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DOING FOR CIRCULAR TIME WHAT SHOEMAKER DID FOR TIME WITHOUT CHANGE: HOW ONE COULD HAVE EVIDENCE THAT TIME IS CIRCULAR RATHER THAN LINEAR AND INFINITELY REPEATING

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Abstract. There are possible worlds in which time is circular and finite in duration, forming a loop of, say, 12,000 years. There are also possible worlds in which time is linear and infinite in both directions, and in which history is repetitive, consisting of infinitely many 12,000 year epochs, each two of which are exactly alike with respect to all intrinsic, purely qualitative properties. Could one ever have empirical evidence that one inhabits a world of the first kind rather than a world of the second kind? We argue for the affirmative answer, contra Quine (1979), Newton-Smith (1980), and Bergström (2013). Our argument for that conclusion differs from an argument for the same conclusion due to Susan Weir, reported by Richard Sorabji (1988). Weir's argument is probabilistic and explicitly requires having evidence against determinism. Our argument is a direct appeal to the simplicity of laws, and it involves no probabilistic component. It is modeled on Shoemaker's (1969) argument that one could have evidence of time without change.

> In fact, Alcmaeon says that people die simply because they are not able to join beginning to end . . . Now if there is a circle, and a circle has neither beginning nor end, people could not be earlier by being closer to a beginning, neither we earlier than they, nor they than us.
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> Pseudo-Aristotle *Problemata*, quoted in Sorabji (2006: 329)

1. INTRODUCTION

There are possible worlds in which time is circular and finite in duration, forming a loop of, say, 12,000 years. There are also possible worlds in which time is linear and infinite in both directions, and in which history is repetitive, consisting of infinitely many 12,000 year epochs, each two of which are exactly alike with respect to all intrinsic, purely qualitative properties. Could one ever have empirical evidence that one inhabits a world of the first kind rather than a world of the second kind? We argue for the affirmative answer, contra W. V. Quine (1979), William Newton-Smith (1980), and Lars Bergström (2013). Our argument for that conclusion differs from an argument for the same conclusion due to Susan Weir, reported by Richard Sorabji (1988). Weir's argument is probabilistic and explicitly requires having evidence against determinism. Our argument is a direct appeal to the simplicity of laws, and it involves no probabilistic component.

We proceed as follows. In section 2, we briefly discuss a similar issue that has received much more discussion. In section 3, we provide a more precise formulation of the thesis that we will defend. In section 4, so that the reader can appreciate the significance of the challenge, we consider some tempting but unsuccessful proposals about how one might have evidence that time is circular rather than linear and repeating, or vice versa. In section 5, we mention three possible kinds of evidence, besides what we offer in our main argument. In section 6, we give our main argument, which articulates a possible situation in which we would have evidence that time is circular rather than linear and repeating. In section 7, we reply to objections to our main argument. Our reply to the final objection consists in a second, more complex possible situation in which we would have the relevant evidence.

2. AN ANALOGY

In 'Time without Change' (1969), Sydney Shoemaker argued for the thesis, call it E1, that it is possible to have evidence for the existence of 'global freezes', periods of time in which nothing changes intrinsically. E1 is surprising and seems to have been widely denied before the publication of Shoemaker's paper. We can put the following words into the mouth of Shoemaker's opponent.

> The E1-Denier: Consider two possible worlds, Freeze and No Freeze. We stipulate that in No Freeze, there are no freezes, no periods of time in which nothing changes intrinsically. We stipulate that in Freeze there are intervals of time throughout which everything freezes and nothing changes intrinsically: when the freeze ends, everything snaps back into action as if no freeze had ever happened. Freeze and No Freeze are as similar as is consistent with the fact that they differ as to whether freezes occur. Imagine that you are to be placed in one of these worlds without being told which world it is. The question then is — just what possible observation could you make to ascertain whether you are in Freeze or in No Freeze? My suggestion is that there is nothing you could do. While these are apparently very different kinds of worlds, the question as to which world it is that you are in is empirically undecidable.[1]

Shoemaker's case for E1 is simply a counterexample to the suggestion above. You could have empirical evidence in support of the generalization that the universe is divided into three sectors, A, B, and C, which undergo year-long local freezes every three, four, and five years, respectively. But this generalization supports the conclusion that there is a year-long global freeze every sixty years. Shoemaker writes that 'If all this happened, I submit, the inhabitants of this world would have grounds for believing that there are intervals during which no changes occur anywhere (1969: 371)'. Newton-Smith agrees:

> Shoemaker's argument, while open to objections, is plausible and can be amplified to make it considerably more plausible. Rather than consider his case in any detail, I will strengthen his conclusion by offering the same style of argument based on a different fantasy world. . . . Basically, both Shoemaker's argument and mine are designed to show that talk of time without change has sense through providing a description of conditions under which we would be warranted in asserting the existence of temporal vacua. (1980: 20)

We mention Newton-Smith's acceptance of Shoemaker's argument, because we think it adds initial credibility to Newton-Smith's denial of the parallel claim about circular time.

