

# How to Know That Time Travel is Unlikely without Knowing Why

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Abstract: What's the point of time travel? Not to change the past; no matter how carefully a time traveler plans, no matter what extremes she goes to, and no matter how many times she tries, all of her attempts to change the past end in failure. Paul Horwich (1987) has argued that the implausibility of such failures gives us reason to doubt that there will be frequent time travel to the local past. I defend a modified version of Horwich's argument from criticisms endorsed by various writers and conclude that we are all in the very strange position of being able to gain evidence about the chance of there being frequent time travel in the future without having any information that explains why that chance value obtains. Typical relationships between chance, explanation, and prediction break down when we reason about cases involving time travel, and strange evidential relationships emerge in their place; facts about the psychologies of potential time travelers can serve as evidence that time travel is unlikely.

Keywords: Time Travel, Chance, Metaphysics

## 1. Introduction

I admire Paul Horwich's *Asymmetries in Time* and I wish I had published it. As it happens, I have a working time machine and no moral compass, and so I travel back to 1986 with the intention of scooping Horwich. I bring along my copy of *Asymmetries in Time*, duplicate it with a typewriter upon my arrival, and set about trying to publish the

duplicate under my name. Despite my good planning and bad intentions, Horwich has nothing to worry about. Because it is true that Horwich published *Asymmetries in Time* in 1987, it is not true that I prevented Horwich from publishing *Asymmetries in Time* by scooping him in 1986. Not even time machines make contradictions true.

Some (e.g., Asimov 2003) have wondered whether cases like this one, in which a time traveler attempts to change the past, show that time travel to the local past is impossible. On the one hand, if time travel is possible then I can, for instance, prevent Horwich from publishing *Asymmetries in Time* by scooping him in 1986; it will not be hard to get such an excellent and as of yet unpublished manuscript into print. On the other hand, if time travel is possible then I cannot prevent Horwich from publishing *Asymmetries in Time*; it is true that Horwich published *Asymmetries in Time* in 1987 and so my attempt to scoop him cannot succeed on pain of contradiction. It seems that the supposition that time travel is possible has led to the absurdity that I both can and cannot prevent Horwich from publishing *Asymmetries in Time*.

But modal terms are easy to equivocate. David Lewis argues that “to say that something can happen means that its happening is compossible with certain facts,” and senses of ‘can’ vary with which set of facts context determines. (Lewis 1976, p. 149) On Lewis’s view, I can prevent Horwich from publishing *Asymmetries in Time* relative to, e.g., my means and motives, but I cannot prevent Horwich from publishing *Asymmetries in Time* relative to, e.g., the fact that Horwich publishes *Asymmetries in Time*. Since there is no univocal reading of ‘can’ on which the possibility of time travel implies that I both can and cannot succeed, the supposition that time travel is possible does not, after all, imply an absurdity.

Still, it is hard to shake the feeling that there is something strange going on in stories about time travelers who attempt to change the past. No matter how many times I try, I will not scoop Horwich. What stops me? I send one duplicate of *Asymmetries in Time* to a publisher but it gets lost in the mail. I send a second duplicate just to be safe but the publisher misplaces it. On the way to deliver a third duplicate by hand, I slip on a banana peel while crossing the street. And so on. We know that submitting a manuscript for publication is an easy process that is unlikely to fail, so it is puzzling that I am having so much trouble. It is unlikely for manuscripts to be misplaced, for mail to be lost, and for people to slip on banana peels, but unlikely events such as these (and more, if I continue with my scooping attempts) occur if I travel back to 1986 and attempt to scoop Horwich. Generalizing on this line of thought, Horwich (1987) argues that we should not expect there to be many time travelers who repeatedly attempt to change the local past. Given the empirical claim that it is not particularly unlikely that people will attempt to change the past if they have access to time travel, people will at most rarely travel to their local past.<sup>1</sup>

This rarity calls for explanation. Why will people at most rarely travel to their local past? We ought not answer that a series of unlikely failures (e.g., time travelers tripping on the way to their time machines) just happens to prevent such travel, for we gain nothing by replacing one objectionably unlikely story with another. Instead,

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<sup>1</sup> Several authors (e.g., Meiland 1974, Goddu 2003, Van Inwagen 2009) have offered multi-dimensional models of time travel according to which, each argues, it is possible to change the past. If these authors are correct, Horwich's conclusion is only that a certain sort of time travel will be rare: travel along a single temporal dimension. For ease of discussion, I use "time travel" to refer exclusively to travel along a single temporal dimension—nothing that follows is meant to apply to time travel across more than one temporal dimension.

Horwich concludes that there is some physical fact that prevents time travel (where “to prevent” is to make at least unlikely). Perhaps, for example, the structure of space-time does not allow for travel to the local past, or the fuel costs associated with frequent time travel to the local past are prohibitively steep, or time machines are too complicated for intellects like ours to invent. Horwich’s argument does not tip us off as to what feature of our world prevents time travel, but it gives us a (defeasible) reason to think that our world has such a feature.<sup>2</sup>

If Horwich’s reasoning is correct, we can acquire evidence about whether anything in our world prevents time travel to the local past by investigating whether time travelers would try to change the past by performing tasks that are likely to succeed. That’s a surprising and philosophically interesting result; one might have thought that, say, facts about my psychological proclivity toward scooping prominent philosophers if given access to time travel and facts about the efficiency of the U.S. Postal Service combine to tell us nothing whatsoever about the probability of my traveling to the local past. But while such facts tell us nothing about why time travel is unlikely, Horwich’s argument implies that these facts are nevertheless evidence that it is. The strangeness of Horwich’s argument is a bit like the strangeness of Hempel’s paradox of the ravens (Hempel, 1945). To paraphrase Nelson Goodman (1955), the paradox of the ravens is strange because it seems to imply that we can study ornithology without ever going outside. Similarly, Horwich’s argument is strange because it implies that we can learn

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<sup>2</sup> Since Horwich thinks we have independent reason to believe that space-time allows for time travel to the local past but that the fuel costs associated with such travel do not, Horwich identifies prohibitively steep fuel costs as the fact that uniformly prevents time travel to the past. (Horwich, pg. 123)

about whether our world is conducive to time travel by, say, asking folks what they would do if they had time machines rather than by studying physics. The question of whether Horwich's reasoning is correct is of philosophical interest even if we have independent reason to think that time travel is, or is not, unlikely.<sup>3</sup>

I will argue that, with some amendment, Horwich's reasoning is indeed correct. I begin in section two by considering an analogue to time travel scenarios, which I call "Four Roads". Reasoning carefully about Four Roads will make it easier to reason carefully about time travel cases. In section three, I offer an amendment to Horwich's original argument and I show how the amended argument applies to the scenario in which I travel back to 1986 and attempt to scoop Horwich. In section four, I consider three objections to my amended version of Horwich's argument. Finally, I conclude in section five by reflecting on the strangeness of Horwich's argument.

