Abstract: This paper suggests that time travelling scenarios commonly depicted in science fiction introduce problems and dangers for the time traveller. If time travel takes time, then time travellers risk collision with past objects, relocation to distant parts of the universe, and time travel-specific injuries. I propose several models of time travel that avoid the dangers and risks of time travel taking time, and that introduce new questions about the relationship between time travel and spatial location.

Nowhere Man: Time Travel and Spatial Location

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Science fiction commonly depicts time travellers on lengthy and demanding temporal journeys. In these scenarios, time travel *takes time*: we see the time travelers monitor screens in their time machines, plot arrival plans, a wait to arrive at their destinations. Perhaps the most familiar examples come from countless episodes of Doctor Who in which the Doctor and his companion confer and plan while travelling through time in the TARDIS, awaiting their next adventure. Such science-fictional setups call attention to several interesting and largely underexplored[1] questions about time travel: if time travel takes time, where are objects, events, and people spatially located for the duration of their journeys? This paper suggests that time travel scenarios commonly depicted in science fiction present problems and dangers for the time travellers. In section 1, I set out several problems and dangers that face time travellers whose journeys take time: collision with past objects, the risk of landing at a distant point of the universe, and mismatches between personal time and external time. In section 2, I discuss two alternative models of time travel that avoid the problems but raise new questions about the nature of time travel.

0. Preliminaries

Let us suppose that time travel occurs when an object or person is relocated in time through means other than continuing to exist. We are all moving forward in time by existing, but that is not time travel in the metaphysically interesting sense of the term.

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[1] Notable exceptions are Dowe (2000), Nahin (1999), Grey (1999).

In order to focus on time travel that takes time, the following discussion will largely ignore instantaneous time travel. Science fiction is rife with examples of instantaneous time travel. In *Terminator*, the terminator blinks out of existence in the future and reappears in the past. In *Back to the Future,* the DeLorean blinks out of existence in the present (after achieving a certain speed) and arrives instantaneously in the future. And in *Looper*, Joe and the other time travellers blink into and out of various temporal locations (though a little nauseous even from their instantaneous trips). Other instantaneous time travellers include *Predestination's* Temporal Agent and *Quantum Leap*'s Sam Beckett, each of whom are portrayed as "flashing" out of one temporal location and into another.

One reason to ignore instantaneous time travel is that it doesn't satisfy the concept of *travel* so much as teleportation. Normal spatial travel is conceptualized as travelling *across* space: traversing a mountain, crossing an ocean in a ship or a plane, walking across a college campus. But the concept of spatial travel doesn't necessarily extend to the erasure of a person at the site of departure and reconstruction on the top of the mountain, the other side of the ocean, a distant point of the college campus, or another point of arrival. It's categorically different than continuing to exist—taking up time and space—while travelling. Similarly, instantaneous time travel is rather more like erasing a person at the point of departure, and rebuilding her instantly at the point of arrival—a fundamentally different kind of time travel than the time traveller waiting around to arrive at her destination in her time machine, physically intact throughout.[2]

The instantaneous notion is not problematic per se, but it does turn time travel into the result of a particularly fancy invention. Instantaneous time travel belongs squarely in the realm of science fiction due to its reliance on easily stipulated magical or mysterious devices. I will largely set aside such cases.

I will also set aside a plethora of more commonly discussed metaphysical issues surrounding time travel: the possibility of killing one's own grandfather, the coherence of backwards causation, the relativity of simultaneity, time travel within specific theories of

[2] Even instantaneous time travel isn't metaphysically simple. The split second that it takes a time traveller to disappear and reappear has a minute temporal spread. In order to be truly instantaneous, time travel would have to adjust for the split second it takes to disappear and reappear—a kind of temporal correction of the time traveller's journey.

time, and so on. These are important issues, but not easily tackled in one discussion. Now onto our focus: non-instantaneous time travel.