3. THE ISSUE

In the rest of this paper we argue that one could have evidence that one inhabits a world in which time is circular. More carefully, the thesis we will argue for, call it E2, is that it is possible to have ordinary empirical evidence that favors *Circle Hypothesis* over *Line Hypothesis*:

> <u>Line Hypothesis.</u> Time is linear (open), and the world is what Lewis (1986: 172) calls a 'two-way eternal recurrence' world. Time is topologically and metrically like the real line. There is no first or last instant or first or last n-minute-long interval, and time is of infinite duration. History is composed of non-overlapping epochs
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> $\ldots, e_{-3}, e_{-2}, e_{-1}, e_0, e_1, e_2, e_3, \ldots$

[1] We model this speech on a passage from Newton-Smith (1980) that we quote below.

each of which is of positive finite duration, and each two of which are intrinsic, qualitative duplicates. (For any integers $i \neq j$, $e_i \neq e_j$.)

Circle Hypothesis. Time is circular (closed). It is topologically and metrically like an oriented circle, a circle ordered by arrows going around, e.g., clockwise. There is no first or last instant or first or last n-minute-long interval, and time is of positive finite duration.

To head off confusion, we make two points of clarification.

First, in the case of Line Hypothesis, there need not be any natural, non-arbitrary joints marking the end of one epoch and the beginning of another. History might consist of a billiard ball, bouncing back and forth between the left and right sides of a pool table, at a constant rate of one impact per second, ad infinitum. Such a history admits of many equally natural divisions into non-overlapping, two-second-long epochs. One such division takes each epoch to begin and end with the ball at the right wall. Another, equally natural, division takes each epoch to begin and end with the ball at the left wall. A similar point holds for Circle Hypothesis. Events might be arranged so that no instant stands out as a natural 'time zero'; there need not be a Big Bang or Big Crunch. Time might be a thirty-second loop, and the universe might contain nothing but a riderless carousel that makes one rotation per 30 seconds, at a constant rate, never starting or stopping. One might find it convenient to pick an instant and label it '0'. Once such a choice is made, there is a natural way to label each of the other instants with some real number between 0 and 30, according to their distance in seconds, in the forward direction, from the chosen '0 instant'. But the choice of the '0 instant' is arbitrary.

Second, and relatedly, a particular object can persist through many epochs, in Line Hypothesis, and can wind around the circle of time more than once, in Circle Hypothesis, as the following diagrams make clear:

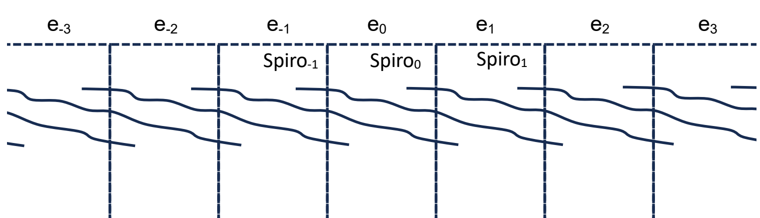

Figure 1

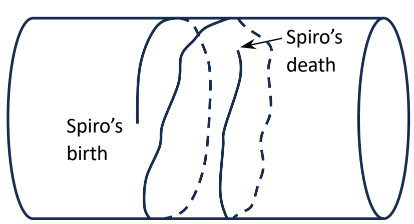

Figure 2

Figure 1 depicts a world in which Line Hypothesis is true. Each epoch is 30 years long. Each two people in this world have lives that are intrinsic, qualitative duplicates of each other. Each such life is 70 years long and extends through several epochs. For each epoch e_i, a person, $Spiro_i$, pops into existence in e_i as an infant, is cared for by a young man, Spiroi$_{i-1}$, and by an older man, Spiro$_{i-2}$, and eventually grows up, becomes an adult, cares for an infant, Spiro$_{i+1}$, gets older, cares for another infant, Spiro$_{i+2}$, and dies at the age of 70. For all integers i and j, if i≠j, then Spiro$_i$≠Spiro$_j$.

Figure 2 depicts a world in which Circle Hypothesis is true. In this world, time is a circle whose circumference is 30 years long. This world is inhabited by exactly one person, Spiro, who pops into existence as an infant and is cared for by a young man, Spiro, and by an older man, Spiro. At a certain point in Spiro's childhood, the older man dies, aged 70 years. Spiro's life winds around the cylinder of time[2] more than once, and there are certain instants through which Spiro lives three times: as a child, as a young man, and as an older man. More cautiously put, Spiro's life is 70 years long with respect to his personal time, in the sense of Lewis (1976, 2023), despite the fact that external time in this world is a loop that is 30 years long. [3] See Sorabji (2006: 320-322) for a detailed discussion of a case like this.

