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On Effects Preceding Their Causes

Zachary Rojas
University of Colorado Boulder

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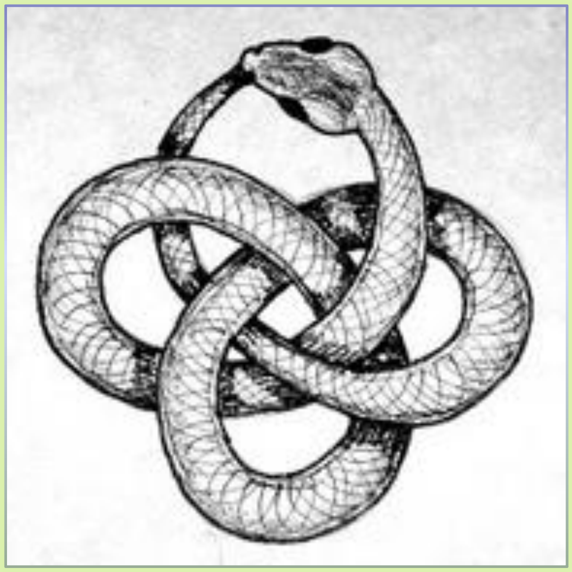
Zachary A. Rojas

Department of Philosophy



Advised by

Michael Tooley, Department of Philosophy

Committee Members

Wesley Morriston, Department of Philosophy

Lewis O. Harvey Jr., Department of Psychology

University of Colorado at Boulder

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Abstract

The general topic of this paper is causality, or the metaphysical relationship between causes and effects. More specifically, I am writing about retrocausation – the occurrence of effects before their causes – and some related contemporary arguments. The first section covers topics in the philosophy of time, with special consideration being paid to the temporal relations between events. It is here that I defend the view of time called Growing Block Theory. The second section is about some arguments concerning the logical possibility of effects preceding their causes. After briefly explicating some arguments for and against such a possibility I critique a particularly strong argument against the logical possibility of retrocausation from causal loops and find it wanting. The third section is an account of some psychological experiments that are supposed to show that a type of retrocausation, namely precognition, has been demonstrated by research participants. I will explain some reasons why precognition is very probably *not* the appropriate explanation of the experimental results. The fourth section concludes this paper with a discussion about causal asymmetry, which could be a reason given for believing time is asymmetric. I claim that reality is underwritten by an objective causal asymmetry that is logically independent of the ways human beings cognize reality, but that is not to say retrocausation in a certain sense is necessarily impossible. It is because objective causal asymmetry is a contingent fact of reality that it is possible for effects to precede their causes insofar as temporally-opposite directed causal processes possibly occupy the same spatial region in at least some instances, given a causal analysis of time.

§1 Time

I am beginning this paper with an analysis of time. Time is important to the discussion of retrocausation because an instance of retrocausation is an instance of an effect temporally preceding its cause. A discussion of retrocausation is almost pointless without first having a clear idea of temporal precedence – viz. what it means for one event to be earlier than another, or later than another. My goal in this part is to defend what metaphysicians call Growing Block Theory (GBT) of time. I will broadly outline three popular theories of time and give reasons why GBT is true. Arguments about the relations between retrocausation and time will be considered in the next section, after an adequate theory of time has been developed. Hence, this part of the paper will be the foundational base upon which I will build arguments in subsequent parts.

Truthmakers

The first problem I am addressing is that of defining the conditions needed to be met by a satisfactory account of time. A theory of time must be able to explain the fact that some things change over time. A theory that is internally consistent will be measured in its predictive power by the elegance of its true causal explanations. So a satisfactory account of time will explain change in causal terms. It is without question that change occurs. The weather at noon on Sunday, for example, may be quite different than the weather at noon on Monday. At noon on Monday, it would be true that the weather has changed sometime between then and now. This is so because of the relevant changes during the series of moments beginning at noon on Sunday and ending at noon on Monday. A satisfactory account of time should allow for an elegant causal explanation for things like the changing of the weather from one day to the next. The more general the causal explanation, the more favorable the theory that predicted it is.

The allowance of causal explanations is related to another condition needed to be met by a satisfactory account of time. Given the problem of explaining change, a satisfactory account of time must accurately describe truthmakers for ontologically grounded facts about, at the very least, some given moment. What is it, for example, that makes it true *on July fourth* the statement "today is the Fourth of July"? Craig Bourne, in *A Future For Presentism*, phrases this condition as "the three conditions that any satisfactory account of time should [meet]: it allows us to state truths about the past; it wears its ontological commitments on its sleeve; and it ensures that truth-value links are preserved" (2006, Pg. 65). These three conditions are constellated around the appropriate description of truthmakers for things like *contingently necessary* past facts, facts about temporal relations, general facts about later states of affairs, and causal explanations. It is widely agreed that it is a logically contingent fact that a past event E occurred. After E has occurred it is thereafter necessary, in a certain sense, since it is henceforth impossible for the proposition that E occurred to be false at any later time. The proposition that E occurred is accordingly described as contingently necessary. An example would be the statement "the fact that Caesar crossed the Rubicon is true because Caesar did in fact cross the Rubicon in 49 BC and that event caused his crossing to be well-documented." It is the contingent necessity of this dated fact, about a concretely realized event, that makes it now true that Caesar crossed the Rubicon. If it were not the case that Caesar crossed the Rubicon in 49 BC, or at any other moment, then it would now be false that Caesar crossed the Rubicon. A lengthy discussion of truthmaker theories is not my aim in this paper. Nor is it my goal to defend any explicit truthmaker theory. An account of time is satisfactory if it at the very least makes consistent claims about the ontology of truthmakers of this sort.

The key features of this type of explanation could be that the change in question 1) presupposes the passage of time from one moment, now, to the next, or 2) appeals to intrinsic temporal relations between all moments that underwrite necessary facts about the happenings of all moments, or 3) requires the spontaneous creation of indexically dated facts that do not exist before now but are made true by some feature of reality. Combinations of options (1), (2), and (3) correspond to the terminology used by various tensed and tenseless theories of time.

Time and change

Sydney Shoemaker has argued, in *Time Without Change*, that time does not necessarily involve change (1969, Pg. 371).He makes reference to making an inference that time had elapsed during which no change occurs in any part of a cluster of regions in the same universe. We can think of his argument as depending on the logical possibility of a many-in-one causal system, the three spatio-temporal sections of which “freeze” and “unfreeze” all causal processes for the duration of exactly one year at regular intervals. Section A freezes every three years, B freezes every four years, and C freezes every five years. Because people living in one section would regularly observe the freezes occurring in one or two of the other sections, and could infer that their own section freezes by observing that other sections seem to “jump forward” at times during which their own section is frozen, it follows that they could infer that there is a temporal duration of one year out of every sixty in which no change occurs in all three sections because there is a global freeze. This could be done by setting up clocks near the boundaries between sections and measuring the relevant rates of change, or lack thereof.

This is different than a kind of change described by a tensed ontology of time. Shoemaker's argument depends on extensive change rather than intensive change. Extensive change is change in the relational properties of objects, or the intrinsic non-temporal properties of events. Intensive change is a matter of change in an event's relational temporal order in terms of the properties of pastness, presentness, or futurity. This contrast is important to the present discussion in the sense that the extensive change described by Shoemaker is not the same as the temporal properties of events changing over time. There has to be some additional fact, that brings about change in terms of the type of temporally "gappy" causality (processes with some duration between causes and effects) described by Shoemaker, which unfreezes everything, without itself changing, after a global freeze in order for the story to be consistent.

Tensed ontologies of time can reject the assumption that causes need not be temporally contiguous with their effects, as would have to be the case, to support the conclusion that temporal duration does not require change. Additionally, tensed theories of time assume that intensive change, like an events changing from being a present event to a past event due to the discrete passage of the present moment from one instant to the next, is not reducible to any kind of extensive change, or to permanent temporal relations like "being earlier than" or "being later than." Because this paper is concerned with the problem of retrocausation, and the extensive change described by Shoemaker is possible only if there are no spatio-temporally contiguous causal connections capable of bringing about change for the time during which sections are momentarily frozen, the following is important. First one must get clear about the importance of changing temporal properties – pastness, etc. Second, one must consider the possibility of an effect being temporally separated from its cause.

McTaggart's taxonomy

In *The Unreality of Time*, J.M.E. McTaggart introduces the notions of the A-series, B-series, and the C-series as representations of the ways that events could be temporally arranged. The A-series consists of groups of past and future moments which are separated by the present moment. As time elapses, the analytically basic temporal properties of events change from being future to being present and finally to being past. The B-series consists in a group of moments which all stand in permanent temporal relations to each other. Accordingly, propositions about past and future events are reducible to earlier-than or later-then relations. The term "present moment" picks out a particular instant that is *tenselessly* temporally located later than some moments and earlier than others. Tenseless temporal locations are similar to the relational properties of integers along a number line, the statement "3 is less than 4" is tenselessly true regardless of *what time it is*. The C-series is a series of arbitrarily discrete moments. As there is no temporal direction, or intrinsically directional temporal properties, built in to the arbitrary series "A E Q B", there is no temporal direction or intrinsically relational properties built in to the C-series. An example of a C-series description of time is the history of the world described strictly in terms of dates at which events occurred. It is not unless one can say something in addition to the date of a C-series timestamped event, like "is earlier than," or "is currently present", that the notion of temporal precedence is relevant. An example of doing so would be stating that the present year is 2013, and an earlier year is 2012. The goal of this section is to give a tenseless description of time that appeals to the concepts of presentness, pastness, and the later-than relation. A discussion of the debate between tensed and tenseless accounts of time will be necessary, as is a brief discussion of precedence and causality.