1. Time Travel and Spatial Location

1.1 Time Travel Takes Time

Consider time travel that *takes time*. This scenario is familiar from science fiction: the Doctor plots his world-saving plan while waiting for the TARDIS to deliver him to his destination; *Contact's* Ellie is subject to various physical hardships of time travel en route; *The Time Machine*'s protagonist struggles to keep hold of his watch as the time machine does its work; The Enterprise in *Star Trek* whisks its passengers between years; The Very Slow Time Machine's titular mechanism takes years to transport its passenger a short distance to the past.

Lewis (1976) famously characterizes time travel as involving a difference between personal time (roughly speaking, the time for the time traveller) and external time (roughly speaking, time on the "normal" forward-evolving timeline.) According to Lewis:

> "Inevitably, [time travel] involves a discrepancy between time and time. Any traveller departs and then arrives at his destination; the time elapsed from departure to arrival […] is the duration of the journey. But if he is a time traveller, the separation in time between departure and arrival does not equal the duration of his journey […] I reply by distinguishing time itself, external time as I shall also call it, from the personal time of a particular time traveller: roughly, that which is measured by his wristwatch. His journey takes an hour of his personal time, let us say." (Lewis 1976)

If time travel takes time, it takes personal time on the part of the time traveler to travel in external time on the "normal" timeline. More formally:

> (Time Travel Takes Time) Time travel takes time if there is a non-zero span of personal time *p*t such that the time traveller takes *p*t to travel *e*t, a non-zero span of external time.[3]

[3] Note that this differs slightly from Lewis' formulation, according to which time travel must involve a mismatch between personal and external time. One reason among others not to hold this definition is that

Let's call the Time Travel Takes Time principle 'TTTT'. Consider an example of TTTT at work. Stipulate that any travel through time—for example, ten years into the future or three hours into the past-- takes one year in personal time. Suppose that Bianca, our time traveller, travels from 2010 to 1920. We imagine her in her time machine for the year, sleeping, eating, and excitedly awaiting her arrival in 1920, much like a very long airplane flight.

But unlike an airplane flight, which occupies empty spatial regions at successive points in time, there is a more complicated question about the spatial location of the journey: *where* is Bianca spatially located for the one year in which she is travelling backwards through time? Presumably, Bianca is located wherever her time machine is located. Let us suppose that the time machine is located in Bianca's house in Phoenix, Arizona in 2010 at space s1 and that the time machine stays still for the duration of her journey to 1920. Then, for the year-long duration of Bianca's journey, the time machine is located in her house. To Bianca, time proceeds as normal. Bianca takes one year to travel 95 years—increasing time's rate of passage, for her, to one year per 95 years. If Bianca's time machine has a window, those located on the normal, forward-directed timeline peer into the window as Bianca is travelling backwards, witnessing her very slow and backwards-seeming movements.

1.2 Problem #1: Collisions with Past Things

The first problem with such a scenario is the possibility of collision with past things. For how can Bianca be sure that the spatial region containing her time machine remains empty as she moves through the past? To make this problem clearer, imagine that between 1980 and 1990, the spatial region filled by Bianca's house in 2010 was filled with a giant block of industrial concrete. If Bianca's time machine is spatially located in the same spot, space s1, for the duration of her time travel, she and her time machine will collide with the concrete when they reach 1990 on the timeline.

