Boltzmannian Immortality*

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ABSTRACT: Plausible assumptions from Cosmology and Statistical Mechanics entail that it is overwhelmingly likely that there will be exact duplicates of us in the distant future long after our deaths. Call such persons "Boltzmann duplicates," after the great pioneer of Statistical Mechanics. In this paper, I argue that if survival of death is possible at all, then we almost surely will survive our deaths because there almost surely will be Boltzmann duplicates of us in the distant future that stand in appropriate relations to us to guarantee our survival.

KEYWORDS: Personal Identity; Statistical Mechanics; Survival; Thermodynamics; Boltzmann Brains.

§1 Introduction

The future looks grim. We all will die: Our consciousness will fade, our memories vanish, our bodies disintegrate, and the particles that made up our bodies disperse into far-off corners of space. But what if at some point in the distant future there will be an exact duplicate of you just as you were shortly before your death with your brain and all life functions intact? This person will think about the same things you were thinking about, pursue the same goals, and perhaps even finish the article you were writing. In this paper, I will show that it follows from Statistical Mechanics and Cosmology that it is overwhelmingly likely that there will be such duplicates of us in the distant future long after our deaths. Moreover, I will argue that these duplicates are suitably related to us to plausibly guarantee our survival. In particular, I will show that if survival of death is possible at all, then *all of us will almost surely survive our death*. So there is good news after all.[1]

§2 Boltzmann Duplicates

Thermodynamics describes the behavior of macroscopic systems in terms of quantities such as heat, pressure, temperature, and, most importantly, entropy. Entropy corresponds to the amount of a system's energy that can be extracted for mechanical work and, very roughly, measures the

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1 There is a debate about how if the Everett (or Many Worlds) interpretation of Quantum Mechanics is true, we may have a certain kind of immortality (see Lewis 2000, 2004). My paper aims to show that a similar result follows from assumptions in Statistical Mechanics and Cosmology.

system's degree of disorder. The Second Law of Thermodynamics says that the entropy of a closed system never decreases and typically increases. It predicts for example, that a gas released into a box will disperse; that ice cubes at room temperature will melt; and that we will be older in the future.

The Second Law of Thermodynamics, however, is only a probabilistic law. Work by Ludwig Boltzmann (and others) in Statistical Mechanics, which aims to ground Thermodynamics in fundamental physics, shows that entropy decrease is not impossible but merely extremely unlikely (see, e.g., Albert 2000: chapter 3, and Loewer 2012: 122). So there is a non-zero chance for the entropy of a physical system to decrease. Statistical Mechanics accounts for why we never witness entropy-decreasing behavior because the probability that such behavior occurs within a time period that is small relative to a cosmic scale is extremely low (Callender 2011: 89).

However, a plausible cosmological assumption is that our universe is temporally infinite. Statistical Mechanics predicts that the entropy of our universe is extremely likely to keep increasing until it reaches a state of thermodynamic equilibrium, which has maximal entropy. But once it has reached equilibrium, there still is a non-zero chance that fluctuations from thermodynamic equilibrium into states of lower entropy will happen. In fact Poincare's recurrence theorem says that if our universe is appropriately bounded, then it is extremely likely to come arbitrarily close to every possible macrostate.[2] So it is extremely likely that over an infinite amount of time every possible fluctuation into states of lower entropy will happen, including fluctuations that lead to pianos, solitary brains ("Boltzmann brains"), fully-formed persons, and entire galaxies. It might take billions of years until any particular such fluctuation will occur, but it will almost certainly occur eventually.

This consequence might strike you as outlandish, but contemporary cosmologists take it very seriously. Here is what Sean Carroll writes:

> If we wait long enough, our universe will empty out until it looks like de Sitter space with a tiny temperature, and stay that way forever. There will be random fluctuations in the thermal radiation that lead to all sorts of unlikely events—including the spontaneous generation of galaxies, planets, and Boltzmann brains. The chance that any one such thing happens at any particular time is small, but we have an eternity to wait, so every allowed thing will happen. (Carroll 2010: 313)

It thus follows from Statistical Mechanics and plausible cosmological assumptions that there almost surely will be entropy-decreasing fluctuations that lead to exact duplicates of myself just as

2 See Albert 2000: 73–76 and Winsberg 2012: 396. We cannot be absolutely certain that all of the assumption of Poincare's theorem hold of our actual universe, in particular that the phase space of our universe is bounded. But we may get low-entropy fluctuations even if some of these assumptions fail. In particular, Dyson, Kleban and Susskind (2002) argue that even if the universe as a whole is not finitely bounded, we can treat our current region as if it is finitely bounded due to it being enclosed in a de Sitter horizon (see also Albrecht and Sorbo 2004; Carroll 2010: chapter 10; and Boddy, Carroll, and Pollack 2016).