The tensed and tenseless time debate

Many philosophers follow McTaggart's lead in broadly distinguishing between A-type and B-type theories of time. A-type theories describe the ontology of time in terms of the present moment, or as a series of moments that *tenselessly* began in the past and includes all moments past, present, and future. The B-type theories describe the ontology of time in terms of facts about eternally fixed temporal relations which apply to a series of moments whose ontological status are always the same. The distinction between A- and B-type theories is based on whether a complete theory claims that time is basically tensed or tenseless.

If time is basically tensed, then tensed temporal properties like past, present, and future are not reducible to tenseless temporal relations like "earlier than" and "later than". Put in common terms, the sentence "the year 1922 occurred earlier than this current year" would be read "the year 1922 occurred earlier than the present", where the term *present* refers to some special property that an event has only once – viz. when it is present, or not earlier or later than this very moment. The term "now", on the tensed view, indexically refers to the instant of time that is ontologically distinct in the sense that we are immediately aware of this moment, right now, unlike any other. The key point of a tensed view of time is that the concepts of past, present, and future correspond to mutually exclusive tensed properties instantiated in events as time passes. An objection made by Michael Tooley (1997) to a strictly tensed view of time is that the concept of the future, rather than being analytically basic, itself needs to be analyzed, to avoid circularity. The natural way of doing that is in terms of the idea that the future is what is later than the present. If time is basically tenseless, then such tensed properties are reducible to tenseless relations. A B-type thesis is just the contrapositive of an A-type thesis.

A popular reason for thinking time is tenseless is that (i) the A-series is essential to time because time demands change, and both the B- and C-series without an appeal to the A-series do not describe extensive change of the sort required to notice the passage of time. (i) is problematic because (ii) the A-series, by itself, is incoherent because it leads to a contradiction or circularity. This is because the present moment was future, is now present, and will be past. Since these properties are mutually exclusive, in the sense that they cannot be co-instantiated, the A-series by itself generates a contradiction. The circularity comes about due to the inter-definitional nature of mutually exclusive tensed properties and the passage of the present moment from one event to the next. The same event cannot have all three tensed properties at once, so one must appeal to the B-series, the C-series, or both, in order to make sense of the passage of time. So B-theorists will generally accept (ii) and reject (i) on the grounds that a single event cannot be past, present, and future at once. An A-theorist will generally accept (i) and reject (ii) because one has an intimate sense of epistemic freedom in the present moment alone. A B-theorist's alternative to the tensed view is to reduce all the tensed properties to tenseless relations. As we will see, the best alternative is to analyze the concept of the future as being later than the present moment, and the past as being earlier than the present moment. This entails that the later-than relation cannot, on pain of circularity, be analyzed in terms of tensed properties. This leaves the present moment, and permanent temporal relations, as analytically basic. The next step is to analyze dates in terms of an independent B-series. This resolution to the tensed tenseless debate is prominently defended by Michael Tooley (1997), and supports the GBT of time. The reason why GBT succeeds where others fail will be clear after a short discussion about existential expressions.

Existential expressions

The appeal of A-type theories of time is probably motivated by what B-theorists would call an equivocation inherent in existential expressions in natural languages, like "there is such and such" in English. The proposition $(\exists x)Dx$ "there exists an x such that x is a dinosaur" could be interpreted in two radically different ways. A tensed way is to interpret the expression as meaning *past*-$(\exists x)Dx$ "it was the case there is an x such that Dx." Because A-theorists need to be able to say that dinosaurs are (tenselessly) among real entities (real in the same sense that unicorns, which are not among the set of really exiting things, are *un*-real), the expression is qualified in the past tense. It says, at once, that both "it was earlier true that dinosaurs existed" and also "dinosaurs are among the things that are real." A tenseless way is to interpret the expression $(\exists x)Dx$ as meaning just simply that dinosaurs are among real entities, in the same sense of the word *real* just mentioned. The key part of a tensed interpretation is that one past, present, or future tense must be added to specify expressions of the form $(\exists x)Dx$ – which is problematic for reason (ii) in the last paragraph. If the existential expression "there is" should be interpreted in a tensed way, then time is tensed because "now" and "past" really refer to ontologically distinct realms in which only the appropriate tensed properties obtain. If one should interpret existential expression "there is" tenselessly, then time is tenseless because all actual events are ontologically on par, despite the apparent passage of time.

A tenseless interpretation of existential expressions does not presuppose multiple tensed modes of existence like past, present, or future. To say (∃x)Tx *tenselessly* is simply to say that, with regard to all necessary facts about all moments, it would be true to say that a dinosaur exists at some moment. If all moments partake of an ontologically equivalent mode of existence (exist tenselessly), then a B-type theory of time gives the complete story regarding what makes propositions about tenseless temporal relations true or false. Let x occur during the year 1956 and y occur during the year 1957. The proposition "x is earlier than y" is true regardless of the date at which it is uttered; facts about tenseless temporal relations are meaningfully true or false both before and after the occurrence of the temporal relata in question. This example demonstrates the elegance of B-type theories. One need not analyze tenseless temporal relations such as the earlier than relation to give a meaningful story about what makes it true that x is always earlier than y. If the B-type theory is complete, then the fact that x is earlier than y is true because x occurred and y occurred sometime after that.

A tensed account of time could try to give a consistent story about what makes the truth-values of tensed temporal propositions, of the form Ne, Pe, Fe (meaning event e is Now occurring, e occurred in the Past, or e will occur in the Future, respectively), change as time passes. Assume e is an instantaneous event that occurs at 2:00. An instantaneous event may obtain only one of the three tensed properties of pastness, presentness, or futurity. Based on the mutually exclusive definitions of past, present and future, we can attempt to derive some consistent truths about the tensed status of e at a given time. Ne and Pe are false, while Fe is true, at 1:00. Pe and Fe are false, while Ne is true, at exactly 2:00. Ne and Fe are false, while Pe is true, at 3:00. The A-theorist's move is to make sense of mutually inconsistent tensed properties to the same event by qualifying existential expressions with tensed operators. The use of tensed expressions in English is the basis for analyzing the tenseless earlier-than/later-than relations in terms of tensed properties. Accordingly, we could just as easily say “there are/were/will be dinsoaurs later or earlier” as say “there are (tenselessly) dinosaurs,” so why not do so? Authur Priori, a prominent Presentist, defends the view that only the present moment exists. His strategy is to use a kind of tensed logic in which the logical form of past-tense propositions includes tensed operators combined with normal tenseless propositions. The expressions themselves are interpreted as being explicitly about the present moment. So propositions like “there were dinosaurs” have the logical form “*past*-(∃x)Dx – in the past(there *now* exist dinosaurs),” instead of as “(∃x)Dx – there are (tenselessly) dinosaurs which is the normal logical interpretation of existential expressions. But there are problems with A-theories – viz. it may be the case that statements like “I will watch the next *Back To The Future* Movie in the future, after it is made” are true now, but are false later. Suppose I despise Adam Sandler movies, and refuse to watch them, but that he is cast in the next *Back To The Future* Movie. The above statement would be both true and false insofar as we think the future tenselessly exists.

Presentism

Presentism is the idea that only the present moment exists; it is the thesis that there is exactly one mode of tensed existence in which everything that can occur actually does occur. The terms “past” and “future” are vacuous in this view. It is as though the present moment that is highlighted by our sentience at any given moment could be represented as the single illuminated frame of an infinitely rolling film reel. Only one frame is illuminated at any moment, but the projected image changes as subsequent frames are fed through the machine and illuminated one by one. The projected image corresponds to existence as the previous and subsequent frames correspond to (tenselessly) non-existent events. The key idea to Presentism is that any previous moment that is remembered during the present does not exist; memories of past events are said to exist, but those memories necessarily lack concretely realized referents. As an event (like lunch time) ends, in terms of Presentism, that event ceases to exist and another event (like study time) spontaneously begins to exist, and so on ad infinitum.

The problem facing a Presentist is that there are no concretely realized truthmakers for facts about events with the properties of pastness or futurity. Presentism is an A-type theory that analyzes time in terms of the tensed properties but cannot give a meaningful account of truthmakers in terms of the A-series or B-series in pain of circularity. A fatal objection to Presentism is that statements like “my birth, in the year 1987, is past at this moment in the year 2013” are neither true nor false on a Presentist account, which is absurd. In order for a statement like this to be either true or false, the referenced truthbearers must actually exist, and there must be some concretely realized truthmaker(s) capable of making it true or false. Since my birth is not presently occurring, the event does not exist on a Presentist account. Since the present year is 2013, based on the mutually exclusive definitions of tensed properties, and the assumption that only the present exists, the year 1987 does not exist either. This is absurd because it is a necessary fact that I was born in the year 1987, and I have changed since my birth insofar as I have gotten older. Presentism cannot give a meaningful account of change because to do so would refer to at least two different moments in which the truthbearer in question obtains one of two mutually exclusive relations to itself, namely being older or younger. So either Presentism cannot account for change, or Presentism cannot give a meaningful account of the relevant truthmakers. Either way the Presentist assumption that only the present moment exists leads to an absurd conclusion.

Eternalism

B-type Eternalist theories are tenseless in the sense that, even during the present moment, the existences of all moments are ontologically equivalent. The years 2012, 2013, and 9843 always *tenselessly* exist. In short, all moments, past, present, and future, would be said to exist in exactly the same tenseless mode. It is in virtue of this assumption of tenseless temporal relations between all existent events that there are necessary facts about all moments which stand in the truthmaker relation to all truthbearers. We can think of Eternalism in terms of the infinitely rolling film wheel again. In the case of Eternalism, the currently illuminated frame and all previous and subsequent frames correspond to existence. The difference between earlier and later moments is that all moments earlier than today are associated with facts that are in principle knowable, while all moments later than today are associated with facts that are in principle not knowable. In light of a later discussion about precognition, a point should be made here about determinism – the idea that all events are predetermined. The epistemic status of all later events, or now-future events, depends on the truth or falsity of determinism. If determinism is true, then future events are knowable in principle. If determinism is false, then future events are in principle unknowable. If an event does not stand in the appropriate temporal relations to all other earlier and later events, then that event does not exist.