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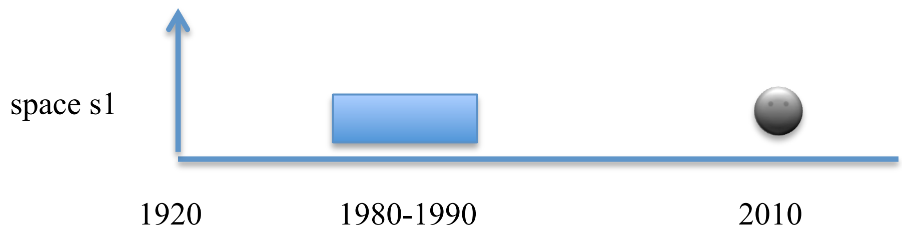
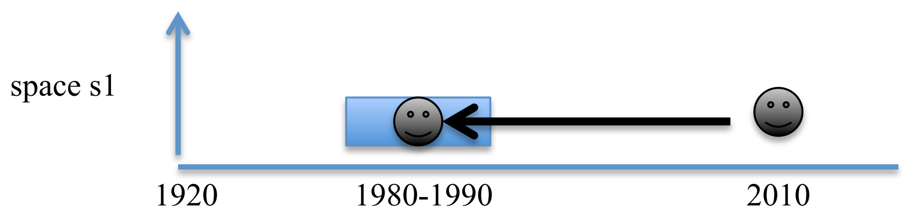
there can be a match between personal time and external time where there is still time travel—for example, when a time traveller takes one hour in personal time to travel one hour in external time into the past.

Pre time travel



Mid time travel



The smiley indicates Bianca's spatiotemporal location. If Bianca's house is filled with concrete from 1980-1990, then she will collide with the concrete on her way into the past. Bianca must be causally isolated from any influences that would interrupt her time travel or disturb her time machine.

Grey (1999), Dowe (2000), and Lepoidevin (2005) also point to the risk of *self*-collision. Imagine that Bianca's time machine is positioned at s1 beginning in 2009, waiting for Bianca's eventual departure to the past in 2010. Upon Bianca's departure, the time machine will immediately collide with itself in the past. (This danger is sometimes called *the double occupancy problem*). It is worth noting that the double occupancy problem is a more specific instance of the general problem of collisions with past obstacles, identical or nonidentical to the time machine itself.

Dowe (2000) suggests that the problem of double occupancy can be avoided by ensuring that the time machine gradually moves in space on its backwards journey so as to avoid itself in the past. But a past-travelling temponaut is always at risk of colliding with *any* objects or people that inhabited the space up to the presence of the time machine. In order to ensure the safety of the time traveller, an empty space must have been dedicated in the past. And the space set aside must be the exact space occupied by the time machine on its journey for the journey's duration. In the diagram above, for example, forward-thinking scientists must set aside the spatial location occupied by Bianca's time machine from 1920 to 2010, beginning in 1920. Only then can her time machine travel backwards in time without the risk of collision with past objects. Well-planned time travel into the past must be initially planned far in the past, with a suitable empty space that the time machine can occupy for the duration of the temporal journey. This makes it very unlikely that time travel to the distant past would be successful: planning for it must have begun generations before the invention and activation of the time machine.

1.2 Problem #2: Absolute Location versus Relative Location of the Time Machine

Distinguish between *absolute* location, fixed location indexed to the universe, and *relative* location, location indexed to the particular position on earth's surface. Paris' relative location remains the same, but its absolute location varies with earth's daily spin and the gradual expansion of the universe. The problem is this: if a time machine stays in the same absolute position for the duration of its journey, it will not land at its desired relative location. A time traveller who wishes to depart 2010 in Phoenix and arrive at that same spot in Phoenix cannot simply remain still in absolute space. Since the earth's absolute location is different in 1920 than in 2010, then the time traveller risks landing in deep space upon arrival, the earth long gone from its spatial position at her point of temporal departure. Even a temporal jump of a few minutes might relocate the time traveller hundreds of miles away given the rate of earth's movement.[4] A well-conceived time machine must calculate the desired relative location of the time traveler, and sync the position of the time machine to the desired earthy arrival point in absolute space. This is true of time travel to the future as well as to the past.