I was shortly before my death.[3] Call these persons "Boltzmann duplicates" and circumstances where there is a Boltzmann duplicate of me after my death "Boltzmann duplication." It will be billions of years from now until such a duplicate has any significant chance of coming about, but it will almost surely come about eventually. The question then is whether the existence of future Boltzmann duplicates of me entails that I will survive my death.

§3 Boltzmann Duplicates and Survival

In this section, I will show that according to some influential versions of the psychological continuity view we survive our deaths in cases of Boltzmann duplication. This result is significant for two reasons. First, it shows that there are plausible accounts of survival according to which we would survive Boltzmann duplication and, hence, almost certainly survive our deaths. Second, I will show that the only accounts according to which we do not survive Boltzmann duplication are accounts according to which survival of death is impossible. So Boltzmann duplication shows that the physics is as kind to our survival as it possibly can be. If we still do not survive death, then it is only because the conceptual requirements on survival are so strict that survival of death is impossible even in principle. In other words, if survival of death is possible at all, then we survive our deaths in cases of Boltzmann duplication.

Most people find it natural that survival consists in the continuation of one's psychology in the future (see Nichols and Bruno 2010). This "psychological continuity view" can be motivated with cases like the following:

Transporter. "The Scanner here on Earth will destroy my brain and body, while recording the exact states of all of my cells. It will then transmit this information by radio. Travelling at the speed of light, the message will take three minutes to reach the Replicator on Mars. This will then create, out of new matter, a brain and body exactly like mine." (Parfit 1984: 178)

It is plausible that I would survive Transporter as the person who wakes up on Mars, even though my brain and my body will be destroyed. The psychological continuity view accounts for this judgment because the person who wakes up on Mars has a similar psychology as I (due to being an exact duplicate) and, moreover, her psychology is appropriately related to mine (due to the radio transmission). So the person on Mars continues my psychology in the future. In the following, I will argue that most versions of the psychological continuity theory predict that I survive my death

3 Cosmologists worry about the troubling epistemological implications of this fact. The worry is that there will be fluctuations that lead to exact duplicates of our brains ("Boltzmann brains") who have the exact same qualitative experiences as we have now. Moreover, there will be many more Boltzmann brains than regular observers. How then can I know that I am not a Boltzmann brain, in which case all of my memories and beliefs, including those that seem to confirm modern Cosmology, would be false? Cosmologists try to avoid this skeptical scenario, but none of the solutions would rule out these fluctuations entirely.

in at least some cases of Boltzmann duplication.

§3.1 Psychological Sequentialism

Different versions of the psychological continuity view disagree about when a person's future psychology is appropriately related to my current psychology to facilitate survival. The most permissive psychological continuity view is "psychological sequentialism." In Transporter, the Mars person's psychology causally depends on my current psychology because the transporter sends the information from my body scan to Mars where my body is replicated based on this information. However, according to psychological sequentialism, we would survive cases like Transporter even if there were no causal connection and the psychological similarity were merely a coincidence (see Campbell 2008, Elliot 1991, and Kolak and Martin 1987). Campbell describes this view as follows:

> [S]trictly speaking, a causal connection is not a part of what matters in survival. The only acceptable ''substitute'' for it, though, is an incredible coincidence which results in exactly the same situation occurring as the appropriate causal connection would have produced. Such a coincidence is, of course, almost impossibly rare (and, practically speaking, would never occur), but that does not make it true that a causal connection is necessary. (Campbell 2008: 393)

So even if the person on Mars had been randomly generated (without using the information from my body scan) and merely happened to have the same psychology as I, I would still survive as the person who awakes on Mars (Campbell 2008: 381–383). In absence of any causal connection this psychological match, of course, would be an incredible coincidence.