We return now to E2, which again is the thesis that it is possible to have ordinary empirical evidence that favors Circle Hypothesis over Line Hypothesis. If one inhabited a world in which Circle Hypothesis is true, could one have such evidence? Strikingly, Newton-Smith thinks not. He writes that

> [Line Hypothesis] and [Circle Hypothesis] are clearly incompatible theories. However, any observation that supports [Line Hypothesis] supports [Circle Hypothesis] equally and vice versa. . . . Consider two possible worlds, A and B. We stipulate that in A time is linear and change precisely cyclical so that [Line Hypothesis] is true of this world. We stipulate that in B time is closed so that [Circle Hypothesis] is true of B. In addition we decree that the entire set of states constituting B is qualitatively identical to the sequence of states in any one [epoch] of A. Imagine that you are to be placed in one of these worlds without being told which world it is. The question then is — just what possible observation could you make to ascertain whether you are in A or in B? My suggestion has been that there is nothing you could do. While these are apparently very different kinds of worlds the question as to which world it is that you are in is empirically undecidable. (1980: 67-68)

More recently, Bergström has made a similar claim:

> But is there any reason to believe that time is closed? Perhaps not. But neither, it seems, is there any reason to believe that time is linear. For all we know, both alternatives seem equally possible. Both are equally compatible with all possible empirical evidence. Furthermore, it seems unlikely that simplicity could break the tie. . . . We may conclude, then, that closed time is a realistic possibility, which in turn appears to imply a plausible version of eternal recurrence. (2013: 171).

Quine goes further. Apparently on the basis of the denial of E2, he claims that 'the two hypotheses are two formulations of a single theory' (1979: 67). In the next section, we add some detail, in the spirit of Newton-Smith's and Bergström's remarks, to strengthen the case against E2.

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[2] By a *cylinder of time*, we mean a cylindrical spacetime in which the temporal dimension is finite and closed, forming a loop. Figure 2 represents such a spacetime. To interpret Figure 2, start with a circle, where the circle represents circular time, and where each point on the circle represents an instant. Now replace each point on that circle with a line, where each line represents all of three-dimensional space at a particular instant. The result is (or is analogous to) a cylinder. Thanks to an anonymous reviewer for prompting us to clarify this expression.

[3] Lewis (1976, 2023) distinguishes between *external time* (time itself) and the *personal time* of a particular person (or other object), which is, roughly, what would be measured by the person's wristwatch. In a relativistic version of this case, Spiro's worldline would have a proper time length of 70 years, whereas there would be inertial closed timelike curves whose proper time length is only 30 years. (A timelike curve is a spacetime path that could be the worldline of an object with mass, always traveling at less than light speed. A *closed* timelike curve forms a loop.) On the distinction between relativistic proper time and Lewisian personal time, in connection with relativistic spacetimes whose temporal dimension forms a loop, see Gilmore (2010) and Eagle (2010b).

4. THE CHALLENGE

Before turning to how we could have evidence for Circle Hypothesis over Line Hypothesis, we want to air some tempting but unsuccessful proposals about how one might acquire such evidence, so that the reader can appreciate the significance of the challenge. To acquire evidence that Circle Hypothesis is true, could you:

1. consult historical records, and find that (O1) there was an earlier time qualitatively exactly like the present time? No, this is exactly what you would expect to find even were Line Hypothesis true. O1 supports Line Hypothesis to same degree that it supports Circle Hypothesis.

2. consult historical records, and find that (O2) numerically the same time, hosting numerically the same people participating in numerically the same events, occurred in the past? No. Though O2 would support Circle Hypothesis over Line Hypothesis, O2 is not observable.[4] There is no observable difference between O2 and O2*, which results from replacing each occurrence of 'numerically the same' with 'qualitatively the same but numerically distinct'.

3. live long enough to see an event, e.g., a particular basketball game, that you remember seeing earlier in your life, and observe that (O3) game1 is earlier than game2, and game1=game2? No. O3 would support Circle Hypothesis over Line Hypothesis, but O3 is not observable. There is no observable difference between O3 and O3*, which stands to O3 as O2* stands to O2.

4. live a life that has no beginning or end, no birth or death, but rather a life whose topology and metric matches time itself, and come to believe, on the basis of introspection and memory, that (O4) you had this particular token experience some years ago? No. O4 would favor Circle Hypothesis, but neither introspection nor memory could justify the belief that the experience that you had some years ago was *this* token experience, as opposed to a numerically distinct qualitative duplicate.

5. leave a trail of breadcrumbs, and eventually observe that (O5) you have returned to the time and approximate place of your earlier dropping of a breadcrumb? No. See #3 above.

Taken together, these considerations might be used as the basis of an inductive argument against E2. Similar points can made about some initial proposals for acquiring evidence in support of Line Hypothesis over Circle Hypothesis. Since our focus in this paper is on E2, we relegate these to a note.[5]

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[4] Similar points have been made in connection with Nietzsche's theory of eternal recurrence. See especially Jenkins (2012: 209-213).

[5] What about the other way around? To acquire evidence that favors Line Hypothesis over Circle Hypothesis, could you:

6. observe that (O6) your birth occurred, and before that an exactly similar birth occurred, and before that an exactly similar birth occurred, and so on? No. O6 may be observable, but it supports Circle Hypothesis to the same degree that it supports Line Hypothesis.
7. observe that (O7) your birth occurred, and before that an exactly similar but numerically distinct birth occurred, and . . . ? No. O7 is not observable.

