren't so straight forward under multiverse time travel. As there seems to be an argument for observing yourself appear upon the rooftop of the factory at 4:00pm and argument for the opposite conclusion. Let us examine each of these arguments in turn.

For the sake of clarity, let us list the relevant events according to multiverse time travel:

- You depart Universe 1 at 5:00pm from your lab
- You arrive in Universe 2 at 4:00pm on the factory rooftop
- You depart Universe 2 at 4:30pm from the factory rooftop
- You arrive in Universe 3 at 3:30pm on the penthouse balcony
- You observe the factory rooftop in Universe 3 at 4:00pm from the penthouse balcony

Do these events, plus the features of multiverse time travel identified so far, give us enough information to determine what we would see upon the factory rooftop at 4:00pm in Universe 3? Perhaps not. To understand why, consider two arguments – one for why you will not see a time traveller arrive on the factory rooftop, and one for the opposite conclusion.

The first argument is for a time traveller not appearing on the rooftop of the shoe factory at 4:00pm in Universe 3. This argument attempts to demonstrate that none of the reasons that might cause a time traveller to appear on the rooftop in Universe 3 apply in this case. We can present this argument as follows,

1. If a time traveller appears on the shoe factory rooftop in Universe 3 at 4:00pm, then this event is either caused by the time traveller arriving from Universe 2, or this event is qualitatively identical to one that occurred in Universe 2 and occurred in Universe 3 prior to the arrival of the time traveller from Universe 2.

2. This event is not caused by the time traveller arriving from Universe 2. (This is because of key feature (e).)

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3. This event is not qualitatively identical with one that occurred in Universe 2 and occurred in Universe 3 prior to the arrival of the time traveller from Universe 2. (This is because the time traveller from Universe 2 arrived in Universe 3 at 3:30pm and the event in question occurs at 4:00pm.)

So,

4. It is not the case that, a time traveller appears on the shoe factory rooftop in Universe 3 at 4:00pm.

If this argument is sound, then there is reason to think that you would not observe a time traveller appearing on the rooftop of the shoe factory at 4:00pm in Universe 3. Let us now consider an argument for the opposite conclusion.

This next argument relies on the possibility that the act of time travel gives rise to a kind of brute fact. The notion of a brute fact was introduced briefly back in Section 3.0, in regards to the bootstrap paradox (the example being the loop that resulted from a time traveller giving the plans for a time machine to their younger self, who in turn grows up, builds the machine as per the plans and uses it to give the plans to their younger self, and so on). If such a loop is possible, it would be a brute fact, having no ultimate causal origin.

Consider now the notion of a relative brute fact; that is, something that is not caused by anything that is spatiotemporally relative to it. Take the following example: let us presume there was a first spatiotemporal event (perhaps the Big Bang), and that it was caused by something. This something would have to be non-spatiotemporal (for if it was not, the spatiotemporal event it caused would not be the first event). Given that this first spatiotemporal event cannot be explained by referring to any other spatiotemporal event, we might describe it as a relative (that is, relative to anything else in space-time) brute fact.

Given multiverse time travel, when a time traveller arrives in one universe from another, their arrival also seems to be a relative brute fact. That is, the cause of their arrival is not spatiotemporally relative to it, nor did it occur (relative to the events in this universe) before, after, or at the same time as their arrival. Likewise, the cause of their arrival is not located above, below, to the side of, or in the same place as, their arrival.

The following argument relies on the assumption that such relative brute facts are passed on from one generation of a universe to another. (Perhaps other properties are passed on this way, like genes, from parent to child. For example, if the fundamental laws of nature are a particular way in a parent universe, we might expect the same laws in the child.) In other words, if any universe with a relative brute fact were to parent a child universe, this brute fact would also carry over from parent to child, regardless of when the time traveller arrived in the child universe. Were this true, the following argument could be mounted:

1. The cause of the time traveller appearing on the rooftop of the shoe factory at 4:00pm in Universe 2 is outside Universe 2.

2. Any event which has a cause outside of the universe it occurs in, is a relative brute fact of this universe.

So,

3. The time traveller appearing on the rooftop of the shoe factory at 4:00pm in Universe 2 is a relative brute fact of Universe 2.

4. If event E is a relative brute fact of a universe, and a backwards time traveller arrives in a second universe from this universe, then event E is a relative brute fact of the second universe.