Psychological sequentialism entails that Boltzmann duplication guarantees survival. Boltzmann duplicates are psychologically perfectly similar to me. They have the same beliefs, desires, and behavioral dispositions as I had before my death. So if this similarity is all that matters for survival, their existence guarantees my survival. Boltzmann duplicates exemplify the rare coincidences that Campbell is talking about in the above quote, though he is wrong that they "practically speaking" would never occur. Over an infinite amount of time incredible coincidences do happen. So there is at least one theory of survival according to which we would straightforwardly survive as our Boltzmann duplicates.

§3.2 The Widest Causal View

Most psychological continuity views, however, are causal theories that require that my future psychology causally depends on my current psychology. In what follows, I will show that we still would survive Boltzmann duplication according to those causal theories that allow for the survival of death at least in principle.

The most permissive causal view of survival is the "widest causal view" (see Parfit 1984: 283–287). It says that any kind of causal relation between my current self and my future self is

appropriate to secure psychological continuity. It might seem as if there is no causal relation between my current psychology and the psychology of any of my Boltzmann duplicates. After all, these duplicates arise from fluctuations out of thermodynamic equilibrium billions of years after my death. By this time all macroscopic traces of my current psychology will be long gone, including my brain, the brains of anybody remembering me, or any scans of my brain. But I will argue that my current psychology nonetheless very likely causes the psychology of at least some of my Boltzmann duplicates.

A widely accepted sufficient condition for causation is counterfactual dependence such that for two distinct occurring events C and E, C is a cause of E if: If C had not occurred, then E would not have occurred (Hall 2005; Lewis 1986a: 563). So to show that my psychology causes the psychology of one of my Boltzmann duplicates, it is enough to show that for sufficiently many pairs of mental states Mn and Mn*, where Mn is a mental state of mine and Mn* a corresponding mental state of my duplicate, the following counterfactuals are true: If my mental state M1 had not occurred, then mental state M1* of my Boltzmann duplicate would not have occurred; and if my mental state M2 had not occurred, then mental state M2* of my Boltzmann duplicate would not have occurred; and so on for sufficiently many pairs of mental states. For example, it needs to be the case that if I had not seen a white light just prior to my death, then my future Boltzmann duplicate would not have remembered seeing such a light.[4]

Some stage setting will be needed to show that sufficiently many of these counterfactuals are indeed true for at least some of my Boltzmann duplicates. I am making three background assumptions. First, I am adopting a standard recipe for determining the truth values of counterfactuals that goes back to Maudlin (2007: 21–34) and has been adapted for the needs of counterfactual accounts of causation by Paul and Hall (2013). According to this recipe, we determine the truth value of "if C had not occurred, then E would not have occurred" as follows:

> [C]onstruct a counterfactual state of the world at time t as much like the actual state at time t as possible, save for the fact that C does not occur. Think of taking the actual time-t state of the world, and ringing carefully localized changes on it just sufficient to make it the case that C does not occur. […] We then evolve the resulting state forward in time, in accordance with the actual laws of nature. If the resulting history yields E, the conditional is false; otherwise it is true. (Paul and Hall 2013: 47–48)

This recipe provides a way of determining whether a mental state M* of my Boltzmann duplicate counterfactually depends on my mental state M: Take the entire state of the world at the time of M and make localized changes such that M no longer occurs.[5] Then evolve the resulting state of the world forward in time in accordance with the laws of nature. If M* does not occur in the resulting history, then M* counterfactually depends on M.

Second, I am assuming that all mental events, including my and my Boltzmann duplicate's

4 There are issues about how to characterize memories without already presupposing facts about personal identity. See Parfit (1984) for discussion.

5 As Paul and Hall (2013: 51–53) point out, there is a further question of what exactly replaces events such as M when we make these changes. How this issue is resolved will not matter for my argument.

mental states, supervene on physical events. This supervenience entails that if we take the current state of the world and make localized changes such that some mental state M does not occur, the resulting state will be a different *physical* state than the original state. The supervenience of the mental on the physical is widely accepted.

Third, I will assume that the fundamental dynamical laws of physics are deterministic in both temporal directions. If the physical laws are deterministic in this sense, then the complete physical state of the world at any one time fixes a unique future and a unique past. So any world that differs from the actual world with respect to its physical state at any one time also differs from it at any other time. Many of our best past and present candidates for the fundamental dynamical laws of physics are deterministic in this sense.[6]

These three assumptions entail that my current mental states prior to my death cause events in the distant future at the time when my Boltzmann duplicate forms. If mental-physical supervenience holds, then a state of the world that is as much like the actual current state as possible, save for the fact that some mental state of mine does not occur, is physically different. If determinism is true, then evolving this different physical state forward in accordance with the laws of nature also yields a different physical state of the world billions of years later at the time when my Boltzmann duplicate forms. Because this physical state is different from the actual physical state at the time, it does not contain certain events that actually occur. Hence, in accordance with the above recipe for evaluating counterfactuals, these actual events counterfactually depend on my current mental state. This argument shows that my current mental states cause events at the time of my Boltzmann duplicate, though it does not say which events.