Perhaps one could have other kinds of ordinary empirical evidence that would favor Line Hypothesis over Circle Hypothesis. On this question we take no stand.

5. OTHER ROUTES TO KNOWLEDGE

Before turning to our main argument in section 6, we want to mention a few other ways in which, it might be thought, one could come to know that Circle Hypothesis is true and that Line Hypothesis is false, or vice versa.

First, one might think that belief in Circle Hypothesis, or in Line Hypothesis, could be properly basic (in the sense of Plantinga (1981)), and that one could know one of these hypotheses *without* evidence. We do not want to deny that. Our focus is not on whether one could know that Circle Hypothesis is true, but on whether one could have evidence for it.

5.1 EVIDENCE THAT IS NOT ORDINARY EMPIRICAL EVIDENCE

However, even when our target is narrowed in this way, certain views about evidence threaten to trivialize our question.

First, one might think that one could have *a priori* evidence in favor of Circle Hypothesis, or in favor of Line Hypothesis.[6] Such evidence might take the form of an a priori argument against the possibility of circular time, e.g., Mellor (1981: 160-187). (Weir (1988) replies.) In the other direction, one might argue against Line Hypothesis either (as floated by Sorabji 2006: 318) by appeal to the claim that the past must be finite in duration, or, following Grünbaum (1963: 202), by appeal to the following version of the Identity of Indiscernibles:

PII Necessarily, if x and y have exactly the same purely qualitative properties, then x=y.

Grünbaum uses PII to argue that Line Hypothesis – which posits infinitely many epochs that are qualitatively exactly alike – is impossible. We do not claim that such arguments, if sound, would not count as evidence. Such an argument, however, would not count as *empirical* evidence, which is our focus here.[7]

Second, one might think that one could have evidence for the reliability of an oracle who then says that Circle Hypothesis is true, and that all of that would be evidence – indeed, *empirical* evidence – for Circle Hypothesis over Line Hypothesis.[8] We do not deny this either. Such 'oracular' evidence would not, however, count as *ordinary* empirical evidence.

Obviously, a non-skeptic can make parallel suggestions about any proposition that might be hard to support in an ordinary, empirical way: one can say that belief in the proposition could be properly basic, or that one could have a priori or oracle-like evidence for it. This point is no less relevant to the debate about evidence for time without change than it is to the debate about evidence for circular time.

But we take it that even if a priori arguments and oracles can supply evidence, the epistemic questions about the structure of time that Shoemaker, Newton-Smith and others are addressing are not trivial. So it seems to us that anyone who accepts the possibility of a priori and oracle-like evidence for the relevant hypotheses will need to treat the relevant questions as being restricted to evidence of a certain kind – roughly put, *ordinary empirical* evidence.

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[6] Typically one's evidence for the *disjunction* of Circle Hypothesis (C) and Line Hypothesis (L) will be empirical. Strictly speaking, our focus is on arguments for the conditional claim: $(C \vee L) \rightarrow C$. When an argument for this conditional claim relies on an empirical premise, we classify the argument as empirical, and when it relies only on a priori premises, we classify it as a priori. *Mutatis mutandis* for arguments for $(C \vee L) \rightarrow L$.

[7] Grünbaum (1963: 202) writes that 'there is a rather simple way of seeing how manlike beings might discover that the cosmic time of their universe is closed, despite the seriality of the local segment of cosmic time accessible to their experience'. He then suggests that they might acquire empirical evidence for the disjunction of Circle Hypothesis and Line Hypothesis, and then invoke PII to rule out Line Hypothesis. We classify this as an a priori argument for Circle Hypothesis on the grounds that Grünbaum's argument for $(C \vee L) \rightarrow C$ is a priori. See note 6.

[8] Similar claims are made by Loeb (2010: 17-18) in connection with Nietzsche on eternal recurrence. See Jenkins (2012) for discussion.

We think that the distinction between ordinary empirical evidence and other kinds of evidence is clear enough in application, even if it is difficult to characterize in full generality. Evidence from a priori arguments and oracles is on one side of the distinction; our actual evidence for the existence of tables, and our actual evidence for the existence of electrons, is on the other side, as is the evidence for time without change from Shoemaker's case. We think that the evidence to be described in our example is clearly on the same side of the distinction as the evidence from Shoemaker's case. This will be sufficient for our purposes. From here on, the restriction to ordinary empirical evidence, as opposed to a priori and oracle-like evidence, will be left implicit.[9]

5.2 WEIR'S INDETERMINISTIC CASE

Sorabji (1988, 2006: 317) reports that Weir, in her unpublished dissertation (1986), describes a possible situation in which one has evidence for Circle Hypothesis over Line Hypothesis.[10] Here is Sorabji's characterization of Weir's idea:

> An empirical consideration has recently been suggested by Susan Weir. We should first need some evidence to narrow the correct choice of descriptions down to these two, the circular and repetitive descriptions. We should need evidence, that is, that everything had happened in exactly the same way before. Perhaps inhabitants of circular time could remember things as having happened in exactly the same way before, and even remember remembering. But we must be careful that this first piece of evidence is not of a totally deterministic character, suggesting that everything happens inevitably. For the second piece of evidence we want is something that suggests that a few things at least are *not* required to happen as they do. Taking those two pieces of evidence together, we could reason that it was not likely that world history would repeat itself exactly again and again, unless it was actually required to do so. Since the evidence of indeterminism would show that it was not required to do so, we should have reason to side against the hypothesis of repetition and to prefer the hypothesis of a single circle of time. (1988: 180)

Basically, the idea is that, if we have evidence E_A for the disjunction of Circle Hypothesis and Line Hypothesis, and if we have evidence E_B for indeterminism, then we have evidence, namely $E_A \& E_B$, specifically for Circle Hypothesis. This is because, were indeterminism true, we would not at all expect an infinitely repeating pattern. For that would require the effectively infinitesimally unlikely coincidence of an infinity of "indeterministic choices" being made in exactly the same way.

Weir describes a situation in which one's reason for believing Circle Hypothesis is probabilistic and runs through a belief in indeterminism. In the next section, we describe a situation in which one's reason for believing Circle Hypothesis is not probabilistic but appeals directly to simplicity of laws, much in the manner of Shoemaker's case.

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[9] One might suggest that the notion of ordinary empirical evidence can be characterized simply as *non-testimonial* empirical evidence. We have doubts about this suggestion. First, ordinary empirical evidence often involves testimony. Second, and conversely, we might be able to describe cases in which we have non-testimonial evidence that is relevantly oracle-like, and therefore not ordinary empirical evidence. We could discover a natural phenomenon that, perhaps as a matter of weird, brute fact, in effect functions as an oracle. Suppose we discover that there is a tree with the following feature: if one writes a question on a piece of paper, crumples it up, and stuffs it into a hole in its trunk, the tree delivers an answer one year later, which can be read off a core sample of its tree rings, when those rings are decoded according to a simple rule. We could then acquire evidence of the tree's reliability in a straightforward way. Such a tree might yield evidence that Circle Hypothesis is true, and this might count as non-testimonial evidence. But such evidence would still be relevantly similar to evidence from an oracle, in that it would not be ordinary empirical evidence.

[10] Sorabji (1988: 180) says that Malcolm Murchison suggested a similar idea in conversation with Sorabji.

6. THE MAIN ARGUMENT

We now describe a possible situation in which you would have empirical evidence for Circle Hypothesis over Line Hypothesis, without having evidence for indeterminism. We begin with a simple case that makes the overall strategy clear. In section 7, we consider a more complicated case in response to an objection.

Case 1. In this situation, you have evidence that

(i) either Line Hypothesis is true or Circle Hypothesis is true.[11]

You also have evidence that the length of an epoch (if Line Hypothesis is true) or of time as a whole (if Circle Hypothesis is true) is 12,000 years. Presumably any explanation of how you have the first sort of evidence will also explain how you have the second sort of evidence. Particles of a certain kind, *F particles*, have been observed in widely varying places, times, and conditions. A bit more fully: people have observed a whole bunch of particles exactly alike in terms of various physical properties – such as mass, spin, electric charge, etc. – and thus also exactly alike in terms of many aspects of their behavior. So it is inferred that each is of the same *natural, physical kind* and they are dubbed *F particles*. In all cases of which you are aware, it is found that an F particle begins to exist then ceases to exist exactly 12,000 years later. The observations are made and recorded by overlapping generations of scientists. This, it seems, would amount to evidence that

(ii) all F particles have a duration of exactly 12,000 years.[12]

Drawing out one consequence so far: you have evidence that F particles have a duration that exactly matches the duration of one epoch (Line Hypothesis) or the duration of circular time (Circle Hypothesis); this means that each F particle (at least, each F particle that *begins to exist* – see (iv) below) ceases to exist exactly when a lifetime intrinsic duplicate of it begins to exist (Line Hypothesis) or when that particle itself begins to exist (Circle Hypothesis).[13]

Continuing on, it seems that, for some individual particle o, you could subsequently acquire strong evidence for the following:

(iii) o is an F particle.

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[11] Newton-Smith seems willing to grant that this is possible, somehow. The details can be filled in in various ways. Perhaps, on your hard-drive, you have snapshots, of various resolution and quality, of the whole internet taken at 1 second intervals. You have 12,000,000 years worth of such snapshots, divided into 1000 volumes, arranged from most pristine to most corrupted. Each volume covers a 12,000 year epoch of the internet. All evidence indicates that the epoch, call it e_0, running from the present time back to 12,000 years ago, is a perfect duplicate of the immediately preceding 12,000 year epoch, call it e_{-1}, and that e_{-1} is a perfect duplicate of the 12,000 year epoch, call it e_{-2}, immediately preceding it, and so on back to e_{-999}, though at that point the files are highly corrupted and unreliable. Likewise, as time passes, the pattern continues to play out as one would expect: the snapshots of the internet taken tomorrow match those taken 12,000 years earlier, 24,000 years earlier, 36,000 years earlier, and so on for 1000 iterations. Your computer and hard-drive might be objects that have persisted through an interval that is at least 12,000,000 years long and contains 1000 duplicate epochs, or they might be objects that have 'wound around' the 12,000-year-long circle of time at least 1000 times, having, at each moment, 1000 different token representations of the same 12,000 epoch.