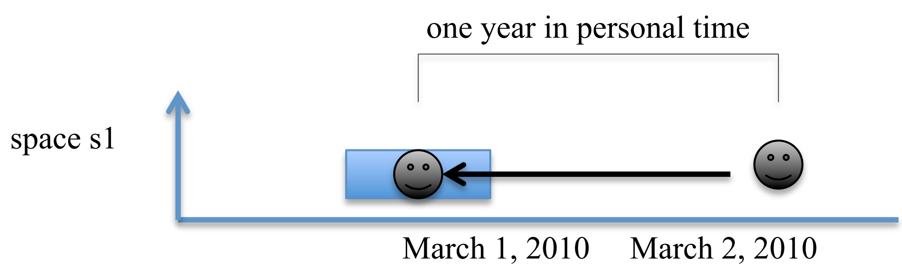
Time travel scenarios that do not include a machine or large device—for example, time travel in which a science fictional character "thinks" herself back in time as in Quantum Leap—must also abide by these recommendations. This planning is an extra

[4] The earth spins at approximately 1000 miles per hour.

burden on the time traveller. She cannot simply envisage the time and location that she wants to arrive and go there; she must calculate the exact absolute position at which her desired in-earth location will be positioned at the time of her arrival. Due to the earth's constant change in absolute location, time travellers must be very good planners. Aside from Timescape, in which scientists carefully project the location of the earth so that tachyons can be sent to the past to avoid ecological disaster, this point is largely ignored in science fiction.

1.3 Problem #3: The Spatial Extension of Personal Time

Assuming that time travel involves a split between personal time and external time, there is a scenario where duration of a journey in personal time outstrips a journey in external time. Suppose that any journey in time, no matter how short, takes one year. And imagine that Bianca seeks to travel back in time one day from March 2, 2010 to March 1, 2010. Then there is a question of where Bianca is located during her one-year journey, which far outstrips the one-hour span on the external timeline. Consider the following diagram:



Here, Bianca experiences one year of travel through time in order to arrive one hour earlier.

Whether this is a problem for time travellers depends on the exact nature of personal time. [5] If personal time is *real* time, then the time traveller's journey might

[5] There has been recent philosophical interest in how to characterize personal time beyond Lewis' original definition. Sider (2005) argues that Lewis' model of time travel *only* works if personal time is substantive. Demarest (2015) articulates two ways of conceiving of personal time—location on a spacetime worm, a clock attached to temporal stages of a time traveller—and argues that both fail to account for important

spatially outstrip space on the external timeline: an entire year-long journey must be spatially "stored" within one day. A time traveller risks running short on the spatiotemporal region needed for her journey. She must be located at s1 for an entire year, a temporal duration much greater than the the one day period on the external timeline.

On Lewis' deflationary picture, personal time is not "extra" metaphysically substantive time added to the universe. It is not, so to speak, a kind of time *itself*; it is distinguished only by being differently experienced by the time traveler. The deflationist insists that the time machine only seems to be moving very rapidly relative to the external timeline, but is not moving rapidly *simpliciter*. Bianca's journey is only an extreme mismatch between time experienced by the time traveller in the machine and time "as it actually is".

But there's something odd about personal time behaving differently than external time while remaining metaphysically indistinct. Imagine an even more exaggerated scenario in which travelling one minute into the past takes twenty years in personal time. Processes inside the time machine evolve for twenty years. There is a slow depletion of food supply, a disintegration of various tools, and a twenty-year aging of the items inside the time machine, all occurring in the space of one minute on the external timeline. The laws evolve in the time machine as if twenty years have passed rather than one minute. From a God's-eye view, the space occupied by the time machine during its journey behaves very differently than the space outside of it. Or consider a scenario in which the entire world is the time machine. Suppose that flipping a switch in Houston, Texas results in the relocation of everyone and everything in 2010 to the year 1920. It would be odd to call the time for the earth *mere* personal time—the external timeline would be moot.