It then remains to be shown that my current mental states cause the right events at the time of my Boltzmann duplicate. Specifically, sufficiently many of my current mental states have to cause the corresponding mental states of my Boltzmann duplicate. I will show that this likely is the case for at least some of my Boltzmann duplicates. Establishing this point requires some background about the physics of entropy-decreasing fluctuations. Boltzmann duplicates come into existence due to fluctuations from a state of thermodynamic equilibrium into a state of lower entropy that contains a fully formed person who is an exact duplicate of me. Consider a particular Boltzmann duplicate and the earlier microstate of thermodynamic equilibrium that leads to it via an entropy-decreasing fluctuation. Call this earlier microstate "S." Boltzmannian Statistical Mechanics entails that S is an extremely atypical microstate. We can represent all possible microstates that are consistent with thermodynamic equilibrium as a region in an abstract space called "phase space" and put a natural measure over this region. According to this natural measure, the overwhelming majority of microstates in this region evolve into states in their immediate future that also are in thermodynamic equilibrium. Only a tiny proportion of microstates fluctuate into a

6 My argument could be adapted for the case that the laws are indeterministic, but things would be more complicated. If the laws are indeterministic, it still is plausible that a different present state of the world would entail a different probability distribution over its state at all future times. But one would then need a recipe for evaluating counterfactuals given indeterminism (see Maudlin 2007: 30–31 for discussion).

state of lower entropy in their immediate future, and only an even smaller proportion lead to an exact duplicate of me. So S is a highly atypical microstate because the overwhelming majority of macroscopically indistinguishable microstates do not fluctuate into a state of lower entropy in their immediate future. Moreover, the overall majority of microstates in phase space that are in the immediate vicinity of S also do not fluctuate into states of lower entropy in their immediate future. The property of leading to a state of lower entropy in the immediate future thus is extremely sensitive against small perturbations (cf. Albert 2000: 151 who uses the same observation for a different purpose).

It follows that any difference to S almost certainly would have made it that my Boltzmann duplicate would not have formed. The number of microstates that lead to a Boltzmann duplicate in their immediate future is vanishingly small, both compared to the entirety of possible equilibrium microstates and compared to the states in S's immediate vicinity in phase space. So a physical state that differs from S in even the smallest respect almost certainly would be a microstate that would *not* fluctuate into a lower-entropy state that contains a perfect duplicate of me in its immediate future.

I have shown above that each one of my mental states causes at least a tiny difference to the physical state of the world at any future time; hence, it also causes at least a tiny physical difference in S. And I have just shown that any tiny difference in S is likely to make it that it no longer leads to a Boltzmann duplicate of me in its immediate future. But if my duplicate had not formed in the first place, then none of its mental states would have occurred. Hence, it is very likely that if any one of my current mental states had not occurred, then none of the mental states of my Boltzmann duplicate would have occurred. So each one of my current mental states likely is a cause of all of the mental states of my Boltzmann duplicate.

My argument is probabilistic: for any Boltzmann duplicate of me it is very likely that each one of my current mental states causes every mental state of this Boltzmann duplicate. Of course, it might turn out that for a particular duplicate none of my mental states are among the causes of its mental states, or that some but not all are. But given the numerous Boltzmann duplicates of me that will almost surely occur in the future, it is extremely likely that at least some of these duplicates are such that each one of my current mental states causes all of their mental states. In fact, if time is infinite (as I am assuming), then all my argument requires is that there is a non-zero chance for such a Boltzmann duplicate to form. Over an infinite amount of time there then almost surely will be at least one actual such duplicate.

Boltzmann duplication then guarantees my survival according to the widest causal version of the psychological continuity view as long as there is at least one such duplicate, which is extremely likely. Since each of my current mental states causes all of the mental states of this duplicate, it is, a fortiori, true that each of my mental states causes the corresponding mental state of my duplicate. For example, my experience of seeing a white light just prior to my death causes a corresponding memory in my Boltzmann duplicate.