[12] That an epoch, or circular time itself, has a duration of 12,000 years does *not* guarantee that a particle won't last *longer* than 12,000 years; see the discussion in section 3.

[13] For neatness, let's suppose that each F particle, or its corresponding worldline, is topologically open at its beginning and topologically closed at its end.

(iv) o never begins to exist, never ceases to exist, and exists at all times; it has a career that is topologically and metrically like time as a whole. If Line Hypothesis is true, then o has an infinite duration, not a duration of exactly 12,000 years. If Circle Hypothesis is true, then o has a duration of exactly 12,000 years, not an infinite duration.[14]

There might be an ancient but sophisticated laboratory where such a particle is constantly monitored, and ample evidence exists that overlapping teams of scientists and technicians have monitored it continuously for the past 12,000 years, immediately prior to which, and without any gaps in the monitoring, it was monitored in an exactly similar way by an exactly similar sequence of teams for 12,000 years, immediately prior to which it was monitored in an exactly similar way by an exactly similar sequence of teams for 12,000 years, . . .[and so on for 1000 iterations] . . ., at which point our records give out.

Case 1 is possible, and if you found yourself in it, you would have evidence for the conclusion that time is circular, not linear. You have evidence for (i)-(iv), and they entail that Circle Hypothesis is true, hence that time is circular, not linear.

7. OBJECTIONS AND REPLIES

OBJECTION 1: After you learn (iii) and (iv), you no longer have good evidence for (ii), namely, that all F particles have a duration of 12,000 years. A rival hypothesis is (ii*), that some F particles are infinite in duration, and others – all the rest – are 12,000 years in duration.

REPLY: But (ii) is simpler than (ii*), and both are compatible with all the observed data in the case. So, unless there is some reason to prefer (ii*), it would seem that (ii) is preferable all things considered. Someone might suggest that you should prefer (ii*) because circular time is impossible. We reply by granting that (ii*) should be preferred by those who believe that circular time is impossible on the basis of some independent argument, some argument that does not depend on the claim that it is impossible to have evidence for circular time. But our target audience consists of those who do not accept any such independent argument. It consists of those who either (a) do not believe that circular time is impossible or (b) do believe that it is impossible, but only on the basis of their belief that we could never have evidence for it. (We suspect that very few contemporary philosophers would admit to being in group (b).) Those in group (a) will not appeal to the impossibility of circular time to justify a preference for (ii*). If those in group (b) make such an appeal, they beg the question against our argument that one *could* have evidence for circular time.[15]

OBJECTION 2: One can concede that (ii), the hypothesis that all F particles have a duration of 12,000 years, is simpler than (ii*), the hypothesis that some F particles have a duration of 12,000 years, while others are infinite in duration. However, the loss in simplicity in the shift from (ii) to (ii*) is less than the loss in simplicity in the shift from linear time to circular time, which requires altering global temporal topology.

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[14] If Circle Hypothesis is true, o never begins to exist and never ceases to exist because its career is a loop, i.e., because it is an 'object loop', *not* because it winds around circular time (in the way discussed in section 3) infinitely into o's personal past and infinitely into o's personal future. On object loops, see Sorabji (1988: 165-183, 2006: 320-322), Hanley (2004), Gilmore (2007, 2010), Eagle (2010a, 2010b), and (Lewis 2023: 35-37).
[15] This dialectic precisely mirrors an aspect of Shoemaker (1969: 368).

As a result, Line Hypothesis plus (ii*) constitutes a package that is preferable, all things considered, to Circle Hypothesis plus (ii). (We thank an anonymous reviewer for suggesting this objection.)

REPLY. This talk of 'altering' global temporal topology, merely to accommodate a simple system of laws, suggests that linear time is always the default hypothesis, and that circular time is an exotic alternative to be accepted only under duress. We deny this. We think that, in the context of our F particle case, there is no default. The two hypotheses should start out on equal footing in that setting. Likewise, we don't see any reason for supposing that the hypothesis of linear time (as such) is simpler than the hypothesis of circular time (as such). That is, we don't see any reason for supposing that there is *a* respect in which any hypothesis of linear time is simpler than any hypothesis of circular time, or vice versa.

For what it's worth, the existing literature seems to share our assumption that the two rival hypotheses are roughly equally simple. Without that assumption, there would be a clear reason for preferring one hypothesis to the other, and the standard view seems to be that there is no such reason.