## 2. Four Roads: An Analogy

Before critically evaluating Horwich's reasoning about cases involving time travel, it will be helpful to consider some relevantly analogous reasoning about non-time travel cases. First, recall the following familiar reasoning about which of two rival hypotheses is confirmed by a given piece of evidence. Suppose we are wondering whether a particular coin is fair or heavily biased towards heads. Suppose further that, before tossing the coin, we have no evidence that favors either hypothesis over the other and that we are equally confident in each. Now we toss the coin ten times and each time

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<sup>3</sup> We might, for example, discover that time travel to the local past is physically impossible. In that case, Horwich's argument tells us nothing of interest about the probability of time travel, but the question of whether Horwich's reasoning is sound remains of philosophical interest.

it comes up heads. Had we believed that the coin is fair, we should have also believed that the coin is not likely to land heads ten times in ten tosses and so should not have expected that outcome. Had we believed that the coin is heavily biased toward heads, we should have also believed that the coin is reasonably likely to land heads ten times in ten tosses and so should have been reasonably confident in that outcome. Other things being equal, evidence confirms whichever hypothesis would have made us, had we believed it prior to learning that evidence, most confident in that evidence. So, the fact that the coin lands heads ten times in ten tosses confirms the hypothesis that the coin is heavily biased towards heads over the hypothesis that the coin is fair.

The following case, though slightly more complicated than the coin case, invites the same general reasoning:

Four Roads: Yesterday I participated in a game, the object of which was to traverse a two-mile road. At the start of the game, I was exactly as prepared to complete a two-mile journey as I am when I leave the house on a typical day, which is to say that I was well prepared for easy treks and poorly prepared for difficult ones. According to the rules of the game, the road I faced might have been either hospitable or inhospitable, and either guarded or unguarded. Hospitable roads are paved, located in pleasant climates, flat, and nowhere near various environmental threats such as lava pits and jagged cliffs. Inhospitable roads are just the opposite: unpaved, located in extreme climates, composed of sheer climbs that give way to deep ravines, and near all manner of natural hazard. Guarded roads are manned with trained and armed guards, who have orders to

prevent anyone from reaching the end of the road. Unguarded roads, whatever other dangers they might present, at least do not feature any agents who will try to stop me. Needless to say, I was hoping for a hospitable and unguarded road.

A reliable witness has informed you that, although she does not know whether I won the game, she is certain that exactly one of the following four outcomes occurred (and neither she nor you have any further information as to which):

- (1) I faced a hospitable and guarded road, and I made it to the end.
- (2) I faced an inhospitable and guarded road, and I made it to the end.
- (3) I faced a hospitable and unguarded road, and I did not make it to the end.
- (4) I faced an inhospitable and unguarded road, and I did not make it to the end.

Given the information presented in Four Roads, what kind of road should you expect me to have faced? Prior to narrowing down the possible outcomes to one of (1)-(4), you had no reason to expect that I faced one sort of road rather than any other and so you should have been equally confident in each hypothesis about what sort of road I faced. Now, however, you have additional evidence. First, you know that if I faced a hospitable and guarded road then I made it to the end. Based on what you know about typical human physiology, the mechanics of small arm weapons, etc., you should think that it is unlikely that I made it to the end given that I faced competent and armed guards. So, you now know that if I faced a hospitable and guarded road then an unlikely outcome occurred. Second, you know that if I faced an inhospitable and guarded road then I made it to the end. Given what you know about the difficulties typical humans face in, e.g., climbing

steep ridges in the freezing cold, navigating narrow canyon paths in brutal heat, etc., you should think that it is even more unlikely that I made it to the end given that I faced both guards and an inhospitable road than it is given that I faced guards and a hospitable road. So, you know that if I faced an inhospitable and guarded road then a very unlikely outcome occurred. Third, you know that if I faced a hospitable and unguarded road then I did not make it to the end. You have no reason to think that I am any great athlete, but, given what you know about typical human physiology, you should think that it is unlikely for me to fail to travel two miles in a pleasant environment with no agents trying to stop me. So, you know that if I faced a hospitable and unguarded road then an unlikely outcome occurred. Finally, you know that if I faced an inhospitable and unguarded road then I did not make it to the end. While there were no guards to stop me, I nevertheless faced two miles of dangerous and difficult environmental obstacles. Given what you know about typical human physiology and the difficulties associated with such obstacles, you should think it is reasonably likely that I failed to make it to the end given that the road was unguarded and inhospitable. So, you know that if I faced an inhospitable and unguarded road then a reasonably likely outcome occurred.

To summarize, you have four hypotheses about the sort of road I faced yesterday from which to choose. On three of those hypotheses, an unlikely thing happened to me yesterday. Had you believed any of those three hypotheses prior to learning the witness's testimony, you should have been skeptical that one of (1)-(4) is true. On the fourth hypothesis, a comparatively likely thing happened to me yesterday. Had you believed that hypothesis, you should have been reasonably confident that one of (1)-(4) is true (because you should have been reasonably confident that (4) is true). Since you have no

other information that favors any hypothesis over the remaining three, you should be most confident in the hypothesis that, had you believed it prior to learning that one of (1)-(4) is true, would have made you most confident in that evidence. That is, you should be most confident that I faced an inhospitable and unguarded road. Since you know that if I faced an inhospitable and unguarded road then I did not make it to the end, you should be similarly confident that, unfortunately but not improbably, I failed to win the game.