One might object that the argument equally shows that every other present event almost certainly causes all of the mental states of at least one of my Boltzmann duplicates. For example,

if the cup on my desk were positioned differently, then the physical state of the world at the time shortly before some Boltzmann duplicate of me forms also would have been different. And this difference probably would have made it that the duplicate would not have formed in the first place.

This consequence of my argument, however, is not an objection. We know from the literature on causation that events have vastly more causes than we ordinarily think or would mention in an explanation (Lewis 1986b: 214–216). And this is especially true for very sensitive outcomes, such as the formation of my Boltzmann duplicates, whose occurrence depends on a conspiracy between numerous different factors. The widest causal view only requires that my current psychology is a cause of my Boltzmann duplicate's psychology. And my argument shows that this is almost certainly the case for at least some duplicates, regardless of what other causes these duplicates' mental states may have in addition.

§3.3 The Wide Causal View

A more restrictive psychological continuity view of survival is the "wide causal view" (cf. Parfit 1984: 207). It says that not just any causal relations can facilitate survival but only causal relations that meet certain formal constraints. There is no agreement on what these constraints are. But a standard proposal is that causal relations need to be *reliable* and *law-like* in order to facilitate survival. In this section, I will argue that Boltzmann duplication conforms to a plausible interpretation of these constraints that captures the main motivation behind the wide causal view.

It may initially seem as if the causal relations in Boltzmann duplication are not reliable and law-like in the required sense. It is natural to understand the idea that causal relations are reliable in terms of the counterfactual insensitivity of the corresponding causal claims. Following Woodward (2006: 2), a "causal claim is insensitive to the extent to which it would continue to hold under various sorts of changes in the actual circumstances." So my current mental state M causes a mental state M* of my Boltzmann duplicate reliably, just in case the claim "M causes M*" would continue to hold under various sorts of changes in the actual circumstances. By contrast, a causal relation is unreliable if the corresponding causal claim "holds in the actual circumstances but would not continue to hold in circumstances that depart in various ways from the actual circumstances." (Woodward 2006: 2)

Law-likeness can be understood as the requirement that a causal relation between two token events needs to be part of a law-like causal pattern at the type level. If there is a law-like relation between my mental states and my Boltzmann duplicate's mental states, then it is not just the case that my actual mental states cause corresponding mental states of my duplicate. It also needs to be the case that if my mental states were different, my different mental states would cause correspondingly different mental states of my duplicate. For example, if I had memories of growing up in China, then these memories would cause my future duplicate to also have memories of growing up in China. Reliability and law-likeness are different properties. A causal relation between two token events might be reliable without it being the case that other tokens of the first type also would cause tokens of the second type.

The causal relations in Boltzmann duplication are not reliable and law-like in the above sense. Fluctuations from equilibrium that create Boltzmann duplicates are extremely sensitive against small changes in current circumstances. So if the present circumstances had been even slightly different, any particular fluctuation almost certainly would not have happened. In such circumstances none of my actual duplicates would have formed and, hence, none of their mental states would have occurred. Hence, causal claims such as "my current mental state M causes mental state M* of my duplicate" would have been false in these circumstances. Moreover, if my current mental states had been different (say, if my memories had been different), then the fluctuations that create my actual duplicates almost certainly also would not have happened. My different mental states would then not have caused correspondingly different mental states in my duplicate because my duplicate would likely not have existed. So it might seem as if I do not survive Boltzmann duplication according to the wide causal view of psychological continuity. This conclusion, however, would be premature.

I will argue that there is an important sense in which the causal mechanism in Boltzmann duplication *is* reliable and law-like and that this sense suffices for Boltzmann duplication to accord with the main motivation behind the wide causal view. The following analogy will motivate this point. Consider a transportation device similar to the one described in Transporter. This device scans your body, destroys it, and radio-transmits information about your body to a different place where an exact replica is created. The modified transportation device, however, is peculiar in that where and when your duplicate will be created depends on your exact mental states and the exact circumstances at the time when you enter the device. For example, given your actual mental states and circumstances, the device will create a duplicate of you on Mars five minutes after the scan. But if your mental states or the circumstances had been even slightly different (say, if the air pressure had been a bit higher or your memories had been slightly different), the device would have sent the information from your scan to a different place (such as Venus) where a replica of you would have been created at a different time.