However, if we were to concede that linear time is simpler than circular time, the question would arise, 'Could one acquire some countervailing evidence in favor of Circle Hypothesis over Line Hypothesis, perhaps even enough evidence to outweigh the advantage in simplicity associated with linear time?' Our F particle case would still bear on that question. Furthermore, we suspect that there are variants of the F particle case, involving many other kinds of particles and associated laws, in which the evidence for Circle Hypothesis (arising from the simplicity of laws governing the particles) would outweigh the evidence for Line Hypothesis (arising from the simplicity of linear time itself). We do not, however, concede that linear time is simpler than circular time.[16]

OBJECTION 3: After you learn (iv), you no longer have good evidence for (iii), that o is an F particle. Or, if we imagine that the alleged evidence for (iii) and (iv) comes simultaneously, then: against a background which includes evidence for (i) and (ii), nothing could be good evidence for the conjunction of (iii) and (iv). For the purposes of discussing this objection, it will be easier to think in terms of getting the alleged evidence for (iii) before getting the alleged evidence for (iv).

REPLY: Given how (we are supposing) you learn of the existence of F particles, there is a certain constellation of features that you justifiably associate with all and only F particles. Let's say that a particle with that constellation of features has an *F profile*; in that case, before learning (iv), you (correctly) took

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[16] An anonymous reviewer raised a related concern, framed as an inductive argument to support the hypothesis that there are two different kinds of F particles, finite and infinite. "Now, in the 12,000 year history of the universe, surely the scientific understanding developed. First, mass was discovered, later charge, then spin,... As such, the scientists of this world would have thought that all particles of the same mass were of the same sort until they discovered charge, then they could distinguish different classes. Then they later discovered spin, and so what were thought to be the members of a single category were again divided. So, now we have F particles with a finite life and F particles with an infinite life. Just another similar step in the progress of science. Wouldn't we thus have empirical evidence that disallows the inference to circular time?"

We reply first by conceding that there are worlds, similar to our F particle world, in which some observers have inductive evidence for believing that there are both finite and infinite F particles. However, we can add further detail to our case to guarantee that no one in that case has such evidence. We can stipulate that the evidence indicates that all particles with the same mass also have the same charge, the same spin, etc., so that there are no inductive reasons to expect F particles to subdivide into two natural subspecies, finite and infinite. Given all this, the evidence does not directly support the hypothesis that some F particles are infinite in duration. Rather, it directly supports the hypothesis that some F particles exist at all times, never begin or cease to exist, and have a topology and duration that matches the topology and duration of time as whole. It does not follow from this that some F particles are infinite in duration. We thank the reviewer for pressing us to address this point.

yourself to have evidence for: (F) All and only particles with an F profile are F particles. If, upon learning (iv), you come to reject (iii), that would involve rejecting (F) in favor of the alternative hypothesis: (F*) Some but not all particles with an F profile are F particles, as some other particles with an F profile are particles of a different (natural, physical) kind. But (F) is simpler than (F*), and both are compatible with all the observed data in the case, so, unless there is some reason to prefer (F*), it seems that (F) is preferable all things considered. For that reason, continuing to believe (iv), and Circle Hypothesis, is also preferable all things considered.

OBJECTION 4: The alleged evidence for (iv) is actually evidence for something weaker, which, in part, says (iv*): If Line Hypothesis is true, then *either* (a) o has an infinite duration, not a duration of exactly 12,000 years, *or* (b) there is an infinite string of F particles, each exactly 12,000 years in duration, and each coming into existence right where and when the previous one ceases to exist. And (i), (ii), (iii) and (iv*) are consistent with the truth of Line Hypothesis, because (i), (ii) and (iii) are consistent with (iv*, b).

REPLY: We suspect that our current Case 1-based argument can be defended against Objection 4 as is. However, this would involve an extended back and forth with the objectors, which readers are likely to find inconclusive. Fortunately, there is a less tedious and more convincing strategy available. We will shift our focus to a more complicated variant of our first case:

> Case 2. In this situation, you have evidence that spacetime is Newtonian in its geometrical structure, so there are facts about absolute velocities. You inhabit a planet that is absolutely at rest, and you have evidence of this. Certain particles, for example, tend toward zero absolute velocity unless acted upon by a force. Further, you have evidence that
>
> > (i) either Line Hypothesis is true or Circle Hypothesis is true.
>
> You also have evidence that the length of an epoch (if Line Hypothesis is true) or of time as a whole (if Circle Hypothesis is true) is 12,000 years.
>
> Particles of a certain kind, *F particles*, have been observed in widely varying places, times, and conditions. A bit more fully: people have observed a whole bunch of particles exactly alike in terms of various physical properties – mass, spin, electric charge, etc. – and thus also exactly alike in terms of many aspects of their behavior. So it is inferred that each is of the same *natural, physical kind* and they are dubbed *F particles*. Further, you have ample evidence for the following generalizations:
>
> > (ii) an F particle begins to exist in a region r at a time t if and only if two G particles collide there and then,
> >
> > (iii) an F particle ceases to exist in a region r at a time t if and only if two G particles are emitted there and then.
> >
> > (iv) for each F particle x, the duration-in-years of x is equal to 12,000 + n, where n is x's 'mileage', the total spatial distance it has traveled through absolute space, in thousands of astronomical units (kau). (1 kau = 1000 au.)
> >
> > (v) no F particles move faster than .9 kau per year.