A related question concerns what personal time "attaches" to when time travel occurs—how large the spatial region governed by personal time is. It's not *just* "time for the time traveller", as if only her body were aging and changing at a different rate than external time. All of the items in the time machine also age with the time traveller. And consider the question of what would happen if a time traveller were to stretch her hand out of a moving time machine: would her hand age with her backwards-moving body, or

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intuitions about personal identity. Tweedt (ms) argues for a deflationary conception of external time according to which it just is a kind of personal time.

with forward-evolving reality outside of the time machine?[6] If the arm continues to age with the backwards-moving body, the rules of personal time seem arbitrary, for there is no reason why being spatially connected to the time machine should count as being *within* the time machine and thus contained within its personal timeline. Even stranger is the question of what would happen if the time traveller poked her head out of the machine for a few minutes: would she be spared the rigors of aging several years in personal time?[7]

The deflationist picture has an important explanatory shortcoming: journeys of different personal temporal duration cannot be distinguished. Suppose that Bianca's journey takes one year in personal time to travel one day in external time, and David's journey takes twenty years in personal time to travel one day in external time. Intuitively, there is something more than each time traveller's experience in virtue of which these journeys are different. But on a deflationary conception of personal time, there is no distinction but the difference in the time travellers' respective experiences—a phenomenological, rather than ontological, difference.

These problems make room for a rival to the deflationist view of personal time. Suppose that personal time *is* substantive: an extra portion of time "attached" to the time traveler. Time does not simply feel different to the time traveller; it speeds up or slows down *simpliciter*. On this view, personal time is more like an extra kind of external time: an independent timeline against which the time traveller's journey can be measured.

Imagine that Bianca's time machine is located in s1 for one year in order to travel one hour into the past. The year must, in a sense, be "contained" in the space of the time machine, and proceeds at a very rapid pace relative to its surroundings. The spacetime region within the machine is denser than that outside of it, for there is an entire year proceeding in the time machine in the space of one hour in external time. For every second that ticks by on the external timeline, countless seconds occur in Bianca's time machine. If observers were to peer into the window of the time machine, they would see

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6 This question is subtly suggested by the time traveller's watch floating outside the time machine in the film version of H.G. Wells' *The Time Machine*.

7 One might be tempted to think that the time traveller would simply lose her arm or her head by doing something so silly, but if personal time really is time passing slower or faster for the time traveller, there is no reason such injury should occur: the outstretched hand or head should gently age with the external timeline.

Bianca's reality unfolding very rapidly, at a rate of 365 days to one day—the rate of passage of external time to personal time. Note that, from a God's-eye view, this scenario *looks* no different than the deflationist's conception of personal time, according to which observers also see a backwards-seeming, rapidly-evolving stream of events in Bianca's machine. The difference is that Bianca's reality is distinct, in an important sense, from her environs, whereas on the deflationist picture, the difference is illusory.

2.0 Models that Avoid Problems with TTTT

Aside from a meticulously planned journey that includes space set aside in the past, there are several metaphysical models of time travel that avoid the problems of self-collision and spatial collision. Here I describe two such models, the first of which shares some similarity with the immediately preceding discussion.

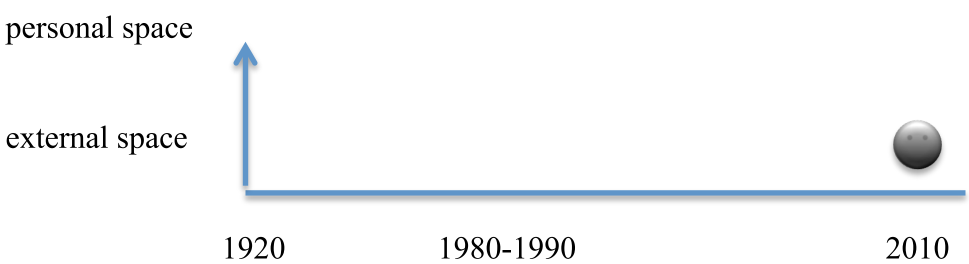
2.1 Solution #1: Personal Space and External Space

The first model involves a distinction between personal space and external space similar to Lewis' distinction between personal time and external time. It is not directly analogous in that Lewis' distinction doesn't posit "extra" time in addition to external time—no new temporal points are added to the universe when a time traveller initiates a journey. A personal space/ external space distinction, on the other hand, requires an extra dimension of space for the time traveller, like the picture according to which personal time is a substantive addition to reality.