In this modified transporter scenario your actual mental states cause the corresponding mental states of your duplicate on Mars. These causal relations, however, are not reliable and law-like in the above sense. They are not reliable in the above sense because if you had entered the device in different circumstances, then your Mars duplicate would not have existed, and so your mental states would not have caused any of your duplicate's mental states. And the causal relations are not law-like in the above sense because if you had entered the transporter with different mental states, then there also would not have been a duplicate of you on Mars. Your mental states, thus, would not have caused correspondingly different mental states in your duplicate on Mars.

Nonetheless there is a sense in which the causal mechanism in the modified transporter case is reliable and law-like. If circumstances had been different, then your mental states would not have caused the future mental state tokens that they actually cause. However, the device then would have created a different duplicate at a different place and time, and your mental states would have caused mental state tokens of the *same types* in this duplicate. Hence, while your mental states do not reliably cause the mental state tokens that they actually cause, they reliable cause tokens of the

relevant types. Similarly, if your mental states had been different, these different mental states would have caused correspondingly different mental state tokens in some duplicate of you somewhere in the future. For example, if you had entered the transporter with different memories (say of growing up in China), then no duplicate of you with these memories would have formed on Mars; but your different memories then would have caused corresponding memories in a duplicate that would have formed somewhere else. So, there is a reliable and law-like causal mechanism in virtue of which your current mental states cause future mental states of a particular type.

Proponents of the wide causal view should say that because of this reliable and law-like causal mechanism, you survive entering the transportation device. The main motivation of the wide causal view is that it should not be an accident that your current psychology causes the continuation of your psychology in the future (see McKinnon and Bigelow 2001: 474; Parfit 1984: 286–287). The modified transportation case satisfies this requirement. The operative causal mechanism makes it entirely non-accidental that your current mental states cause future mental state tokens that are of the right type to continue your psychology. Your current psychology, hence, is guaranteed to cause its continuation in the future. It is accidental when and where your psychology will continue. But it is hard to see why this contingency should matter to your survival. For example, we can imagine that even in the original transportation case, where the scan of your body is always sent to Mars, it may be accidental when the scientists on Mars will get around to reproducing your body and where they will do so (for example, in which of several clinics). This contingency does not seem like a good reason for thinking that we would not survive the transport.

I will argue that we survive Boltzmann duplication according to the wide causal view because it involves the same kind of reliable and law-like causal mechanism as the modified transportation case. Your current mental states cause the future mental states of at least some of your Boltzmann duplicates. If current circumstances had been different, then almost certainly none of your actual future duplicates would have formed. So your mental states would not have caused the same future token mental states. However, my argument in §3.2 shows that in such counterfactual circumstances other fluctuations almost certainly would have created different duplicates of you (at different places and times), and your current mental states almost certainly would have caused the token mental states of at least some of these duplicates. Consequently, if current circumstances had been different, your mental states still would have caused future mental state tokens of the same types as they actually cause. Similarly, if (for example) your memories had been different, the fluctuations in these counterfactual circumstances also almost certainly would have led to the formation of other duplicates of you (at different places and times). Your memories then almost certainly would have caused corresponding memories in at least one of these duplicates. So we find the same kind of reliable and law-like causal mechanism in Boltzmann duplication as in the transportation case. In particular, your mental states causally guarantee that your psychology continues in the future by causing, across a wide range of counterfactual circumstances, future mental state tokens of the right types to continue your psychology. This causal mechanism then guarantees your survival according to the wide causal view.

A worry about this argument is that in Boltzmann duplication the fact that you have some

psychological duplicate in the future (somewhere, sometime) does not counterfactually depend on your current mental states. If your current mental states had not occurred, then the particular future duplicates (and their token mental states) that your current mental states cause would not have occurred. However, chance fluctuations in these counterfactual circumstances almost certainly would have created other duplicates with the same types of mental states, and so your psychology still would have continued. One then might take this lack of counterfactual dependence to shows that your current mental states are not causally responsible for the continuation of your psychology in the future. How then can Boltzmann duplication constitute survival according to the wide causal view?