The above reasoning requires a bit of clarification. I have repeatedly invoked the notion that some events (such as my making it to the end of an inhospitable and guarded road) are “unlikely”, while other events (such as my making it to the end of a hospitable and unguarded road) are “likely”. Probabilistic concepts such as these can be interpreted in many different ways. When I use “unlikely”, “likely”, “probable”, and “improbable” throughout this essay, I mean to refer to a kind of probability that philosophers sometimes call “macro-chance”. Despite the unwieldy name, macro-chances are arguably the probabilities with which we are most familiar. When we speculate that, e.g., the next U.S. president will probably be a woman, the Royals are likely to make the playoffs, and the ace of spades has very little chance of being the first card dealt from a well-shuffled deck, we are invoking macro-chances. And macro-chances do not just feature in our commonsense theories—mature sciences, such as thermodynamics and evolutionary biology, arguably investigate the macro-chances of various phenomena.

Macro-chances introduce a host of interesting and controversial philosophical questions, the majority of which I will avoid in what follows. That said, it will be important to distinguish macro-chance from three features of the world that can also be modeled as probabilities: actual relative frequency, micro-chance, and degree of

confidence. First, macro-chances are distinct from actual relative frequencies; the frequency with which an outcome occurs (relative to the total number of occurrences) need not match that outcome's macro-chance. For example, the macro-chance that a quarter lands heads when properly tossed is, purportedly, .5. However, the frequency with which a quarter lands heads among a sequence of tosses need not be .5 since, for example, the quarter might never be tossed, or might not be tossed an even number of times, or might never land on heads.

Second, macro-chances are distinct from micro-chances, which are the sort of probability most often associated with classical and quantum mechanics. That the two are distinct is perhaps easiest to see when we consider worlds with non-extremal macro-chances but extremal micro-chances. If our world is fundamentally deterministic, then all micro-chances take values of either 0 or 1. However, both our commonsense and scientific theories allow for fundamentally deterministic processes to give rise to macro-chances that take values between 0 and 1. For example, common sense treats the underlying processes at work in poker games (i.e., shuffles and deals) as deterministic, but nevertheless assigns a macro-chance of  $1/52$  to the proposition that the first card dealt from a well-shuffled deck is the ace of spades. And classical statistical thermodynamics assumes that the microevolution of a gas is governed by deterministic laws but assigns a (merely) very small macro-chance to the proposition that a gas's behavior will violate the second law of thermodynamics. There are difficult and important questions about how there can be non-extremal macro-chances in worlds with only extremal micro-chances and about what this possibility reveals about the nature of macro-chance and micro-chance, but many philosophers (e.g., Loewer 2001, Hoefer 2007, Sober 2010, Lyon 2010,

Emery 2015) have argued that non-extremal macro-chances are compatible with fundamental determinism.<sup>4</sup>

Finally, macro-chance is distinct from an agent's degree of confidence. It is often useful to use probabilities to represent an agent's confidence that various propositions are true—the more (or less) confident an agent is in the truth of some proposition, the higher (or lower) is the value of the probability that models her doxastic attitude toward that proposition. Often degrees of confidence diverge from macro-chances because an agent is ignorant of the macro-chances, as when I expect that it will not rain because I did not hear this morning's weather report. In most cases in which an agent knows the macro-chance of an outcome, her confidence in that outcome should equal whatever she believes to be that outcome's macro-chance. However, there are some cases in which degrees of confidence diverge from macro-chances because an agent knows more about an outcome than its macro-chance. For example, with sufficient knowledge and computational power (and assuming that coin flips are fundamentally deterministic processes), I can perfectly predict the outcome of every coin toss and so should not have a confidence of merely .5 that a quarter will land heads when flipped. Nevertheless, the macro-chance that a quarter lands heads when flipped is .5.<sup>5</sup>

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<sup>4</sup> My argument does not require that macro-chances and micro-chances are of the same ontological kind, but it does require that macro-chances (like micro-chances) are neither actual relative frequencies nor subjective degrees of confidence. For examples of accounts of macro-chance that would suit my purposes, see Loewer 2001 and 2004, Hoefer 2007, and Sober 2010.

<sup>5</sup> The most famous statement of the relationship between chance and degree of confidence is Lewis's (1986) Principal Principle. Some philosophers (e.g., Lewis 1986, Schaffer 2007) have used the Principal Principle to argue that there are no non-extremal macro-chances in fundamentally deterministic worlds. However, I agree with Loewer (2001), Hoefer (2007), and Strevens (2011) that the Principal Principle, or some suitable variant, is compatible with non-extremal macro-chances.

Four Roads provides us with yet another example in which macro-chances and degrees of confidence diverge. I have argued that, given the information presented in Four Roads, you should be most confident that I faced an inhospitable and unguarded road. Suppose that my macro-chance of making it to the end of an inhospitable and unguarded road was .4. Because you know that I fail to make it to the end of the road if it is inhospitable and unguarded, your confidence that I make it to the end given that the road is inhospitable and unguarded should be much less than .4. By learning that at least one of (1)-(4) is true, you acquire information that goes beyond my macro-chance of making it to the end of the road, and so your degree of confidence need not match that macro-chance.<sup>6</sup>

### 3. Amending Horwich's Argument

Now that we have some familiarity with choosing between rival hypotheses in cases without time travel, let us turn to Horwich's reasoning about cases in which an agent travels to the local past. Horwich writes,

Bilking, in the context of... time travel is bringing about some past event that did not occur, such as killing one's infant self or doing something one remembers was not done. Now we know... that attempts at such things will

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<sup>6</sup> In what follows, I assume without further argument that there are non-extremal macro-chances in our world and that they are distinct from actual relative frequencies, micro-chances, and subjective degrees of confidence. Admittedly, that assumption is contentious (though see the many citations above for authors who defend it). Because I will argue that surprising results follow if there are such non-extremal macro-chances, skeptics may read the rest of what follows as additional support for their skepticism.

invariably fail. But we recognize that there is considerable strangeness in this-something ad hoc and unsatisfying about explaining the repeated failures in terms of changes of mind, guns misfiring, and so forth. Since it is implausible that such mishaps would occur so faithfully over and over again, we conclude instead that there would not be frequent attempts to initiate self-defeating causal chains.