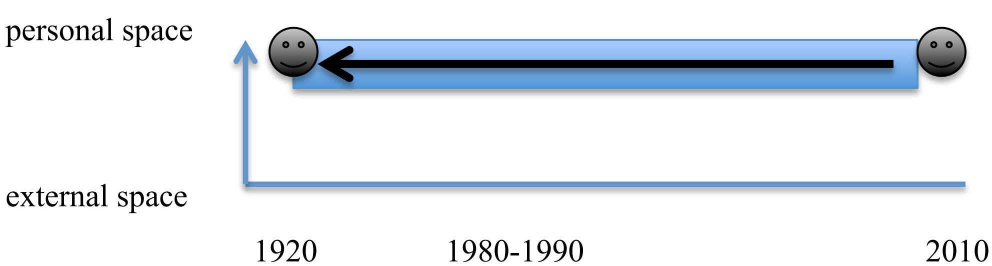
Here's how it works. Rather than spatial co-location with past objects and people in external space, we might instead stipulate that the time traveller occupies "personal space" distinct from the "external" space in the spatiotemporal manifold. With this distinction in hand, time travel would involve a discrepancy between personal space and external space.

Suppose that Bianca is spatially located at spot s1 in Phoenix, where she initiates past-directed time travel to 1920. She stays in s1 for the one-year duration of the time travel. Then the space occupied by her and her time machine *splits* from external space, like so:

<u>Pre time travel</u>



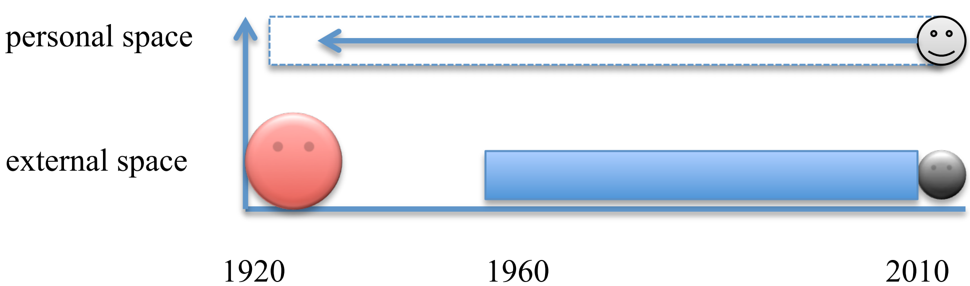
<u>Mid time travel</u>



When she arrives, she reappears back in external space.

Such a scenario results in a strange kind of spatial trilocation. External space contains both a continuant of the time traveller stretching from her birth to the moment of her departure, and another version of the time traveller after she arrives in the past. Personal space contains a time traveller located in personal space for the duration of the trip between 2010 and 1920. A diagram will help. Suppose that Bianca was born in 1960. In 2010, she takes one year in personal time to travel back to 1920:

<u>After time travel</u>



Here, Bianca's "normal", pre-time travel existence stretches from 1960 to 2010, as indicated by the rectangle. In 2010, Bianca begins her voyage to the past, placing her in personal space for one year, as indicated by the upper line. In 1920, Bianca arrives and is again located on the external timeline, as indicated by the larger smiley.

This model avoids the problem of self-collision, but at the cost of many more explanatory burdens. First, *where* is personal space is located? By definition, it can't be co-located with external space, or it would run into the above problems of co-location and collision. Second, we might wonder what the *mechanism* is by which space splits. If the mechanism is an extra ability of the time machine or time traveller, it would require science fictional superpowers like those on display in *Star Trek* or *X-Men*. Time travel would be doubly as strange, requiring power over space as well as time.

A personal/ external spatial split might also occur in virtue of a split between personal and external time, a consequence of a close metaphysical relationship between space and time. One tool that incorporates a close metaphysical relationship between space and time is *hyperspace*. Hyperspace implements personal space as an extra spatial dimension in addition to the three normal spatial dimensions. Personal space supports the model of personal space as shortening the temporal distance between two destinations: rather than taking 90 years to travel 90 years, it can take one year. Time travel via hyperspace appears in *Babylon 5*'s "jump engines", *Hitchhiker's Guide to the Galaxy*'s Vogon travel, and *Star Trek's* Warp Drive, among others.