The problem with Eternalism is that the type of causal explanations provided by such B-type theories do not elegantly account for change, or the perception thereof. According to B-type theories, an event X is necessarily temporally connected to another event Y – both before and after either X or Y occur. Let X represent facts about the state of a radioactive isotope before time t when it emits an alpha particle. Let Y represent facts about the state of the same radioactive isotope at time t* after it emits an alpha particle. X involves facts about the mass and charge of the isotope which are not exactly the same as those involved with Y. This is because alpha decay is a process by which an isotope indeterminably changes states. The key point is that the alpha decay between time t and time t* is not entirely causally determined. Until that moment, there is a non-zero probability that it will decay and a non-zero probability that it will not decay. The release of the alpha particle is underdetermined, both before or after time t, though that event is causally determinate at every moment after time t. There are no natural facts before time t which necessarily make it true that Y occurs exactly as it does. At moments before time t, it is just as likely that Y occurs at t* as it is as likely that Y does not occur at t*. B-type theorists have no elegant causal explanation for this kind of event.

Similar arguments from indeterminism can made against the B-type theories in terms of free will and top-down mental causation. If one freely chooses to execute an action, then that action is underdetermined until the moment it is executed. Again, the key point is to not confuse the notions of determinability and determinateness. The action is determinate in the sense that it is a sufficient condition for some later actions. But it is underdetermined in the sense that the action could have happened otherwise, or not at all, insofar as another freely executed action could prevent its occurrence. My goal in this section is not to enter in to a lengthy discussion of free will, or an interpretation of quantum mechanics, but to give examples of events that seem to be underdetermined and determinate. If it seems like freely executed actions or radioactive decay are such events because they could have happened otherwise, then there are no facts or concretely realized truthmakers for at least some events of that type. Some B-type theorists like David Lewis (1979) have tried to explain underdetermined determinate events in terms of separate metaphysically robust realities which enter into temporally forward-branching causal relationships at some times but not at others. Such explanations are not elegant because they posit the existence of multiple ontologically equivalent realities in order to causally explain particular concretely realized events.

Growing Block Theory

GBT is the notion that, at any given moment, all earlier moments tenselessly exist and that no later moments yet exist. The term "future" is analyzed as being whatever exists later than the present. The present moment is like an infinitely thin hypersurface of reality along which new facts are generated and ordered in terms of the C-series. As an underdetermined determinate event occurs, the determinate facts about it are added to the sum of all necessary facts about reality-simpliciter, and that event becomes concretely realized as a part of existence. It would presently be said that all earlier events are like a static block of reality to which additional surfaces are constantly being added. The present is the boundary between reality and unreality because earlier moments now exist and later moments do not now exist. We can think of reality as a rolling film projector in terms of GBT, such that the currently illuminated frame has only two real spatial dimensions, all previously illuminated frames exist, and subsequently illuminated frames do not exist until they are instantaneously created, fed through the machine, and become previously Illuminated frames. Given a causal analysis of time, according to which the direction of time is analogous to the direction of causation, if the past had been different then so too the present would have to be different. This is because the way the present moment is causally depends on things that happened earlier. But there is no temporally opposite counterfactual dependence relating the present to the way the future will be. So, whatever happens later than *now* depends on present and past events, and causal laws.

GBT is not subject to the same previously acknowledged criticisms of Presentism or Eternalism. GBT explains change by an appeal to facts about the temporal relations between all earlier events and spontaneously generated present events. The present events are sometimes underdetermined determinate events, like the decay of an isotope. As underdetermined determinate events become parts of the history of the world, some particular aspects of reality undergo various transformations which are represented as necessary facts. The events comprising the history of the world are truthmakers for appropriate truthbearers insofar purportedly future events are not appropriate truthbearers.

§2 Retrocausation

Because there is a diverse literature on retrocausation I will begin this section broadly, and narrow the focus to one particularly strong argument toward the end. The first pages will provide an overview of some simple arguments involving the idea of effects occurring before their appropriate causes. The last pages will be an exposition of D.H. Mellor's time machine argument against the possibility of retrocausation. My hope in the first half of this section is to provide a brief precursor to the argument in the second half. As Mellor's argument is among the most recent literature on retrocausation, I will begin with the least recent and proceed chronologically along the line of arguments until culminating with Mellor's argument.

Michael Dummett's chief retro-dances for earlier bravery

Serious discussion of retrocausation began with papers written by Michael Dummett and Antony Flew for the same symposium entitled *Can an Effect Precede its Cause?* Both authors wrote about strict deterministic (retro)causation of the form "C always causes E" or "applying heat to copper always causes it to expand." This is different than underdetermined causation of the form "there is a certain non-zero probability that C causes E" or "there is about a fifty percent chance that my flipping a coin will cause it to land heads-up." Dummett advanced the notion that retrocausation is logically possible given the right conditions. Flew argued the opposite, citing a contradiction inherent in the notion retrocausation. Dummett defends a view that C causes E IFF C's occurrence is a sufficient condition for E's occurrence. This view is distinct in the sense that events of type C could be both causally sufficient and causally necessary for events of type E. If the latter is the case, then events of type E are *sufficient*, but not *causally sufficient* for events of type C. The distinction between the terms sufficient and causally sufficient is important because one can imagine a world in which an earlier event E causally necessitates the bringing about of a later event C, but the occurrence of C is itself is causally sufficient to bring about the earlier event E. Likewise, one gets the interesting conclusion that if such an earlier event E does not occur, then it will be possible to try to cause the later event C, but one would invariably fail because E is a necessary condition of C's later occurrence. A cause is simply the sufficient condition of its effect, regardless of the temporal ordering of each occurrence. So there is no contradiction in a cause occurring after its effect because the term "cause" is not analyzed as the earlier of two constantly conjoined events and the term "effect" is not analyzed as being later than its cause. If an event seems to have had no previous or simultaneous causes, why not simply suppose it has not yet occurred?

Retrocausation is possible if a retrocause is the best explanation of some unknown but possible earlier event. Dummett gives an example to illustrate the point (1964, Pg. 349). Imagine a shamanic chief who executes the appropriate dances for a brave hunt while the hunters of the tribe are away. It takes two days for the hunters to return. The chief's dancing during those two days causes the hunters to have been brave for the hunt. An objection is that if the hunters were brave, then if the chief does not dance during those days, the hunters still would have been brave. But the chief could respond by saying the propositions "if I dance, then they were brave" and "if I do not dance, then they were not brave" are logically compatible with the truth of the statement "they were brave." But then one could argue such a possibility is absurd because doing something now in order for something to have happened is identical to simply doing something now in order to learn whether or not something had actually happened. This is because the past is fixed; if it had not happened, then one could not possible do anything now to ensure that it did happen. If it did, then one could not make it not happen. Dummett's claim is basically that there is no intrinsic temporal asymmetry involved in causality.

Antony Flew's world of levers

Antony Flew argues that retrocausation is impossible because it would entail that it is possible to change the past. Since the past cannot be changed, retrocausation is not possible. If so, then this is a prima facia reason to think retrocausation is not possible. Flew's analysis of causation imports the notion of irreflexive relations of temporal priority between all causes and effects. C causes E if C and E are constantly conjoined, and C occurs before E, while E occurs after C. As long as nothing else prevents its effect from occurring, according to Flew, a cause is the earlier component of a binary causal process while an effect is the later component. As the notion of retrocausation describes an effect E preceding its cause C, and causes always precede their effects, retrocausation involves a contradiction in terms – which is absurd. Flew's account holds that the notion of retrocausation represents a conceptual impossibility because an effect preceding its cause would be a contradiction in terms.

Without such a strictly forward-directed analysis of causality, the concept of a cause is counterintuitive because once an actual retroeffect would occur the retrocause could not possibly be prevented from occurring, or else the retrocause is not a sufficient condition for the retroeffect's occurrence. If a retroeffect does not occur, then it would impossible to do anything later so that it does occur because the reason above, and the fact that causality at a temporal distance is implausible given the possibility that the interim duration could actually harbor relevant causal factors. This is because once an action is determinate, it would be either redundant or fruitless to try to prevent it (1954, Pg. 62). Flew also argues that retrocausation is impossible in a deeper way than with the forward-directed analysis of causality. By defending a bilking argument of the same sort originally expounded by Max Black. Flew does not consider the possibility of the appearance of retrocausation from the perspective of one of many oppositely-directed causal processes. If causation is relative to things like reference frames, or initial boundary conditions, then there is no intrinsic temporal asymmetry of causality. The debate about the intrinsic temporal asymmetry of causation will be further covered in §4.

Bilking the retrocause like Max Black

Max Black (1955-6) argues retrocausation is impossible because one could arrange to prevent an allegedly later retrocause of its earlier retroeffect and thereby nullify any notion of retrocausal relationships of that type. This is called the bilking argument. If one could not prevent the alleged retrocause, then it would seem as though the earlier "retroeffect", or some combination of earlier causes, actually caused the later "retrocause". The term retrocause would be meaninglessly conflated with the term effect in this case because the allegedly later retrocause would be identical to an effect of the allegedly earlier retroeffect together with the relevant action.

Consider the case of Zoltar buying a lottery ticket because he has a premonition that the winning numbers are XYZ. If his premonition is correct, then there is a causal chain connecting the selection of XYZ backward through time to his premonition. The selection of XYZ would be the retrocause, and Zoltar's premonition would be its retroeffect. Now suppose, unknown to

Zoltar, the lottery is rigged so that Zoltar's evil twin can choose the winning numbers before they are announced. Zoltar's evil twin hears Zoltar bragging about his premonition. He decides to select ABC in order to prevent Zoltar from winning. Assuming the winning numbers are selected, there are two possibilities. Either Zoltar's evil twin chooses ABC, thereby disproving any precognition, or Zoltar's evil twin is unable to prevent the selection of XYZ. The latter's occurrence could be explainable in terms of a forward causal chain connecting Zoltar's "premonition" to the selection of the winning numbers. Labeling the earlier event as the retroeffect would be arbitrary in the same sense that labeling the eating of an omelet as the retrocause of a chicken laying the eggs is arbitrary.