In reply, I argue that survival according to the wide causal view does not require that the type-level fact that you have some psychological duplicate (somewhere, sometime) counterfactually depends on your current mental sates. Boltzmann duplication is a case of survival according to the wide causal view because of a reliable and law-like causal mechanism at the token-level. Your current mental states cause the token mental states of at least some of your future Boltzmann duplicates; and if circumstances had been different, your mental states still would have caused corresponding token mental states in at least some of your Boltzmann duplicates in these counterfactual circumstances. Due to these token-level causal relations, your current mental states causally guarantee that there will be token mental states in the future that are of the right types to continue your psychology. The existence of these causal relations is fully compatible with the fact that in the absence of your mental states, other processes (in the form of fluctuations) still would have caused other psychological duplicates of you. So the continuation of your psychology in the future does not counterfactually depend on your current mental states. But this fact is irrelevant for the existence of a reliable and law-like causal mechanism at the token-level, and so it is irrelevant for your survival according to the wide causal view.

An analogy with the transportation case will illustrate this irrelevance of counterfactual dependence at the type-level for survival. Imagine a transportation device where entering the transporter causes the creation of a duplicate of you in the future. As before, it is part of how the transporter works that where and when it will create this duplicate depends on the exact circumstances at the time when you enter the device. I have argued above that according to the wide causal view we would survive entering this transporter. But now suppose further that, in addition to the duplicate created by the transporter, another duplicate of you will be created in the distant future regardless of whether you enter the transporter. The creation of this duplicate is a mere coincidence and does not causally depend on your entering the transporter or even the existence of your current mental states. With this modification added, entering the device still causes a duplicate of you somewhere in the future regardless of your exact circumstances and exact mental states. But it is now the case that if none of your current mental states had occurred, there still would have been a duplicate of you in the future because the coincidental duplicate still would have existed. So the case is analogous to Boltzmann duplication in that the type-level fact that you have some psychological duplicate in the future (somewhere, sometime) does not counterfactually depend on your current mental states.

The presence of this additional duplicate, however, does not matter for survival according to the wide causal view. All that matters for survival is the reliability and law-likeness of the causal mechanism that sends your psychology into the future. The existence of the additional duplicate does not affect this causal mechanism. Entering the transportation device still causally guarantees that there will be mental state tokens in the future that continue your psychology by causing the creation of a future duplicate of you. And it does so regardless of whether some other future duplicate of you would still have existed if your mental states had not occurred. It, therefore, is irrelevant to survival according to the wide causal view whether the fact that you have some duplicate (somewhere, sometime) in the future counterfactually depends on your current mental states. Boltzmann duplication then also constitutes survival according to the wide causal view because it is exactly analogous to this version of the transportation case.

§3.4 Impossible Criteria

I have shown that Boltzmann duplication guarantees survival according to several versions of the psychological continuity view. However, there is one last version according to which Boltzmann duplication would not be a case of survival. This version holds that survival requires the same kinds of causal relations that are present in ordinary cases of survival. Peter Unger characterizes this "narrow causal view" as follows:

> [F]or a person to survive, some of her psychology, her core psychology, must be carried forward in ways that are, on the whole, not terribly different from the ways that psychological continuity is achieved in ordinary cases. (Unger 1990: 70)

This view, for example, predicts that Transportation is not a case of survival because the radio-transmission that sends our psychology to Mars is unlike the causal processes involved in ordinary cases of survival.

According to the narrow causal view, Boltzmann duplication would not be a case of survival. The causal relations that connect our current psychological states to those of our Boltzmann duplicates in the future are certainly different from the causal relations involved in ordinary survival. Ordinary survival minimally involves the continued existence of one's brain, but your brain will be long decayed by the time a Boltzmann duplicate of you might form.

That Boltzmann duplication would not guarantee survival according to the narrow causal view, however, does not diminish its relevance for the question of whether we will survive our deaths. Death, according to a standard definition, involves the irreversible cessation of the functioning of the entire brain. So death, unsurprisingly, prevents the causal processes involved in ordinary survival. The narrow causal view, since it says that survival requires the same causal processes involved in ordinary cases of survival, thus entails that surviving death is conceptually impossible. Hence, it then comes as little surprise that Boltzmann duplication would not be a case of surviving death. Nothing is.

Boltzmann duplication is interesting because it entails that we almost certainly will survive our deaths according to plausible theories that do allow the survival of death. Survival of death, if

possible, thus is not a distant or outlandish possibility. On the contrary, Boltzmann duplication shows that all the physical facts that our survival would require are actually in place. The physical facts are such that if survival of death is conceptually possible, then it almost certainly is actual. If we still do not survive death, then only because it is a conceptual impossibility. I will address possible objections to my argument in the next section.