(Horwich, p. 121)

Why is it “implausible” that such mishaps would repeatedly occur? Horwich’s answer is that a correlation between an attempt to bilk and circumstances that would frustrate that attempt constitutes an “inverse fork”: a correlation between two events that is not screened off by a temporally prior third event. (Horwich, 1987, p. 97-98) Typically we observe correlations that do not constitute inverse forks. Barometer readings, for example, are correlated with the occurrence of storms but that correlation is screened off by prior changes in atmospheric pressure. In contrast, if I frequently attempt to scoop Horwich then there will be a correlation between, say, my crossing the street on the way to the publisher’s and my slipping on a banana peel. Since that correlation is not screened off by any prior event, it constitutes an inverse fork. Horwich reasons that since we have not observed the occurrence of inverse forks in the past, we should not expect to observe many occurrences of inverse forks in the future.

It is important to Horwich’s overall project in *Asymmetries in Time* that he formulates his argument about time travel in terms of correlations and inverse forks. Since I am presently interested in finding the best version of Horwich’s argument, independent of whether that argument is consistent with Horwich’s other commitments, I

will omit talk of correlations and inverse forks. Instead, on my preferred version of Horwich's argument, failures are "implausible" in the sense that, according to our best scientific and commonsense theories, they are unlikely. I will use phrases such as "Horwich-style reasoning" and "Horwich-style argument" to remind the reader that I have made an amendment to Horwich's original argument. In section 4.2 we will see why that amendment is essential.

Horwich-style reasoning about time travel cases is analogous to my reasoning about Four Roads. Consider a fleshed out description of my attempt to scoop Horwich:

Scooping Horwich: The year is 1986. As of yet, nobody has published *Asymmetries in Time*. I might attempt to scoop Horwich or I might not. I do not have the temerity to ever acquire Horwich's unpublished manuscript of *Asymmetries in Time* using conventional means such as cat burglary, hacking, or bribery; I will attempt to scoop Horwich only if I travelled to 1986 from the future with my copy of *Asymmetries in Time*. Furthermore, I am highly motivated to scoop Horwich if I have access to time travel to the local past, and so if I time travel then I attempt to scoop Horwich. Finally, if I attempt to scoop Horwich then my attempt will be credible. I will not, for instance, attempt to scoop Horwich by burying a copy of his (as of yet) unpublished manuscript in my backyard rather than by delivering it to a publisher.

Time travel to the local past might be hard, or it might not be. Time travel is hard exactly on the condition that there is some physical fact in virtue of which time travel to the past is at least unlikely. Examples of such candidate physical

facts include the structure of space-time, the fuel cost associated with time travel, a widespread fear of time travel among creatures with psychologies like our own, and so on.

Apart from the information above, you have no further evidence one way or the other about whether I attempt to scoop Horwich and whether time travel is hard. But you do now know that one of the following four outcomes occurs:

(1\*): I attempt to scoop Horwich and time travel is not hard. I do not scoop Horwich and I do time travel to my local past.

(2\*): I attempt to scoop Horwich and time travel is hard. I do not scoop Horwich and I do time travel to my local past.

(3\*) I do not attempt to scoop Horwich and time travel is not hard. I do not scoop Horwich and I do not time travel to my local past.

(4\*) I do not attempt to scoop Horwich and time travel is hard. I do not scoop Horwich and I do not time travel to my local past.

Before highlighting the analogies between Scooping Horwich and Four Roads, I admit that there is an obvious way in which they two are not analogous— in Scooping Horwich, unlike Four Roads, we learn that exactly one of (1\*)-(4\*) is true before one of the outcomes described by (1\*)-(4\*) occurs. However, the time at which new evidence is acquired is not relevant to the question of which hypothesis that evidence confirms.

Recall the case in which we are trying to decide between the hypothesis that a coin is fair and the hypothesis that a coin is heavily biased toward heads. The fact that the coin lands heads on every toss is evidence that the coin is heavily biased regardless of when we

obtain that evidence. If a reliable time traveler testifies that the coin will land heads on every toss many years from now, we have just as much reason to suspect that the coin is heavily biased as we would have had we observed that outcome ourselves many years from now.

The two scenarios are otherwise analogous in all important respects. In Four Roads, I asked what kind of road you should expect me to have faced. The analogous question about Scooping Horwich is whether you should expect that I attempt to scoop Horwich and time travel is easy, or that I attempt to scoop Horwich and time travel is hard, or that I do not attempt to scoop Horwich and time travel is easy, or that I do not attempt to scoop Horwich and time travel is hard. Just as in Four Roads, you have no prior reason to prefer any one hypothesis to the remaining three. Now that you have learned the details of Scooping Horwich, which imply that exactly one of (1\*)-(4\*) is true, you have new evidence. You know that if I attempt to scoop Horwich then I traveled back in time. That does not mean, however, that having scooped Horwich increases my macro-chance of time traveling. I take it that, on our current understanding of the mechanics of publishing and time travel, neither attempting to scoop Horwich nor succeeding in scooping Horwich makes one more or less likely to eventually time travel; I would very much like to time travel one day, but I do not think that plagiarizing anyone's work will make any difference to my odds of eventually meeting that goal. The only factor in the scenario that is relevant to my chance of time traveling (as opposed to our confidence that I time traveled) is the difficulty of time travel.<sup>7</sup> Furthermore, having traveled through time does not make one's attempt to scoop Horwich any more or less

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<sup>7</sup> Compare: in Four Roads you know that if the road is inhospitable then I made it to the end, but that the road is inhospitable does not increase my chance of making it to the end.

likely to succeed. That you know I fail if I attempt to scoop Horwich should not confuse us into thinking that, e.g., there is something about being a time traveler that makes one somehow unlikely to successfully submit manuscripts for publication.<sup>8</sup> So, the only factor that is probabilistically relevant to whether I successfully scoop Horwich (as far as macro-chances are concerned) is whether I make an attempt.<sup>9</sup>