Michael Scriven precognizes the big picture

Michael Scriven suggested the notion of a kind of retrocausation in which an effect is partially determined by later causes and partially determined by earlier causes. This is important because it motivated philosophers to acknowledge the possibility of undetermined retrocausation. He also described some necessary features of any experiment designed to demonstrate an instance of retrocausation. These features are 1) the use of many reproducible isolated instances as evidence, 2) the use of statistical inference to conclude any significant retrocausal interaction, and 3) the use of rigorous randomization in the employment of retrocausal variables as part of the experimental design. 1-3 are important in the next section.

Scriven's points are best illustrated by considering the following thought experiment. On Monday some experimenters randomly select a sample of people to try to draw a representation of a picture that will be randomly selected by experimenters on Tuesday. The pictures, drawn by a random group of people, are the data used as evidence. (1) is satisfied by this feature of the experimental design. After the pictures are collected and sealed on Monday, experimenters randomly select some picture with the best means of randomization presently available. (3) is satisfied by this feature. Then suppose there is a very significant statistical correlation between the drawings made by participants on Monday and the picture selected on Tuesday. We could then infer, based on statistical analyses of the data, that "there seems to be good prima facie reason for saying that the choice on Tuesday determines – to some extent – the drawings done on Monday" (1956, Pg. 5). Such a finding would satisfy (2). One could argue that some alternative explanations of the data should be considered more palatable. Some examples of some relevant competing hypotheses will be discussed in §3.

D.H. Mellor: from causal loops to Dr. Who's time machine

D.H. Mellor gives a two-part argument against the possibility of retrocausation. The essential part of a Mellor-style argument is that it depends on a causal analysis of time. The direction of time is accordingly analogous to the direction of causation. Let's say C starts a causal process which raises the probability of E's occurring, given the right necessary conditions. If E occurs, then C would be earlier than E, just as E would be later than C. Mellor starts by assuming that if retrocausation is possible, then causal loops would exist. His next step is to show that the existence of causal loops entails a contradiction. If so, then we have a clear refutation of the notion that retrocausation is possible (1998, Pg. 132-5). But there are problems with Mellor's reasoning. Causal loops do not exist if Dr. Who – a fictional character who has a time machine – backward time-travels *as a ghost*, like Ebenezer Scrooge from Dickens's *A Christmas Carol*, who cannot affect any changes in the outside world around him.

If an event C’s occurrence in a loop increases the probability of another event E’s occurrence and E’s occurrence increases the probability C’s occurrence, then there is a logically independent probability of C occurring and also a probability that is arbitrarily close to 1 that C will occur given the fact that C’s occurrence increases the probability of E’s occurrence and vice versa. Since the arbitrarily high probability of C’s occurrence is different than the logically independent causal probability of C’s occurrence given E’s occurrence, and both causal probabilities are entailed by the antecedent occurrence of C, it follows that such a loop could not exist. This is because an arbitrary probability of C’s occurring, given the logical independence of E’s occurrence, is inconsistent with the antecedent probability of C’s occurrence. The thought is basically that, If retrocausation is possible then causal loops are possible. Because causal loops are impossible, it follows that retrocausation is not possible.

D.H. Mellor’s argument on Pg. 135 of *Real Time II* (1998)

(1) If it is possible for Dr. Who to time-travel into the past, then it is possible that Dr. Who kills his grandmother before she has any children. (Premise)

(2) If Dr. Who kills his grandmother before she has any children, then it is impossible for Dr. Who to time-travel into the past. (Premise)

(3) If *p* entails *q*, then possibly *p* entails possibly *q*. (Premise)

From (2) and (3):

(4) If it is possible that Dr. Who kills his grandmother before she has any children, then it is possibly impossible for Dr. Who to time-travel into the past.

(5) In S5, if it is possible that it is impossible that *p*, then it is impossible that *p*. (Premise)

From (4) and (5):

(6) If it is possible that Dr. Who kills his grandmother before she has any children, then it is impossible for Dr. Who to time-travel into the past.

From (1) and (6), by the transitivity of "If . . . then - - -":

(7) If it is possible for Dr. Who to time-travel into the past, then it is impossible for Dr. Who to time-travel into the past.

(8) If it is possible for Dr. Who to time-travel into the past, then it is both possible for Dr. Who to time-travel into the past and also impossible for Dr. Who to time-travel into the past.

Therefore, **from (8),** it is not the case that it is possible for Dr. Who to time-travel into the past.

Mellor frames his argument in terms of a tenseless theory of time. He is supposed to have established the truth of a causal B-type analysis of time in previous chapters. Accordingly, the direction of causation in a given region entails the direction of time within that region. We are directly acquainted with a series of mental states as we are alive. This is called the causal form of inner sense, which is "infallible knowledge of the time order of our own experiences" (Mellor, Pg. 115). These mental states have neural correlates which are understood in terms of discreet facts about concretely realized events. The exact temporal ordering of events of this type subsequently causes the temporal order of mental states to appear ordered as such. An example of this could be witnessed by standing near a lightning strike. Almost immediately after the strike, one sees a bright flash of light. Shortly after, one hears the crash of thunder.

The visual perception is caused almost immediately by light dispersing, exciting the appropriate brain areas, and eventually giving rise to mental states associated with seeing lightning. The auditory perception is caused later by the subluminal sonic vibrations in a similar manner – the only difference being a differently augmented perception brought about slightly later than the visual one. In either case, the causal ancestry of the perception of lightning is traceable to one and the same strike. If the strike had occurred differently, then the perceptions of it would be different. Mellor traces causal ancestry of Dr. Who's time-travelling journey similarly to a single series of events – the outside world. These events include Dr. Who's birth, his parents' births, and his setting off into the past. Mellor sets out to disprove the possibility of backward time-travel by suggesting that there is a single basic universe-wide direction of time. He then points out the contradiction arising from one's not noticing the causal difference between the private direction of time inside the time machine, and the general direction of time outside it.

Here are my thoughts about the argument. The argument is committed to the position that the direction of time is analogous to the direction of causation. Because the argument depends on a causal analysis, the two oppositely-directed causal processes (viz. Dr. Who, and the outside world) actually represent two unique opposite directions of time. The argument would not prove the point intended to be proven by Mellor if Dr. Who is just always travelling backward through time relative to the outside world because his causal ancestry would not counterfactually depend on the history of the world. The contradiction only arises because Mellor, who defends a B-theory of time, does not acknowledge this difference between two oppositely directed causal processes. He calls the scenario an instance of retrocausation because the time of Dr. Who's grandmother's birth would be both earlier and later than the moment Dr. Who begins travelling backward in time from Dr. Who's reference frame. But retrocausation is not the same thing as the past once being one way, and then another. In terms of the growing block theory, as described in §1, which accounts for underdetermined determinate events, an instance of retrocausation is the determination of a past event by a present event. This is so because moments later than the present do not *tenselessly* exist.

If backward time travel is possible, then it seems like is instance of retrocausation, but only in terms of B-theories of time. The argument is valid if (1) and (2) are true. But there are some reasons to think (1) or (2) are false. Mellor's formulation of the argument interprets "If *p* then *q*" as a strict implication rather than as a material conditional. This means the sentence "If *p* then *q*" is being read as "*p* entails *q*." The premises I have labeled (1), if it is possible for Dr. Who to time-travel into the past, then it is possible that Dr. Who kills his grandmother before she has any children, and (2), if Dr. Who kills his grandmother before she has any children, then it is impossible for Dr. Who to time-travel into the past, do not sit well with the idea that Dr. Who's future is analogous to Dr. Who's grandmother's past and vice versa.

Consider the case of Dr. Who not being able to affect any changes in the world around him after he steps outside the time machine during the time of his grandmother's infancy. The time machine could be such that anybody who steps into it permanently becomes an immaterial mind and backward time-travels as a passive perceiver, but is unable to change the history of the world. Dr. Who's experience would be like watching an extremely realistic movie of the history of the world in reverse. If that is the case, then (1) is false. Mellor could reply by saying that Dr. Who would have to be able to at least raise the probability of the past changing.

In such a case, there would have to be bi-directional causation between the two processes. But if the past can change like that, then the past could change only so much that (2) is false.

Namely, it could be the case that Dr. Who is actually able to kill his grandmother and also that she is resurrected through human cloning and is then able to act as the precursor of Dr. Who's causal ancestry. The objection is that insofar as Dr. Who's time-travelling can change the past, it is possible that the past changes just enough so that story does not entail a contradiction. This would be a reason to think (2) is false. Again, it is only because Mellor does not properly distinguish between the nuances of two oppositely directed causal processes that a contradiction arises. In short, if (1) Is false, then (2) is vacuous. If (1) is true, then (2) is false. Because it is possible to imagine that Dr. Who has no causal efficacy over the past, or has just enough so the story is consistent, the argument is invalid. So Mellor's argument against the possibility of retrocausation fails to prove the intended point for the reasons above.

§3 Precognition

This section begins with a discussion about the possibility of supporting a hypothesis of precognition via some recent bilk-proof experiments. I am going to conclude by considering the relevance of the nature of time to precognition. Some clarification of relevant terms is in order before the discussion gets underway. A precognition, E, about a later event, C, is an example of retrocausation in terms of a tenseless view of time. This is because a later event, C, somehow r-causes an earlier precognition, E, it must happen in a way similar to which an earlier event causes a later memory of that event. It is a simple fact of human cognition that a phenomenon that depends on some appropriate things being consciously represented. Before something, the blueness of an object for example, can be cognized, a conscious representation of blueness must be caused by way of the brain processes that are correlated with consciousness. It is only after the brain processes occur that one can have an experience of the blue variety.