5. A time traveller arrived in Universe 3 from Universe 2.

So,

6. The time traveller appearing on the rooftop of the shoe factory at 4:00pm is a relative brute fact of Universe 3.

7. If some event E is a relative brute fact of a universe, then E will occur in this universe.

So,

8. The event of the time traveller appearing on the rooftop of the shoe factory at 4:00pm in Universe 3 occurs.

So, based on the assumption that relative brute facts carry over from parent to child universes in this manner, one could argue that there is reason think that you would observe a time traveller appearing on the rooftop of the shoe factory at 4:00pm in Universe 3.

If we accept this assumption then we could modify key feature (a) as follows:

According to multiverse time travel, if something x from Universe A travels back in time from t to t-y, then:

(a) x arrives in Universe B;

• (a.1 – with relative brute facts) and something qualitatively identical to x will arrive at t-y in all child universes of B;

(b) Universes A and B are qualitatively identical up until t-y;

• (b.1 – with a parallel multiverse) but not numerically identical up to until t-y;

• (b.2 – with a branching multiverse) and numerically identical, up until t-y;

(c) the only difference between Universes A and B at t-y is that x is present in B, but not in A;

(d) x cannot return to Universe A.

(e) nothing else from Universe A can arrive in Universe B.

Note that our aim here is not to suggest (a.1) is the case, but rather to draw attention to its possibility.

7.0 – Conclusion

The aim of this paper was to formulate five important features of multiverse time travel. These features were established in order to help writers construct more coherent multiverse time travel narratives (and to help consumers, and scholars, of such narratives more easily spot inconsistencies). That is, I hope that if fictional worlds are constructed with these features in mind, they will avoid the paradoxes common to such worlds. However, just as importantly, this paper also aims to encourage others to answer questions which arise from the different versions of multiverse time travel identified here. In particular:

1) Does each child universe include the same relative brute facts as their parent? And;

2) Does each child universe branch off of, or runs parallel to, their parent universe?

The answers to these questions make a tangible difference to narratives that employ multiverse time travel. For if the answer to the first question is yes, then once a time traveller travels back in time, their appearance at this time and place will occur in every subsequent child universe. And if the answer to the second question is that child universes run parallel to parent universe, then one can never travel back in time to meet people from your past (only facsimiles of such people).

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It is worth noting, in parting, why this analysis is particularly relevant to science fiction. Science fiction writers conjure worlds that are often both out-of-this-world and mundane – narratives that employ fantastic elements, such as time-travel, aliens, and space travel, but are grounded in respectable theories, such as physics, exobiology, and astronomy. But the real magic of science fiction, to make the incredible credible, requires more than attendance to scientific theory. It also requires writers to pay tribute to more fundamental principles – logical principles. And one such principle, is the law of non-contradiction, which states that it is not the case that p and not p. Paradoxes break this law; they are instances where p and not p are the case. So, for those writers who wish to weave the threads of hard realism through their worlds, is it arguably more important to avoid paradoxes than it is to avoid factual or theoretical inaccuracies. So, since paradoxes abound in time-travel narratives, and time-travel narratives are a staple of science fiction, this type of analysis (one aimed at identifying and/or avoiding such paradoxes) is of particular worth to the genre.

Notes

1. Superman may have saved Lois by 'rewinding time' locally (i.e. sending the direction of causation backwards just around Earth). This poses a number of problems outside the scope of this paper – so for the sake of simplicity, we will gloss over this possibility.

2. Interestingly, at least some scientists don't. For example, Carl Sagan (1999) states that 'inconsistencies might very well be consistent within the universe'.

3. I am borrowing from Effingham's formulisation of multi-dimensional time travel here – however please note that multi-dimensional time travel is distinct from multiverse time travel. Also, note that we are here primarily concerned with time travel narratives, whereas Effingham (and indeed most others cited in this paper) are focusing on possible real world time travel (as informed by our current physical models).

4. It is worth noting that if such brute facts are not impossible then, strictly speaking, these cases should not be described as paradoxical.

5. Numbers are used when we talk about particular universes (e.g. Universe 1 where this particular event occurred), but letters are used when we talk about universes more broadly (e.g. when someone travels from Universe A to Universe B both universes will be the same up until the moment the traveller arrives in universe B).

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