As we did with *Four Roads*, let us consider each of the four hypotheses in turn. First, you know that if I attempt to scoop Horwich and time travel is not hard then I do not scoop Horwich and I do time travel to my local past. It is not that unlikely that I time travel to my local past given that time travel is not hard, but it is unlikely that I fail to scoop Horwich given that I try; submitting manuscripts for publication is easy and publishers are eager to print quality manuscripts such as *Asymmetries in Time*. So, you know that if I attempt to scoop Horwich and time travel is not hard then an unlikely outcome occurs. Second, you know that if I attempt to scoop Horwich and time travel is hard then I do not scoop Horwich and I do travel to my local past. As before, it is unlikely that I fail to scoop Horwich given that I make a credible attempt. Furthermore, it is also unlikely that I travel to my local past given that time travel is hard. So, you know that if I attempt to scoop Horwich and time travel is hard then a very unlikely outcome will occur. Third, you know that if I do not attempt to scoop Horwich and time travel is not hard then I do not scoop Horwich and I do not travel to my local past. It is not at all unlikely that I fail to scoop Horwich given that I do not try, but it is somewhat unlikely

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<sup>8</sup> Compare: in *Four Roads*, you know that if the road was guarded then I made it to the end—but that fact should not confuse us into thinking that there is something about a road being guarded that makes it safer for travel.

<sup>9</sup> Though see section 4.3 for a more thorough discussion of whether time travelers and non-time travelers have the same macro-chance of successfully performing various tasks.

that I do not travel to my local past given that time travel is not hard; it would be much more likely for me to not time travel if time travel were hard. So, you know that if I do not attempt to scoop Horwich and time travel is not hard then a somewhat unlikely outcome happens. Finally, you know that if I do not attempt to scoop Horwich and time travel is hard, then I do not scoop Horwich and I do not travel to my local past. Given that I do not attempt to scoop Horwich, it is (once again) not at all unlikely that I do not scoop Horwich. Furthermore, it is not at all unlikely that I do not travel to my local past given that time travel is hard. Overall, then, nothing unlikely happens on the supposition that I do not attempt to scoop Horwich and time travel is hard. So, you know that if I do not attempt to scoop Horwich and time travel is hard, a reasonably likely outcome occurs.

Let's take stock. Just as in Four Roads, you have been asked to pick between four hypotheses and, on three of these hypotheses, an at least somewhat unlikely outcome occurs: I either fail to scoop Horwich even though I try or I fail to time travel even though it is not hard. Had you believed any of those three hypotheses prior to finding out that one of (1\*)-(4\*) is true, you should not have expected that one of (1\*)-(4\*) is true. On the fourth of these hypotheses, a reasonably likely outcome occurs: I do not scoop Horwich because I do not try and I do not time travel because it is hard. Had you believed the fourth hypothesis, you should have been reasonably confident that one of (1\*)-(4\*) is true (since you should have been reasonably confident that 4\* is true). Since you have no other information that favors any hypothesis over the remaining three, you should be most confident in the hypothesis that, had you believed it prior to learning that one of (1\*)-(4\*) is true, would have made you most confident in that evidence. That is, you should be most confident that I did not attempt to scoop Horwich and that time travel

is hard. Since you know that if I did not attempt to scoop Horwich and time travel is hard then I did not scoop Horwich and I did not time travel, you should be similarly confident that I did not scoop Horwich and I did not time travel. We have now reasoned to Horwich's conclusion as applied to Scooping Horwich: you should expect that I will not time travel and that time travel is hard (i.e., there is some physical fact in virtue of which time travel to the local past is unlikely).

One point of clarification is in order before moving on. My Horwich-style argument concludes both that time travel is at least unlikely and that I will not travel to the local past. However, I do not argue from the fact that time travel is unlikely to the conclusion that I will not time travel because that argument is fallacious. Just as our degrees of confidence can diverge from macro-chances in Four Roads, so too our degrees of confidence can diverge from macro-chances in Scooping Horwich.<sup>10</sup> Importantly, I argued that we should not expect time travel to the local past on the grounds that we should not expect there to be failed attempts to change the past, rather than on the grounds that time travel is unlikely.<sup>11</sup>

The Scooping Horwich scenario is fictionalized. Most potential time travelers will not be motivated to scoop Horwich. No matter; to generate a case that is relevantly analogous to Scooping Horwich for actual agents, we need only identify an attempt that has the following features (relative to that agent):

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<sup>10</sup> The analogous point about Four Roads is that, though you should conclude both that I am unlikely to make it to the end of the road (since it is inhospitable) and that I do not make it to the end of the road, your reason for thinking that I do not make it to the end of the road is not that I am unlikely to make it to the end of the road.

<sup>11</sup> In other words, the reasoning I advocate about both Four Roads and Scooping Horwich does not involve any fallacious application of the Principal Principle, or of some variant of the Principal Principle designed to accommodate macro-chances. (See footnote 5.)

- i. The attempt is likely to succeed.
- ii. The attempt fails.
- iii. If the agent travels to the local past, then she makes the attempt.
- iv. If the agent makes the attempt, then she travels to the local past.

Features (i), (ii), and (iii) combine to imply that a particular unlikely event, a failure, happens if the agent travels to the local past. These three features are essential to the argument since if, say, I time travel without attempting to scoop Horwich or scooping Horwich is very hard or I succeed in scooping Horwich, then we have no reason to think that I will not travel to my local past. Feature (iv) implies that the unlikely event does not happen if the agent does not travel to the local past. This fourth feature is essential because if, say, I improbably fail to scoop Horwich regardless of whether I travel to the local past, then we (once again) have no evidence that I will not travel to the local past.<sup>12</sup>

Suppose that most people, if given an opportunity to travel to the local past, will form a strong intention to change some particular aspect of that past. Some of those people might not follow through on their strong intention, but it is plausible that most of them will by attempting to bring about whatever event it is that each wishes had occurred. Some of those attempts might succeed because the agents who make them falsely believe that the past did not go as they wished, but our beliefs about the past are accurate enough that it is plausible that most of these attempts will fail. Of the attempts that fail, some might have been attempts that were likely to fail because some agents might attempt to

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<sup>12</sup> I assume that events are not so finely individuated that this possibility is trivially rule out.

bring about events that are difficult to bring about. However, since access to time travel allows one to show up well prepared and well informed, it is plausible that most of these failed attempts were likely to succeed. Finally, since these agents intended to change some particular aspect of the past, it is plausible that most will not make the attempt if they do not travel to their local past. For example, I am not even tempted to try to scoop Horwich by submitting a copy of *Asymmetries in Time* under my name now. On the supposition that most people with access to time travel will intend to change the past, it is plausible that there is some attempt that satisfies (i)-(iv) for most people. So, on the supposition that most people with access to time travel will intend to change the past, Horwich-style reasoning implies that most people will not travel to the past and that time travel is unlikely.