Overview

As noted in the previous section, in *Randomness and the Causal Order*, Michael Scriven set out some design features for precognition experiments. These features are 1) the use of many reproducible isolated instances as evidence; 2) the use of statistical inference to conclude any significant retrocausal interaction; and 3) the use of rigorous randomization in the employment of retrocausal variables as part of the experimental design (1956, Pg. 8-9). (1) is supposed to ensure the generality of causal explanations predicted by the theory being tested. If I ran the experiment I would want other researchers to reproduce my design and find similar data because that would mean the theories on which I base my explanations apply to their data as well. If other people run the experiment and find significantly different data, then those instances would be evidence that some relevant theories are falsified and my findings are false-positive statistical artifacts. (2) is basically standard practice in the social sciences like psychology. The thought is that the sample (smaller group of people) from which data is collected must be representative of the population (all people). Tests of statistical significance weigh the likelihood that the data supports general explanations in terms of a theory. (3) is important to precognition experiments because if a later r-cause C is a sensory stimulus truly chosen at random, then it would be impossible to do anything before C is chosen to prevent it from being chosen and bilk the alleged r-causal relationship. As Max Black pointed out, in *Why Cannot an Effect Precede Its Cause"*, r-causes may be bilked (1956, Pg. 54). If one thinks precognition E was caused by a future event C, and prevents E's occurrence after C occurs, then C does not cause E and C is not a precognition. But it seems to me that even the ability to prevent C, even if one does not actually do so, is enough to show that C is not the cause of E.

Psi-research and methodological practices

Some recent examples of precognition experiments, which fulfill the above criteria, have been published in by Daryl Bem's article entitled *Feeling The Future*. Bem concluded that precognition is the best explanation of the data and published his findings in the *Journal of Personality and Social Psychology* (2011). His paper discusses a few alternative explanatory hypotheses. Nine experiments involving over one thousand participants are reported in Bem's paper. The experiments are easily run on a home computer, and software packages for each experiment were made available online so anybody with a computer could replicate the experiments. For these reasons, (1) is satisfied by Bem's experiments.

Etienne Lebel and Kurt Peters, in *Fearing the Future of Empirical* Psychology, give a critique of Bem's research practices in terms of method-relevant beliefs and theory-relevant beliefs. Standard modal research practice MRP is "the accepted methodology empirical psychologists most commonly use in their research" (2011, 371). MRP is determined by method-relevant beliefs held by experimenters. Accordingly, tests of statistical significance are used to interpret the data gathered from all of Bem's experiments. There are various types of analyses, of various degrees of rigor, used to infer correlations, explain data in causal terms, and make novel predictions. Bem's chosen data analyses are one sided t-tests used to compare participants' hit rates (operationally defined as the percentage of "precognitions" out of all trials) – which ranged from about %51-53 overall, with the likelihood of obtaining the same data given random chance alone – which is estimated as %50. The participants did better than chance on a few trials out of every hundred. This data is statistically significant in terms of MRP, because of the large sample size, and because the reported p-values are lower than the chosen alpha-levels. P-values express the probabilities of obtaining the data given the truth of a null hypothesis or negation of the hypothesis of question. A lower p-value means it is more likely that the data is "significantly" different than chance given a correct rejection of the null hypothesis. Statistical significance is a technical term used to researchers to assess whether observations represent a correlated pattern of states of affairs rather than would obtain by chance. The significance of p-values is interpreted entirely in terms of researchers' chosen alpha-level. The alpha-level of a statistical

Hitrate = $(A + D) / (A + B + C + D)$

	Target is on the Left	Target is on the Right
Participant Prefers Left Picture	A (Hit)	B (Miss)
Participant Prefers Right Picture	C (Miss)	D (Hit)
	(A + C)	(B + D)

analysis indicates the probability that the observations represent false-positive correlations. Alpha-levels are chosen somewhat arbitrarily, by researchers, to provide an indication of significance. Standard MRP allows a 0.05 alpha-level to be used to determine significance. This could mean that five out of one hundred articles reporting correlations as “significant at a 0.05 alpha-level” are false-positives. Some of Bem’s colleagues ran alternative analyses of the reported data with different methods and found fewer significant differences between the participants’ performances and chance. Their approach will be discussed in a later paragraph of this section. (2) is met by these experiments.

In order to prevent bilking in these experiments, Bem designed the programs to randomly select stimuli C only a few milliseconds after participants made response choices E. Some versions of these precognition experiments used computer software to randomly select the stimuli. Others used a hardware based random number generator that randomly selects stimuli based on radioactive decay or diode noise. Hardware based random number generators are indeterminate in the quantum mechanical sense, and select stimuli more randomly than software based random number generators because they are determined by physical processes rather than pre-programmed algorithms. The use of hardware based random number generators was made by the one experiment which was not later reanalyzed and found not significant. The experiment in question will now be explained in greater detail. (3) is fulfilled by Bem’s experiments.

Imagine you are taking part in the following experiment. In front of you is a computer screen depicting two closed curtains. You are asked to select one of the two curtains to be opened in order to look at a picture behind it. The computer will randomly select a pleasant picture to be displayed behind one curtain and an unpleasant picture to be displayed behind the other. Only after you have chosen which one to look behind will the picture placement be randomly selected. You cannot possibly know what will be behind either curtain because there will be nothing behind either curtain until after you choose which one to look behind according to a growing block theory of time. This is because the present moment does not have the same ontological status as the future placement of pictures behind either curtain. Accordingly, propositions about the placement of the pictures behind either curtain are neither true nor false.

Some alternative explanations of the data

Assume you are somehow able to select the curtain behind which a pleasant picture will be displayed significantly more than you would by chance alone. Bem suggests we may explain this tendency in terms of one of four competing hypotheses (2011, pg. 410).

(A) *Precognition /retrocausation:* You somehow have cognitive access to information about future events that are not yet determined; the causal relationship between stimulus and cognition is reversed.

(B) *Clairvoyance:* You somehow have access to already determined information "in real time", information that is stored in the computer.

(C) *Psychokinesis:* You are somehow influencing the random number generator's placement of target pictures by the choices you make.

(D) *Artifactual correlation:* The output from the random number generator is inadequately randomized, containing patterns that fortuitously match your response biases. This produces some spurious correlation between your guesses and the computer's placements of the target pictures.

A reason might be offered for thinking the clairvoyance hypothesis (B) best explains the data depends on the computer implicitly "knowing" what will be displayed based on the algorithm used by the software-based random number generator. The thought is that if the participants are not demonstrating precognition because the causal arrow between the computer's "knowing" what will be selected and what participants select extends in the forward direction only, then the computer's "knowing" what will be selected causally determines participants' choices. The problem with this hypothesis is that if the random number generator involves any sufficiently challenging level of calculation, then even if somebody could clairvoyantly learn the complete state that the computer was in at the moment they were about to choose a curtain, as humans they would not have the sufficient arithmetical ability to perform the appropriate calculation, and thus determine which curtain would have a pleasant picture behind it.

A reason might be offered for thinking the psychokinesis hypothesis (C) explains the data is that participants are able to exert an influence on the hardware-based random number generators in such a way as to determine the positions of pictures before they are displayed. In such a case participants would mistakenly believe they perceive the placement of the pictures when in reality they are causally predetermining the placement of the pictures by some sort of esoteric mental powers. This explanation is ruled out by the fact that software-based random number generators were used to obtain similar data to that obtained by hardware-based random number generators and the picture placement is implicitly determined by the algorithms inherent in the computer's programming language. Additionally, even if humans had psychokinetic powers, given that one would lack detailed information about states of the computer's circuitry, one could not even know what one had to affect. So, for these reasons, we can reject (C).

Bem cites two reasons for thinking (A) the precognition hypothesis is favorable to (D) the artifactual correlation hypothesis (2011, Pg. 411). The first is that pleasant pictures were detected significantly more frequently than randomly interspersed unpleasant pictures, and that unpleasant pictures were not detected significantly more frequently than chance. The second is that a virtual control experiment using random inputs instead of inputs by human participants yielded null results – meaning that the truth of (D) a hypothesis that the output from the random number generator is inadequately randomized, and that there is some spurious correlation between participants' guesses and the computer's placements of the target pictures, is significantly unlikely. Philosophical considerations aside, Bem concludes that (A) is the best of these four causal explanations of the data.

If it can be shown that (D) is in fact a favorable hypothesis to (A) in terms of Bem's research and MRP, then Bem's conclusion goes wrong, not only for philosophical reasons, but also because of methodological problems reflecting general deficiencies in MRP not addressed by Scriven's criteria. And that is just what some of Bem's colleagues set out to do (LeBel & Peters, 2011; Wagenmakers, et. al, 2011).

A critique of Bem's methods

In addition to these arguments, an epistemological concern surrounds the issue. It seems foolish to approach a controversial topic with certainty, especially in a case such as this one, in which there is little to no agreement among experts. This is because, as we have just seen, the statistical evidence may be interpreted in terms of the antecedent probabilities of the truths of many competing hypotheses – P(H), evidence given the hypothesis in question – P(E|H), and the antecedent probability of the evidence in question – P(E). Because research-relevant beliefs determine at least some of these values, some prefer Bayesian data analyses.