§4 Objections and Replies

§4.1 Biological Criteria

So far I have only considered psychological continuity theories of survival. The first objection consists in denying that psychological continuity of any form suffices for survival. In particular, defenders of biological criteria argue that a person survives just in case the biological organism that constitutes her persists (see, e.g., Olson 2007). The objection then is that according to this biological approach Boltzmann duplication would not constitute survival because it would not secure the continued existence of my biological organism.

My reply is that the dialectic does not change significantly if we shift to a biological approach. After all, my Boltzmann duplicate also is biologically indistinguishable from me, save for its causal history. The question is then what kinds of relations can facilitate that I survive as a biologically similar self in the future. Either, we hold a "narrow biological view" that says that only the kinds of causal relations involved in ordinary cases of survival can carry a biological organism toward the future. In that case, survival of death is conceptually impossible just like on the narrow psychological view. Or, we allow that mere sequence, any causal relations, or reliable and law-like causal relations can also facilitate the persistence of my biological organism. In this case, it is plausible that Boltzmann duplication would constitute survival even according to the biological approach. My Boltzmann duplicate has all of the same biological functions as me. Moreover, the above arguments, *mutatis mutandis*, would show that my current biological features stand in the appropriate relations to the biological features of my Boltzmann duplicates.

§4.2 Externalism

The second objection says that I do not survive Boltzmann duplication because the duplicate would not have my psychology. Externalists about mental content argue that the content of mental states, such as beliefs and memories, is (partly) grounded in their causal history. For example, my memory of visiting Paris is only about Paris if it stands in an appropriate causal relation to the city. The objection then is that the mental states of my Boltzmann duplicate would lack the right causal history and so would not be about the same things as my mental states. My mental states have arisen from interactions with cities and people; my duplicate's mental states have arisen from crawling out of equilibrium soup. Hence, my duplicate does not have the same psychology as I.

I have two replies: First, many philosophers recently have argued that at least some aspect

of content does supervene on the intrinsic features of an agent regardless of causal history (see Lau and Deutsch 2014, section 3). In this case, my Boltzmann duplicate would be psychologically similar to me even if his mental states lack a suitable causal history. Second, even if externalism is true, it is plausible that my duplicate inherits the externalist content of my mental states, at least in cases where her mental states are caused by my psychology. As an analogy, suppose an Egyptian slave carves "Ramses oppressor" into a clay vase. Through a long-winded and improbable causal history, I find the vase thousands of years later and form the belief that Ramses was an oppressor. It seems that my belief would be about the same person as the slave's belief although the causal link is very weak. Similarly, my duplicate's mental states plausibly are about the same things as my mental states merely due to having been caused by my mental states.

§4.3 Fission

A third objection is that there could be multiple Boltzmann duplicate of me at the same time. This fact gives rise to what the literature calls "fission," where more than one person is psychologically continuous with me. Fission raises the worry that psychological continuity may not suffice for survival. After all, it would be arbitrary to say that in a case of fission you are identical to one of your successors but not the others, yet it also seems that you cannot be identical to more than one person at once.

My response is that I can use any one of the moves that defenders of psychological continuity theories make in response to fission cases. My preferred response is that identity is not necessary for survival. In cases where two Boltzmann duplicates at the same time are psychologically continuous with me, I survive as both people, though I am not identical to either. The existence of these duplicates nonetheless constitutes my survival because each person is a fitting object for my selfish concerns (Parfit 1984). Alternatively, one can consistently describe fission cases as involving multiple persons even before the fission, and hence maintain that survival requires identity, by adopting an ontology of temporal parts (Lewis 1976).

§5 Conclusion

I have argued that if survival of death is possible at all, then we almost surely will survive death because we almost surely have Boltzmann duplicates in our future. As a consequence, our lives will carry on infinitely because there will always be another duplicate in the future that will continue your thoughts and carry on your life projects. What then is the catch? Apart from the fact that living forever might have disadvantages of its own, most Boltzmann duplicates will be lonely creatures floating in empty space (as these are the most minimal entropy-decreasing fluctuations) who will soon suffer whatever ill fate awaits humans in a vacuum. Some duplicates, however, will have fully-formed galaxies around them and live for much longer. And even short-lived duplicates ultimately survive because there almost surely will be another suitable Boltzmann duplicate of them in the future.

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