Is the supposition plausible? As Stephanie Rennick (2015) has recently argued, an agent cannot intend to bring about some event while also being certain that she will fail to bring about that event, and so agents who are (justifiably) certain that they will fail to change the past cannot even intend to change the past. If it is irrational to be (even) open to the possibility that an event both does and does not occur in the past, only the irrational can intend to change the past. Perhaps, then, we should reject the supposition that most people with access to time travel will intend to change the past on the grounds that most potential time travelers, like most people in general, will be rational. Smith, for example, dismisses Horwich's argument partly because "mass irrationality on the part of time travelers" is just as improbable as is the time travelers' failed attempts. (Smith, pg. 182) As for myself, I am not as confident as is Smith that mass irrationality is improbable. Safely confined as I am to the present, it is easy for me to be certain that I

will fail to change the past if I try. But if I actually found myself in 1986, sitting in a publisher's office with a duplicate of *Asymmetries in Time* in my hand, I doubt that I could stay so certain. Sure, contradictions are false and I will not change the past... but the publisher is right there and if I just sign my name to this plagiarized copy and hand it to her... what could go wrong?

At any rate, the question of what potential time travelers will (or will not) believe and intend is an empirical question into which I have no special insight. What interests me about the question is that, assuming potential time travelers have psychologies that are relevantly similar to our own, we can, in principle, find out the answer. And if it turns out, as Horwich claims and Smith denies, that potential time travelers will (if given access to time travel) form the strong intention to change the past, then we have reason to believe that a non-fictionalized version of Scooping Horwich applies to most potential time travelers. So, if the Horwich-style reasoning about Scooping Horwich is good, we can learn that time travel is unlikely by investigating what potential time travelers will (or will not) believe and intend. That the psychologies of potential time travelers could be evidence about the likelihood of time travel is a philosophically interesting result even if Smith is right that most potential time travelers are unlikely to attempt to change the past.

#### 4. Objections

The following three objections are each targeted at my claim that I am unlikely to scoop Horwich given that I make a credible attempt.

#### 4.1. Failed Bilking Attempts Are Not Unlikely

Jenann Ismael, in criticizing Horwich's original argument, points out that failed bilking attempts, described as such, are not unlikely. She writes,

It is almost irresistible to suppose... that there is something anomalous in the [repeated failed bilking attempts] considered *collectively*... But that is not right either; there is nothing *ad hoc* or mysteriously coincidental in the scenario... for we never succeed in ordinary cases... in which we fail, either. And it is built into the description of [bilking attempts] *that* that they are failures... there are diverse and unrelated explanations of... individual failures, but nothing spooky or coincidental about the fact that *all* flounder. (Ismael, p. 308)

A bilking attempt, recall, is an attempt to bring about an event that does not occur. It is guaranteed, rather than unlikely, that an attempt to bring about an event that does not occur will fail. Horwich sometimes seems to miss this point, as when he writes, "... we have good reason to believe that the persistent failure of bilking attempts is highly improbable." (Horwich, pg. 122) The persistent failure of bilking attempts, described as such, is certainly not improbable. Inspired by Ismael, one might object that my Horwich-style reasoning about Scooping Horwich makes the same mistake. I claimed that it is unlikely that I do not scoop Horwich given that I attempt to scoop Horwich. However, my attempt to scoop Horwich is an attempt by a time traveler to do something that is not, in fact, done. So, one might argue, it is guaranteed (rather than unlikely) that I do not scoop Horwich given that I attempt to scoop Horwich.

The objection is unfounded. The relevant issue is not whether it is unlikely that I do not scoop Horwich given that I bilking-attempt to scoop him, but is instead whether it is unlikely that I do not scoop Horwich given that I attempt to scoop him. Perhaps this response will seem like cheating, since my attempt to scoop Horwich is a bilking attempt. To see that it is not, recall that my reasoning about Four Roads required that it is unlikely that I make it to the end given that the road is guarded. However, since I make it to the end of the road if it is guarded, every guard fails to stop me. Let us call guards who fail “failed guards”. I take for granted that my reasoning about Four Roads is sound; you should expect that I failed to make it to the end of a hospitable and guarded road. The analogous criticism to my reasoning about Four Roads is that it is guaranteed (rather than unlikely) that I make it to the end of a guarded and hospitable road since it is guaranteed that I make it to the end of a road that is guarded by failed guards. But this criticism is clearly off track; we cannot properly evaluate how unlikely (or likely) an outcome is by holding fixed whether the outcome occurs. No failed attempt seems unlikely relative to a description that includes its failure, but clearly some failed attempts are unlikely—among them are a guard’s failed attempt to stop me from making it to the end of the road (if there is such an attempt) and my failed attempt to scoop Horwich (if there is such an attempt). Ismael is right to point out that Horwich should not frame his argument in terms of the improbability of failed “bilking” attempts as such, but Horwich-style reasoning about Scooping Horwich does not make that mistake.

#### 4.2. Frequencies vs Macro-Chances

As we saw in section 3, Horwich's original argument relies on an inference from the fact that we have not observed correlations between attempts and events that thwart those attempts to the conclusion that we should not expect to see such correlations in the future. Smith (1997) criticizes this move by pointing out that we should not infer from the (mere) fact that we, who have not yet been visited by time travelers, have not observed a particular correlation to the conclusion that we will continue to not observe that correlation in the future (unless we have some independent reason for doubting that we will be visited by time travelers in the future.) Dowe (2003) agrees (as do others, e.g., Sider 2002), and gives this nice summary of Smith's objection:

If time travel to the local past were common, then such correlations wouldn't be improbable, they would be a common feature of the world... We have good reason to think that there are no visitors from the future among us at the moment. The question is, should that fact alone make us think that they will not be coming to arrive? No, if such visitors should begin to arrive, it's reasonable to think that we might see kinds of effects that we are not accustomed to seeing. (p. 581)

Smith and Dowe are right to criticize Horwich's original reasoning. By Horwich's own lights, the regularities we should expect to see if we are visited by time travelers are very different from the regularities we have so far observed. So, we should not expect that the regularities we currently observe will hold in the future unless we have some reason to expect that we will not be visited by time travelers in the future.