Bayes' Theorem

$$P(H|E) = \frac{P(E|H)}{P(E)} \cdot P(H)$$

If, for example, one hypothesis is more or less likely than another regardless of the probability of obtaining the evidence, then the data may need to be analyzed differently because that hypothesis is antecedently less likely than others. This means if Bem's precognition hypothesis (A) is less probable, or the observed regularities are less likely to be reported by a different sample of participants, then Bem's data should be analyzed differently. Bayesian t-tests can provide a much different, more conservative, data analysis (Wagenmakers, et. al., 2011). The one-sided t-tests used by Bem provide illusory evidence for an inference supporting (A), which leads to the possibility of a researcher's bias interfering with an objective interpretation of evidence in related experiments (Francis, 2012, Pg. 3). Because a researcher's expectations are shaped by theory-relevant beliefs about the theoretical constructs that produce behavior, and method-relevant beliefs about the production, measurement, and analysis of data, Bem's study may be interpreted as theory relevant or method relevant (LeBel & Peters, 2011, Pg. 372). Theory-relevant beliefs are those inferred beliefs held by a researcher about the theoretical mechanisms, or constructs, which produce behavior. An example would be the belief that precognition is possible, or the belief that precognition is not possible. Method-relevant beliefs are those beliefs held by a researcher about the procedures through which inferential information is gathered, measured, and analyzed. It is due to the certainty with which Bem makes unusual conclusions, the relatively liberal nature of Bem's data analyses, and skepticism about the behavioral constructs explained by (A), that the lesson to be learned from these experiments is about MRP instead of about precognition.

Three direct criticisms of Bem's publication are (X) it overemphasizes conceptual rather than close replication, (Y) it pays insufficient attention to verifying the soundness of measurement and experimental procedures, and (Z) it is flawed in its implementation of null hypothesis significance testing (LeBel & Peters, 2011). The nine experiments reported by Bem are purportedly conceptual replications of the same type. Bem is interested in measuring the data in terms of a theoretical construct called "psi-phenomena" which is explained by reversing the temporal order of colloquially correlated stimuli and response variables and then searching for significantly different data than would be expected given the truth of a null hypothesis. There are four types of correlations which are accordingly reversed in these experiments – approach or avoidance to pleasant/unpleasant images, priming, habituation, and recall. A null hypothesis is the negation of the hypothesis that is tested. Hypothesis 1, for example, is that participants detect stimulus details before being presented with a stimulus more than they would by chance. The null hypothesis would then be that participants *do not* detect stimulus details before being presented with a stimulus more than they would be chance.

(X) and (Y) are criticisms of construct validity in this experiment. It is possible that the data could explain other theoretical constructs, such as clairvoyance, psychokinesis, as would be explained by Bem's competing hypotheses (2) and (3). An overemphasis of conceptual replication comes about because of too much ambiguity in interpreting the constructs in question. Subliminal priming, as a colloquially accepted construct, has been closely replicated so many times that there is very little ambiguity in the interpretation of experiments about it. Bem's choice of constructs, however, is more like searching for a correlation between spousal love and bravery and then explaining the data by claiming something like "if spouses are braver, they love each other more." (X) means these constructs are not adequately operationalized in Bem's study.

(Z) is problematic in this case for two reasons. First, the standard null hypothesis of no difference will almost always be false when the alpha-level is .05. A lower alpha-level would yield a statistically insignificant result. Second, it divorces theory choice from the context of the broader scientific knowledge system. This encourages a short-sighted interpretation of the data that could result in bizarre conclusions about what has been empirically demonstrated (LeBel, & Peters, 2011, Pg. 374). Without accounting for the antecedent probabilities of the truths of hypotheses in question, there is a five percent chance that any randomly chosen false hypothesis seems significantly different than the null hypothesis. The problem is compounded because hypothesis testing can be done ad-hoc. This is called data mining. If, for example, an initially chosen hypothesis test is not statistically significant, then the researchers can continue modifying their hypothesis tests until rejecting a null hypothesis. When a data analysis does not yield the results an experimenter expects, there is no need to report those findings in a publication. Bem's publication, for example, could exclude dozens of insignificant hypothesis tests. The results could be atypical correlations. For these reasons, and because of controversial nature of the hypotheses in question, Bem's study should be interpreted in terms of method-relevant beliefs rather than theory-relevant beliefs. The structure, rather than the content, of these or any other experiments conforming to standard MRP is what needs to be revised, as do MRP themselves.

Thoughts from the future?

This section has so far considered a direct refutation of an example of some bilk-proof empirical experiments about precognition. The authors cited so far are mostly concerned with whether precognition is empirically impossible in the context of bilk-proof experiments. The difference between Bem's experiments and precognition in a natural context is that in nature something could occur before the precognized event that would prevent the event in question from occurring as precognized. In such a case, the "precognition" would simply be a false belief.

I will now broaden the scope of interest to include reasons to think precognition is logically impossible. Recall in §1 the arguments against presentism and B-theories of time. Open future theory is the correct theory of time because it is not susceptible to the same refutations leveled against the other two. Precognition is only possible given the truth of a B-theory of time, because the B-theory is true IFF the future events in question always exist. Future events do not exist in terms of open-future theory or presentism. Somebody who coincidentally predicts a later event might later think they had precognized the event if they think that future events exist in the same way that past or present events do. But, as §1 set out to prove, B-theories of time do not accurately describe the world we live in, in which bilking is possible. The non-existence of future events means precognition is logically impossible.

I am assuming a necessary condition for human cognition is that the cognized events in question must be constantly causally connected to the cognition by representational memories. Because there are no representational memories that are continuously causally connected to future events in the same way that representational memories are continuously causally connected to past events (viz. as neural connection), precognitive knowledge of future events, should it exist, would be very different than memories of past events. This is because representational memories are neurally encoded by past events and stored in one's skull. Unlike the latter, precognition would have to involve some type of causal action at a distance.

One might object, however, that there is such a continuous process, in that if a person believes at a certain time, t, that event E is going to take place at a later time, t*, then that person will also believe at times intermediate between t and t* that event E is going to take place. But there are at least four objections to the claim. One is that it is the belief at time t that event E is going to take place that causes later beliefs that event E is going to take place, rather than the other way around – which would have to be the case for precognition to be like memory. Second, in the case of memory, there tends to be a gradual degradation of the information encoded in memories as one moves from the past event closer to the present. A parallel degradation of encoded information is not present in alleged cases of precognition as one traces the causal process running from the future event back toward present cognitions. Third, something might happen later than t, but before event E occurs at t*, that wipes away the belief about the occurrence of event E. Fourth, even if the belief is not completely wiped away, as would be the case in the previous reply, there could be a spatial gap at the time of event E between that event and the precognizer. Even if there is no temporal gap, there is a spatial gap – which is not present in other cases of causation in the actual world. So it seems like human precognition is very unlikely to occur in the actual world because of the contingent nature of human cognition – viz. the structure of brains, and relations of cognition to memory.

§4 Causal Asymmetry

The previous three sections have been concerned with an analysis of time, the concept of retrocausation, and experiments about precognition, respectively. This section is distinct in the sense that physics, as an enterprise of natural science, presents a different problem to be addressed when approaching retrocausation. Physics, as does any natural science, is supposed to causally explain phenomena in terms that are as observer-transparent as possible. These terms are different than those used to discuss the topics of the previous three sections because if inanimate objects are involved in retrocausal processes, then the observer's trying to cause something is irrelevant to the temporal order of causality. Such is not strictly the case in the thought experiments discussed by Dummett and others in §2, nor is it the case in the precognition experiments described in §3. Also, the arguments for the different analyses of time depend on one's having experiences with the apparent passage of the present moment in one direction only, or trace memories of earlier events, while objective causal asymmetry, and causal/temporal order, is by definition independent of one's own experiences.

Background

The possibility of retrocausation, of the sort described by Mellor, in physics depends on the lack of an objective causal asymmetry. The natural sciences assume the asymmetry of causation, in terms boundary conditions or some natural law, in order to explain asymmetric correlations between most observed patterns of states of affairs. But philosophers of physics, like J. J. C. Smart, claim that the laws of physics are temporally symmetric, in the sense that "the laws of classical dynamics and electromagnetism, as well as of quantum mechanics, are all expressed by the time-symmetrical differential equations. In other words, if f(t) is a solution to these equations, so is f(-t)" (2006, 468). This is a puzzle because the objective microphysical direction of causation, and hence of time, does not seem the same as the objective macrophysical direction of causation. A successful refutation of Dummett's case of retrocausation being possible, given the right conditions, depends on there being an objective temporal ordering of microphysical causal processes – which are themselves temporally symmetric. Contemporary physics infers such an objective temporal ordering based on the causal asymmetry of macrophysical processes, such as the rotation of clock hands. The case of retrocausation in physics is anomalous because alleged instances of retrocausation may be interpreted differently depending on one's interpretation of quantum mechanics.

Uncertainty and retrocausation

Albert Einstein, et. al., in *Can Quantum-Mechanical Description of Physical Reality Be Considered Complete?,* argues that the probabilistic predictions of the spatial locations of photons given by the wave function in quantum mechanics do not describe reality completely because the position of photons cannot be predicted with certainty without disturbing the system (1935, Pg. 777-80). Because two photons cannot be completely described as having simultaneous reality, and the descriptive wave function assumed in quantum mechanics does describe two distinct photons as having a simultaneous reality, it follows that such a description is not complete. It is the uncertainty of the trajectory and position of a photon in a closed system that is at issue. Roderick Sutherland, in *Causally Symmetric Bohm Model*, claims that it is sound to argue that "a particle always has a definite, but hidden, trajectory" (2006, Pg. 2). This means the position of a photon at a given time makes it the case that at an earlier time the photon was not at certain locations. According to one interpretation of this paradigm, later states of affairs called final boundary conditions seem to causally determine the earlier positions of radiating photons in a field, such that the final boundary conditions consist of a state of affairs that will occur temporally later than the causally contiguous relations between the described elections and the assumed final boundary conditions of the system. As we saw in §1, this makes no sense in terms of GBT. If this type of phenomenon exists, then it seems like we have an example of an effect temporally preceding its cause. It is the uncertainty of the trajectories of photons in fields that gives rise to hypotheses that describe photons in terms of retrocausation. The fact that the equations used to describe electromagnetic radiation can be run in parallel with an inverted time-sense complicates matters because it may be a contingent fact that energy disperses due to thermodynamic disequilibrium. The anomaly arises due to controversy between conflicting interpretations of electromagnetic radiation. A different paradigmatic interpretation of the wavelike eigenfunction used to describe the uncertain superposition of photons inside interacting electromagnetic fields could explain the anomaly.