A variant on hyperspace commonly seen in science fiction is the idea of a "bridge" or spatial area whose entry leads to time travel, including a black hole. *Stargate*'s titular device, the time machine in *Bill and Ted's Excellent Adventure*, and the device in *Contact* typify this model. Time travel bridges avoid problems with TTTT because time travellers are not co-located with past reality when they are time travelling. Similarly with Closed Timelike Curves ("CTCs"), roughly, large spacetime loops which curve back on themselves to deliver a time traveller to her destination. However, such "bridges" or CTCs introduce more questions than answers, including where they are located, whether they are naturally occurring or human-created, and whether time traveller can survive the journey through them.

Solution #2: Nowhere Man Time Travel

A second model incorporates TTTT while avoiding the three major problems for it. According to that model, time travel takes time but the time traveller is not spatially located for the duration of time travel at all. Call this the *Nowhere Man* model.

Suppose that travelling from 2010 to 1920 takes one year. Then for one year, Bianca is not spatially located whatsoever. She blinks out of existence in 2010, and blinks back into existence in 1920, like so:

This kind of time travel essentially kills and reanimates the time traveller, since she doesn't physically exist anywhere for the temporal duration of her journey. Her spatial parts are temporally discontinuous.

A natural way to think about this model is as a kind of "fax" of the time traveller to her temporal destination via time travel device. Suppose that a device scans all of the physical information of a person and arrange or rearrange matter according to the scanned specifications on the other temporal end.[8] In 2010, Bianca's physical information is scanned with maximal specificity, and she blinks out of existence once scanned. Supposing that it takes one year to transmit her information to the past, she reappears in 1920, rebuilt by the temporal fax machine. This scenario is famously depicted in *Star Trek*'s Transporter, which performs the faxing function with distant spatial, but not temporal, travel. The Nowhere Man model avoids the problem of collision with past objects because the time traveller isn't spatially located on her backwards journey. It avoids the problem of incorrect relocation in absolute space because the time traveller can be "rebuilt" at the desired point of arrival. And it avoids problems of spatial

[8] This model additionally opens the possibility of clones of time travellers based on physical scans.

outstripping and the risk of injury because the time traveller's journey consists in the transmission of information rather than transport of a human body.

A worry for the Nowhere Man model is the preservation of continuous personal identity of the time traveller. For the duration of the journey, there's no body with which the time traveller is identical. One might be tempted to identify the time traveller with the information about her as it is being transmitted across the universe—the data as it is being transmitted from 2010 to 1920.

But there are several reasons not to identify a person with her data. First, there is reluctance to do so in cases involving actual gaps in life, as in a case where the time traveller is killed and her consciousness takes 100 years to upload to hardware, after which she is alive again. And there are also examples in which the data entirely ceases to exist for 90 years and is reconstructed later, providing no intermittent physical grounds for identity of the person whose data is stored. Similarly, the "faxing" sort of time travel doesn't preserve a physical basis of identity for the duration of the journey. It avoids problems with spatial location at the cost of the time traveller's continuous existence throughout the journey.

4. Conclusion

Examples drawn from science fiction pose important questions about time travel and spatial location. If time travel takes time, time travellers face unique dangers and risks. They risk colliding with themselves and other objects in the past, relocating themselves to distant parts of the universe, and beginning a journey for which there is not enough external space or time. A substantive metaphysical distinction between personal space and external space avoids these problems, as does a model in which a time traveller is not spatially located for the duration of her travel. Metaphysics can pick up where science fiction leaves off, giving life to the ideas and models suggested by films and books. The details of these models have significance for theories of time and space more generally: a distinction between personal space and external space can be implemented in many theories of time, as can a substantive notion of personal time. Further investigation will yield new insights into time and space more generally.

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