However, Horwich-style reasoning about Scooping Horwich does not make this mistake. I have claimed that my failure to scoop Horwich is unlikely. What justifies this claim? One answer might be that the observed frequency of failed scooping attempts has been low. But that answer, as we have learned from Smith, is no good; we should not expect that the frequency of failed scooping attempts will stay low once time travelers are added to the mix. Instead, the answer I gave is that our best commonsense and scientific theories ascribe a low macro-chance to my failure. This answer is importantly different from the answer criticized by Smith because the frequency with which an outcome occurs can diverge dramatically from that outcome's macro-chance of occurring. Just as a fair coin can land heads 10,000 times in a row but very likely will not, so too a time traveler can fail to scoop Horwich 10,000 times in a row but very likely will not. The fact that the frequency of failure will be much higher if there are time travelers to the local past who repeatedly attempt to change it does not imply that the macro-chance of those failures will differ from the macro-chance of failure for non-time travelers.

In some time travel scenarios, the macro-chance of failure for time travelers is not the same as is the macro-chance of failure for non-time-travelers. For example, consider a modification of Scooping Horwich in which time traveling cops are charged with thwarting all scooping attempts made by time travelers. The cops trail me to 1986 and wait to thwart any attempt I make to scoop Horwich. On this version of Scooping Horwich, it would be a mistake to claim that I am as likely to scoop Horwich as is a non-time traveler—not because of some general rule that the macro-chance of attempts made by time travelers differs from the macro-chance of attempts made by non-time travelers,

but rather because this modified version of Scooping Horwich introduces a factor that systematically interferes with the scooping attempts of time travelers.

But, on the non-modified version of Scooping Horwich, there is no such factor that systematically interferes with the scooping attempts of time travelers. To be sure, something interferes with my attempt to scoop Horwich. Perhaps the publisher misplaces my submission, perhaps I misaddress the envelope, or perhaps the manuscript gets lost in the mail. But these factors interfere with the scooping attempts of time travelers and non-time travelers alike; there is nothing about being a time traveler that makes one particularly likely to suffer such mishaps. The macro-chance that I successfully scoop Horwich given that I try is the same as is the macro-chance that a non-time traveler successfully scoops Horwich given that she tries.

#### 4.3. The Metaphysics of Macro-Chance

Or maybe not. John Roberts has suggested to me that the macro-chance of failure in cases such as Scooping Horwich is, *contra* Horwich-style reasoning, 1. His worry begins with the observation that the values of macro-chances evolve over time. For example, it has become less likely that I will develop osteoporosis since I have been taking these vitamin supplements, and it has become more likely that I will be the next Powerball winner since the first two numbers drawn in this evening's broadcast have matched my ticket. One influential theory (found in Lewis 1986 and 1994) about how the values of chances evolve over time is that the chance of an event at a time is equal to the chance of that event conditional on the history of the world up to that time in

conjunction with the complete theory of chance for that world.<sup>13</sup> Now, that theory will not do as an account of how macro-chance evolves over time. As we saw in section 2, there are non-extremal macro-chances even in worlds that are fundamentally deterministic but if a world is fundamentally deterministic then the chance of an outcome conditional on the complete history and theory of chance for that world must be either 0 or 1. One way to accommodate macro-chances is to amend the theory so that macro-chances evolve not by conditionalizing on the entire history of the world, but on only the macro-history of the world (i.e., the history of the world that can be described in the relevant non-fundamental vocabulary).<sup>14</sup> But this theory of how macro-chances evolve creates problems for my claim that I am unlikely to fail in my attempt to scoop Horwich.

Suppose I have arrived in 1986 and I have just attempted to scoop Horwich by dropping my copy of *Asymmetries in Time* in the mail. The chance now that my attempt will succeed, we are supposing, is the chance that my attempt will succeed conditional on (among other things) the macro-history of the world up to now. The macro-history of the world up to now includes my history up to now, but how should we understand “my history”? I am a time traveler who came from the future, so in one sense my history includes the fact that, in 2015, I came up with the idea to scoop Horwich while reading his published book *Asymmetries in Time*. But, if my history includes the fact that Horwich published *Asymmetries in Time* then the macro-chance that my attempt to scoop Horwich will fail is 1. We might instead say that my history includes no events that are chronologically subsequent to my attempt to scoop Horwich. In that case, the back end

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<sup>13</sup> A theory of chance for a world is a conjunction of true history-to-chance conditionals that specify the chance value of future occurrences for every possible history of that world.

<sup>14</sup> See Loewer 2001 and 2004 for further details.

of my history terminates with the fact that I instantaneously popped into existence in 1986. But now my claim in section 4.2 that the macro-chance of failure for time travelers is the same as is the macro-chance for non-time travelers looks much more dubious. Since the histories of time travelers are so radically different from the histories of non-time travelers, the analogue of Smith's criticism that I dismissed in the previous section now starts to seem compelling; what reason do we have for thinking that the chance of failure for people with histories like ours is anything like the chance of failure for people who mysteriously pop into existence *ex-nihilo*? Our best commonsense and scientific theories seem to have little to say about whether people who are created *ex-nihilo* are likely to successfully submit manuscripts to publishers.

The metaphysics of chance in general (let alone macro-chance) is already vexing, and adding time travel to the mix only makes things worse. I agree with Roberts that the question of how macro-chances behave in worlds in which there are time travelers is difficult and that the answer is crucial to the success of Horwich-style reasoning. Unlike Roberts, however, I do not take this difficulty to motivate the conclusion that e.g., my chance of scooping Horwich must be either 0 or 1. Following Lewis (1976), many philosopher have agreed that there is a sense of "can" associated with ordinary standards of ability on which time travelers can do anything that non-time travelers can. Suppose a non-time traveler breaks into Horwich's house in 1986 and steals a draft of *Asymmetries in Time*. Why think that the non-time traveler can scoop Horwich, but that I (who have come from the future) cannot?<sup>15</sup> We both have a copy of the manuscript, we both know how to submit manuscripts for publication, we are both determined, and we will both

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<sup>15</sup> This example is modeled on Lewis's (1976) example of Tim and Tom.