David Lewis and the asymmetry of causation

We can formulate causal explanations in terms of sufficient conditions and laws of nature like this "A is a determinant of B, if A is minimally sufficient for B, given the laws of nature. An example is "the application of heat to copper is a determinant of the expansion of the copper, if the application of heat is minimally sufficient for the expansion of the copper, given the laws of nature." Take note that the overdetermination of a cause by its effects is implicit in this type of explanation. A presumably precedes B both causally and temporally such that there are more relevant effects than there are causes associated with A. The effects of causal processes started by A are spread out in a forward direction through both time and space, in the sense that the case of outgoing spherical wavefronts is potentially the cause of many other effects. It is the case in our world that the laws of thermodynamics, which are interpreted with an assumption of the completeness of Maxwell's equations, coupled with the instantiation of A, give rise to causal processes which span time and bring about many other patterns of events.

A causal process started by A is said to have fork-like causal asymmetry in the sense that these patterns of events would make the shape of a branching tree if plotted along a three dimensional axis where the passage of time is plotted as one of the axes and the coarse spatial locations separating those patterns are plotted along the other two. The asymmetry of causation is explained by Lewis by the fact of causal overdetermination – viz. observed events have many more future causal traces than past causal traces. As Lewis puts it, "whatever goes on leaves widespread and varied traces at future times. Most of these traces are so minute or so dispersed or so complicated that no human detective could ever read them; but no matter, so long as they exist" (1986, Pg. 50). Take for example the case of tossing a large stone in to the middle of a still circular pond. First you observe the stone displacing a small amount of water shortly after it makes contact with the surface of the pond. The displaced water molecules subsequently displace many more nearby water molecules, and so on, until the entire surface of the pond is oscillating with outgoing concentric waves. If those waves are strong enough to reach the banks of the pond, then those banks act as a boundary across which the waves do not cross. It is because the stone's earlier displacement of a relatively small amount of water is a sufficient condition for the later displacement of a much larger amount of water across the entire surface of the pond, given the laws of fluid dynamics and so on, that the cause has many more effects than the relevant effects have causes. If a hula hoop had been thrown around the perimeter of the pond instead of a stone in the center, the subsequent causal process would not have occurred in the form outgoing concentric waves, but as incoming converging waves.

Lewis claims the asymmetry of overdetermination entails the temporal asymmetry of microphysical causation because, though some microphysical processes are causally symmetric, the asymmetry of overdetermination is extremely skewed such that for every moment, t, there is an earlier moment, t*, during which fewer common causes occur than do causally related effects at t. It is not the case that we see the reversed order of these events occurring naturally in our world – incoming concentric waves converging on a common center area which gains enough potential energy for a large rock to jump out of the center of a pond, the surface of which then becomes still, for example. So it is safe to assume that all of nature is shot through with one temporally asymmetric forward branching fork of causation – i.e. capable of bringing about extrinsic atemporal change of the sort described by Shoemaker in §1. The asymmetry of causal overdetermination which seems metaphysically inherent in the actual world entails that microphysical causal processes are intrinsically asymmetric in the sense that the observed position of a photon at a given time entails that it could not possible be at some places during earlier moments. Building on Lewis' thoughts, if this is the case, then retrocausation is impossible because of some law-like fact about reality. The puzzle of incompleteness in physics may be solved once this fact is properly explained. If collapsing a waveform actually creates reality, then it seems like retrocausation is possible because there is no intrinsic asymmetry.

From causal overdetermination to causal asymmetry

The thought on the table is that there is an intrinsically asymmetric temporal difference between the cause and the effect for all physical processes of both micro- and macro-physical objects regardless of the uncertainty involved in predicting their spatial properties. Jan Faye gives a reason to think the incompleteness involved in a physical theory that describes particulars in terms of a wave function leads to interpretations according to which there is no intrinsic temporal difference between cause and effect. If there is an intrinsic difference, then "if there are processes in the world that might be seen as a manifestation of backward causation, these are not to be depicted by a description that leaves them to be time-reversed cases of ordinary forward causal processes" (Faye, 2010, sec. 4.4.2). The latter consequent is false in terms of some branches of modern physics, so the question arises as to how we are to make sense of the causal symmetry used to describe fundamental physical processes, given the incompleteness of a waveform as the description of a single particular. If the best theories predict an effect preceding its cause, which is possible, then either there needs to be a better theory, or there is no intrinsic asymmetry of causation. The jump from counterfactual reasoning to causal asymmetry would appear suspect if counterfactual reasoning is somehow mistaken.

To recap, fundamental physical processes, like electromagnetic radiation, are causally symmetric in the sense that the same equations used to describe the outward radiation of particles can be used to describe the inward convergence of particles given different boundary conditions. If so, later states seem to affect earlier ones. This is a puzzle for physicists because, given a causal analysis of time, the difference between advanced and retarded waves is also a difference between temporal orders. The following is an attempt at distinguishing between forward and backward causal processes according to a time-symmetric description of microphysics.

It is possible to simply assume that there is such an intrinsic difference between forward and backward causal processes, which is a similar point to the one made by Flew in §2. If causes are temporally unidirectional levers which bring about later effects, and it is not possible to observe an effect preceding its cause, or an effect that is simultaneous with its cause, then there is probably an objective metaphysical asymmetry of causation. One can do this, argues Faye, by making some other basic assumptions about the nature of reality (2010, sec. 4.4.2).

(i) Process tokens and process types are distinct in the sense that only process types are reversible; process tokens are not.

Types are to tokens as words are to *this* word on the page. Recall what happens when you toss a large stone in to the center of a still pond. The observed outward motion of concentric waves is of one type. The inward motion of concentric waves would be of a different type. If the motion of retarded waves is temporally reversed, then they are called advanced waves and vice versa. If you toss a big hula hoop in to a still pond, an inward motion of concentric waves within the hoop would be observed. The two types of waves just described obey the same laws of physics regardless of their manner. The waves themselves are tokens of one type or the other, but not both. You will not toss the stone and observe, for example, waves begin moving outward from the center, and then stop before reaching the banks of the pond only to reconverge back in the center. From this, it follows that the dispersion of energy from a relatively high potential state to a relatively low potential state is not reversible.

However someone who believes time is symmetric might argue that the only solution to the question of how the two processes differ appeals to the idea that they are oppositely directed.

(ii) A normal observer will describe causal processes propagating forward in time in terms of positive mass and positive energy states pointing into her future whereas she will describe the same tokens in terms of negative mass and energy states point into her past.

The opposite would only be observed in extremely rare cases in which retarded waves do not exist, or in which both advanced and retarded waves exist. It is for this reason, and because the laws of nature in the actual world are immutable, that Lewis claims the overdetermination of causation entails the temporal asymmetry of causation. (ii) is reflected by Lewis' earlier claim that whatever goes on leaves widespread and varied traces at future times but has a smaller number of root causes in the past. It is the existence of forward-branching causal traces between a few past tokens and many more later tokens that allows the natural sciences to give causal explanations of the sort mentioned previously.

(iii) One must distinguish between a passive time reversal operation and an active time reversal operation.

Because the microscopic dynamics of particles and fields is temporally reversible, in the sense that their descriptive equations of particle motion can be run in parallel with respect to an inversion of temporal variables, it is reasonable to assume there is a difference between what Faye calls passive and active time reversal operations. "The passive transformation is applied to the same process token by *describing* it in terms of the opposite coordinates and opposite energy states. The active transformation, by contrast, brings about another token of the same process type in virtue of some physical translation or rotation of the system itself, both tokens having the same energy sign point in the same direction of time" (2010, sec. 4.4.2). (iii) is the assumption that there is a fundamental difference between describing particle motion in terms of time-invariant equations and initiating a retrocausal processes.

(iv) The description in terms of positive mass and positive energy flow corresponds to the intrinsic order of the propagation.

This is basically the claim that there is an asymmetry of causation that underwrites the temporal ordering of events. Another way of thinking about (iv) is Flew's analysis of causation where causes are temporally unidirectional levers which bring about their results. The asymmetry described by (iv) is supervenient upon all particular instances of causal relations between events. When describing the earlier conditions of the universe, the initial boundary conditions corresponding to lower entropy, coupled with the intrinsic asymmetric order of causality, explain the later facts. This is the assumption required of Lewis' account that overdetermination entails asymmetry. It is the same assumption Huw Price tries to refute.

Huw Price's reply

The premise that universal overdetermination entails universal causal asymmetry is one that Price finds questionable. His thought is essentially that we cannot infer that the same type of causal overdetermination we observe as deliberative cognizers applies to the whole of reality. If his argument succeeds, then assumption (iv) is not true. In a universe which has reached thermodynamic equilibrium, inwardly converging *advanced waves* would occur as commonly as outwardly radiating *retarded waves* – at a frequency of about once every billion years (1992, Pg. 504-5). Such would be a case of describing backward causation in terms of time-reversed cases of ordinary forward causal processes. The existence of advanced waves in our universe, or of temporally backward travelling advanced matter, would have far-reaching consequences for the enterprise of natural science. This is because causal overdetermination at the smallest descriptive levels of reality has consequences for almost all other descriptive levels of reality. If this is true of the world, then it is a contingent fact about our universe that overdeterimination is asymmetric. It is possible to imagine, for example, a world divided in to two causally isolated halves such that counterfactual dependence seems asymmetric toward the future for people living in one half, but counterfactual dependence seems asymmetric toward the past to the other half. The memories of people from one half would all be described as being about the future by people from the other half and vice versa. Say they could look through a window and see what is going on in the other half. They would see clouds of smoke form over piles of ashes, and then begin funneling down in to cold black flames which would subsequently un-burn a pile of hot logs into existence, and so on. Some causal processes would seem reversed while others follow what one calls the natural order of time. This is an extraordinary case, but an important one because it is apparently consistent with some later states of affairs in our universe given our contemporary descriptions of the laws of nature.