According to (iv), the less an F particles moves, the briefer (and closer to 12,000 years) its life. An F particle that has accumulated a total of mileage of 1 kau over its entire life will have a lifespan of 12,001 years exactly. An F particle whose mileage is .0001 kau will have a lifespan of 12,000.0001 years. According to (v), no F particle moves fast enough to 'outrun death'. No F particle can add more than .9 years to its lifespan per year.

Drawing out one consequence so far: you have evidence that an F particle that is always absolutely at rest will have a duration, 12,000 years, that exactly matches the duration of one epoch (if Line Hypothesis is true) or the duration of circular time (if Circle Hypothesis is true).

Continuing on, for some individual particle, o, you subsequently acquire strong evidence for the following:

(vi) o is an F particle.

(vii) o is always absolutely at rest.

(viii) o never begins to exist, never ceases to exist, and exists at all times; it has a career that is topologically and metrically like time as a whole. If Line Hypothesis is true, then o has an infinite duration, not a duration of exactly 12,000 years. If Circle Hypothesis is true, then o has a duration of exactly 12,000 years, not an infinite duration.

You have evidence for (vi) – (viii) in the form of records from an ancient laboratory that has been continuously monitoring o, as in case 1. The laboratory contains a 'particle immobilizer', which provides evidence that o is always absolutely at rest. The evidence in support of (viii), the claim that o never begins or ceases to exist, will be especially strong. The laboratory can detect G particles, which according to (ii) and (iii) are present whenever an F particle begins or ceases to exist, and the laboratory has never detected G particles in the vicinity of o.

Case 2 is possible, and if you found yourself in it, you would again have evidence that time is circular, not linear. You would have evidence for (i) – (viii), and they entail that Circle Hypothesis is true, hence that time is circular, not linear.

Case 2 avoids Objection 4. According to that objection, you do not have evidence that o never begins or ceases to exist; rather, as far as you can tell, o is just one in an infinite string of F particles, each of which comes into existence where and when the previous one ceases to exist. This point clearly has no bite against Case 2. In this case, you have independent evidence to the effect that G particles are present whenever and wherever an F particle begins or ceases to exist, and you also have evidence that no G particles are present anywhere in the spatiotemporal vicinity of o. One could reply by proposing a version of the Objection 4-hypothesis on which (ii) and (iii) are rejected; but whatever is proposed to replace (ii) and (iii) (and it's not obvious what that would be), this hypothesis would clearly be less simple than the otherwise-equally-good hypothesis that (ii) and (iii) are true, time is circular, and o is an F particle whose career is a loop.

Finally, it is worth addressing a variant of Objection 1 relevant to Case 2. One might claim that, in Case 2, what your evidence supports is not (iv), according to which a given F particle has a duration in years of 12,000 + n, where n is the particle's mileage in kau. Rather, what the evidence supports is (iv*), which says if n is the particle's mileage in kau, then if n = 0, the particle's duration is infinite, and if n > 0, then the particle's duration in years is 12,000 + n. We grant that (iv*) also fits the data. We merely note that (iv) is simpler than (iv*) and otherwise equally good.

It may be worth noting, further, that (iv*) is not merely *less simple* than (iv). Rather, (iv*) is especially ugly and ad hoc. It tells us that, the less an F particle moves, the briefer (and closer to 12,000 years) is its life, unless it never moves at all, in which case its life is, surprisingly, infinitely long. This deserves emphasis. Suppose that (iv*) is true. Now consider a list of particular F particles, ordered by total lifetime mileage, from greatest to least. We start with high-mileage F particles, which have very long lives. As we proceed down our list, the F particles we encounter have lower and lower mileage, and correspondingly shorter and shorter lives. Finally we reach an F particle that has a total lifetime mileage of 0 kau. We might expect its life to be shorter still. But, according to (iv*), its life is, not merely *not* shorter than the others' lives, and not merely *longer* than their lives, but in fact, *infinitely long*!

We conclude that (iv) is preferable all things considered. For what it's worth, Shoemaker's argument concerning time without change appeals to simplicity in the same way. Shoemaker's preferred generalization about sectors A, B, and C is that they undergo local freezes every 3, 4, and 5 years, respectively. If that's right, then the universe undergoes a global freeze every sixty years. As Shoemaker notes (1969: 372-373), there is a rival generalization that fits the data while being consistent with the view there are no global freezes. Roughly, the rival generalization says that sectors A, B, and C undergo local freezes every 3, 4, and 5 years, respectively, aside from would-be 'global freeze years', which are skipped. Shoemaker's generalization is preferable to its rival merely on grounds of simplicity. The same is true of our (i) – (viii) and Circle Hypothesis.[17]

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