(given that Horwich publishes *Asymmetries in Time*) ultimately fail. It is hard to see how having come from the future could in any way impede one's ability to e.g., sign one's name to a manuscript, correctly address an envelope, or put the correct postage on a package. Analogous considerations suggest that the non-time traveler's chance of scooping Horwich is the same as is mine. Once again, we both have a copy of the manuscript, we both know how to submit manuscripts for publication, we are both determined, and we will both (given that Horwich publishes *Asymmetries in Time*) ultimately fail. How could my having come from the future raise or lower my chance of e.g., correctly signing my name to the manuscript, correctly addressing the envelope, or putting the right amount of postage on the package? The factors that determine my chance of success, like the factors that determine my ability to succeed, seem to be exactly the same in my case as in the non-time traveler's.

Note that the issue Roberts raises is not specific to cases in which an agent attempts to do something that, in fact, is not done; his worry applies to the macro-chance of any event that involves an object that has come from the future. Again, I see little motivation for thinking that, for example, cups of coffee brought from the future are not overwhelmingly likely to cool, time travelers cannot lower their chance of developing heart disease by exercising regularly, and evenly weighted quarters from the future are never fair. Of course, one might have some general reason to doubt that the probabilities associated with e.g., thermodynamics, cardiovascular health, and games of chance should be interpreted as macro-chances, but if we allow that there are non-extremal macro-

chances in non-time travel scenarios then I do not see why we should doubt that there can be non-extremal macro-chances in time travel scenarios.<sup>16</sup>

So, I take it to be a *desideratum* for any theory of macro-chance for worlds that permit time travel that the theory allows for the macro-chance of events that occur in time travel contexts to be the same as the macro-chance of events that occur in non-time-travel contexts. Any theory that meets that desideratum will vindicate my claim that my attempt to scoop Horwich is unlikely to fail, since the fact that the success of my attempt is incompatible with what actually occurs creates no additional difficulty. That said, Roberts' worry nicely illustrates one problem we face in building a metaphysics of macro-chance that meets that desideratum. In non-time travel contexts, we never risk trivializing the macro-chance of an outcome by conditionalizing on a cause of that outcome because no event is both a cause and an effect of a chance outcome. In contrast, my evolving macro-chance of successfully scooping Horwich must be independent of all sorts of propositions that are both causally upstream and downstream from my attempt to scoop Horwich; having read *Asymmetries in Time*, for example, is both a cause of my attempting to plagiarize Horwich and an effect of that attempt's failure. What we would like is an otherwise well-motivated theory of macro-chance that neither treats objects from the future as though they were created *ex nihilo* (and so allows us to conditionalize on some causal factors that lie in the relative future) nor trivializes any macro-chance that pertains to them. Admittedly, I cannot presently respond to Roberts's worry with a

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<sup>16</sup> Having said that, here is one reason to doubt that there can be non-extremal macro-chances in time travel scenarios: if there are such macro-chances, then we can get evidence about how likely time travel is by learning about the psychologies of potential time travelers. Fair enough—perhaps the consequent of that conditional is more absurd than is the denial of the antecedent, but nevertheless that is an interesting result derived from Horwich-style reasoning.

theory of macro-chance that does just that, but I see little reason to doubt that some such theory is true (apart from general skepticism regarding macro-chances). If the non-time traveler and I are equally able to plagiarize Horwich, then the macro-chance that I successfully scoop Horwich given that I try is the same as is the macro-chance that the non-time traveler successfully scoops Horwich given that she tries.

### 5. A Strange Epistemic Position

I have argued that Horwich-style reasoning is correct; provided that most time travelers will, if given access to time travel, form strong intentions to change the past, we have (defeasible) reason to believe that there is some physical fact in virtue of which time travel to the local past is unlikely. But Horwich-style reasoning is strange, since it implies that we can learn that time travel is unlikely without knowing why by learning what potential time travelers will (or will not) believe and intend. Now that we can compare Horwich-style reasoning to our reasoning about Four Roads, we are in a position to locate the source of that strangeness.

There are two ways that we come to acquire evidence about the chance of an event. The first way is through learning about facts that are (causally or metaphysically) responsible for that chance value. For example, one way to gain evidence that a coin is fair is by learning that it is evenly weighted, and one way to gain evidence that it is likely to rain is by learning that storm clouds are approaching. The second way is through learning that the event does or does not occur. For example, one way to gain evidence that a coin is fair is by learning that it has landed heads roughly half the times it has been flipped, and one way to gain evidence that it was likely to rain is to get rained on.

Typically, if an event has not yet occurred then we are only able to acquire evidence about the chance of that event in the first way. Once an event occurs, however, both ways are available to us.

The reasoning I advocated about Four Roads is neither surprising nor strange because it is a familiar instance of the second way of getting evidence about an event's chance: after an event occurs, information about the occurrence of that event is evidence about that event's chance. Horwich-style reasoning about scooping Horwich is also a case of the second way of getting evidence about the chance of an event, except that it puts us in the very unfamiliar position of being able to use that second way before the event occurs. If we learn that future potential time travelers will, if given access to time travel, form strong intentions to change the past, then (as I argued in section 3) we are in a position to know that most of their attempts will fail before those failures occur. Since these failures are unlikely we expect that the attempts will not be made, and so expect that there will not be frequent time travel to the local past, and so infer that time travel to the local past is unlikely. That we can learn anything about whether our world is conducive to time travel, not by, say, studying physics, but rather by studying the psychologies of potential time travelers feels strange to us because it is strange; typically we can only gain evidence about the chance of an event by learning about facts that are (at least partly) responsible for that chance. But if, as I've argued, Horwich-style reasoning is correct, then we are all presently in the very strange epistemic position of being able to gain evidence about the chance of an event without having any information that explains why that chance obtains even though the event has not yet occurred. That there are evidential relationships between the macro-chance of time travel and the

psychologies of potential time travelers is, to my mind, the most important upshot of the Horwich-style argument.

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