The following is Price's line of argument about the contingent nature of causal asymmetry. Thermodynamic disequilibrium explains an earlier state of conditions that must have been true of our universe at earlier moments. Disequilibrium makes electromagnetic radiation appear temporally asymmetric in nature - "the asymmetry depends on the fact that we have big disturbances (such as flying stones, or a positive charge) in the initial conditions but not in the final condition" (1992, Pg. 505). For this reason, we must consider boundary conditions and their relation to thermodynamics. In the case of retarded electromagnetic radiation, the dispersion of energy from a relatively high potential energy emitter is considered an initial condition. The absorption of energy by a receiver, or the direct measurement of a photon, is called a final condition. Boundary conditions, such as relatively low levels of entropy of our universe at moments in the distant past, and relatively high levels of entropy far off in to the future, are important because they are needed in order to explain the fact that observed causal asymmetries are now extremely skewed in only one temporal direction, branching out with the future, rather than bidirectionally or converging toward a single event at some later time. So Price's argument shows that causal asymmetry is a contingent fact about our universe.

Price's causal subjectivism

Price's further treatment of causal asymmetry is subjectivist in the sense that there is no objective causal asymmetry independent of deliberations made to ensure survival. A reason to reject the thesis that causal asymmetry is an objective feature of nature is that "it reduces to something very much like Hume's view in the case of microscopic and substatistical systems [viz. electromagnetic radiation], where the causal asymmetry becomes nothing more than a conventional label, applied to mark alignment with a macroscopic statistical asymmetry" (Price & Weslake, 2009, Pg. 36). If so, causal relationships are simply artifacts of our ways of cognition.

Price's argument builds on the fact that we are essentially deliberative creatures whose survival depends on one's executing actions in order to bring about relevant outcomes. Human beings naturally infer causal relationships between a specific action, A, we believe to be able to do, or not do, and the observed outcome, O, which seems to temporally follow the action. "Interpreted in material terms, what we believe is simply that the disjunction $\sim A \vee O$ is true. Moreover, we believe it inferentially, as we might say – i.e. not simply in virtue of already believing one or the other disjunct is true" (2009, Pg. 27). Because of the temporal asymmetry between actions and their outcomes, the perception of causal relationships seems asymmetric to us, even though they are simply ordered by convention.

A reply to Price

There is a counterexample to Price's argument found in some cognitive science research done by Lau, et. al. Researchers used transcranial magnetic stimulation [TMS] to test the time needed for the perceived onset of motor intention to be fully determined. This is basically a process of temporarily damaging key brain areas like the presupplementary motor area in living humans and then performing experiments about the experienced onset of intention after action execution. After the relevant sections of their brains were rendered non-functional, participants were asked to execute simple motor actions and then report their perceptions of the times at which they intended to execute the actions. TMS conditions shifted participants' perceived onset of action intention backward in time and the perceived timing of the actions forward in time relative to control conditions. "The data suggest that the perceived onset of intention depends at least in part on neural activity that takes place after the execution of action, which could not, in principle, have any causal impact on the action itself" (2007, Pg. 9).

Unless a retrocausal explanation of the data is assumed from the start, the actions one attributes to some of one's own executive functions are at least partially determined before it is possible for one to have the experience of intending to act deliberatively. So, the causal relations between one's actions and one's experienced onset of intention follow an objective temporal order. The spontaneous action is the cause; the data and relevant brain activity associated with one's experience of the intention to act are the effects. We here have a clear example of the objectivity of causal asymmetry independent of deliberative actions in this case. So it seems like Price's causal subjectivism does not succeed in explaining causal asymmetry.

Thoughts about a bizarre universe

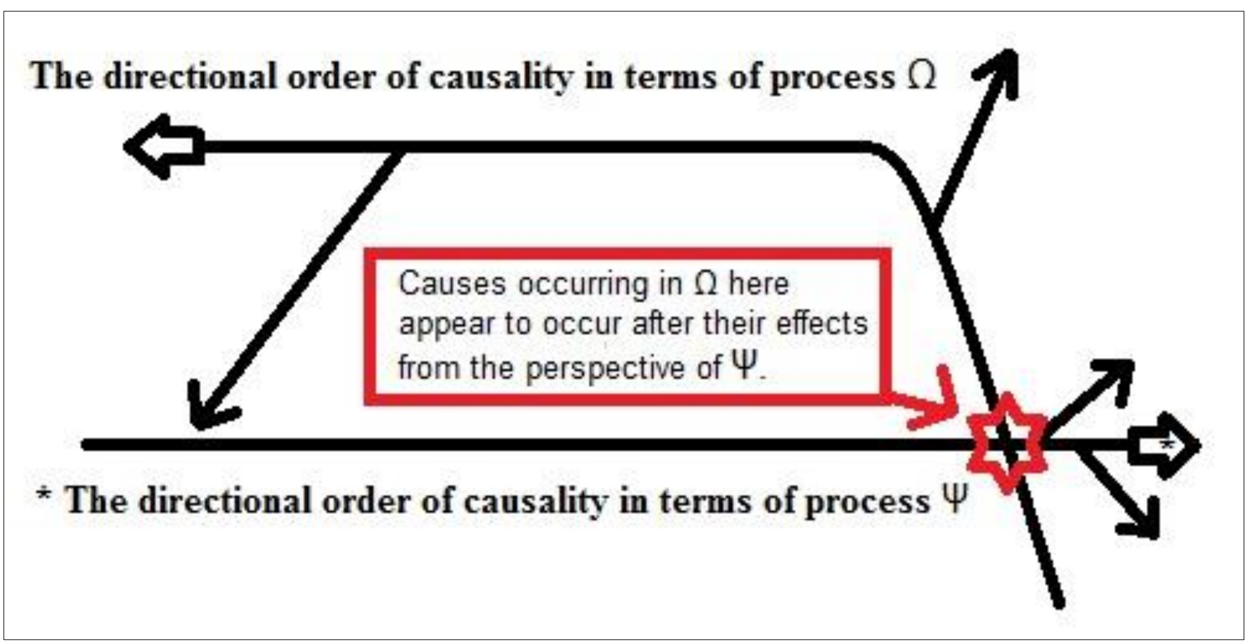
It is possible to imagine a bizarre universe different than ours in one important way – only advanced waves exist, and retarded waves do not exist in the bizarre universe. At an earlier time, the bizarre universe would have high entropy, and then later it would have low entropy. If people living in our universe could somehow observe, but not causally determine, what goes on in the bizarre universe, our universe's laws of electrodynamics would describe inward converging concentric waves meeting upon a common center spatial region which would subsequently gain energy. Insofar as the initial and final boundary conditions of the bizarre universe are basically like ours but switched, similar types of things would happen but they would be manifest in a reversed order. Later events would counterfactually depend on earlier causes, but it would be impossible to discover the roots of such counterfactual dependence until they happen at some later time relative to our time sense. The thought experiment is designed to show that, even though Price's causal subjectivism has flaws, the current paradigms of physics do not explain why it must be the case that there is an objective asymmetry of causation independent of the fact that only retarded waves seem to exist in our universe. We could interpret the fact as good evidence that advanced waves do not exist, but to do so would be a matter contingent on some objective asymmetry of causation which underwrites disequilibrium – which would be circular reasoning.

The key point of a bizarre universe thought experiment is that the overdetermination of causation could run in the same temporal direction, but the asymmetry of causation could run in the opposite temporal direction as in our universe. We could just as well think of the initial high entropy condition, and the causal processes by which the flow of energy is transformed, as earlier events. The final low entropy condition, and the higher energy of the center region, would be later events. The term “smoking gun” is not sufficient to describe the causal ancestry of the bizarre universe, a more fitting term would be “smoking guns” because of the correlation among remote causes all seeming to conspire to bring about one and only one common effect. This may seem unlikely because everything in our universe seems to stem from one common cause, but it is possible. Because it is possible to imagine a bizarre universe, the claim that causal overdetermination entails the asymmetry of causation seems suspicious. Physicists need to first demonstrate the objectivity of causal asymmetry, and then explain anomalies like the behavior of particles in electromagnetic fields, in terms of that asymmetry to safely assume (iv).

Final thoughts

The possible existence of a bizarre universe is highly improbable given the causal ancestry of our universe because the history of our universe is causal asymmetric – there are more later causal traces than earlier causal traces. It shows that boundary conditions are not the only reason to think time is asymmetric. If there is an objective causal asymmetry, as Flew claims in §2, then retrocausation is impossible because there is some law-like fact about the universe which entails that causes precede their effects. If not, then retrocausation is possible.

Consider the case of two oppositely directed intrinsically asymmetric causal processes, Ψ and Ω such that there are only one-way causal interactions running between the two – running from Ω to Ψ. From the perspective of Ψ, the effects of causes occurring in Ω would appear to manifest in the reversed order, even though the same would be true of Ω if the extensive ineffectiveness was switched so that Ψ affects Ω but not vice versa. Such would be the case of an effect preceding its cause. It may be objected that there is no such atemporal reference frame in which Ψ and Ω could interact as such. But insofar as there is objective causal asymmetry and an incomplete description of causally symmetric processes, there is no reason to posit some extra fact about reality that makes the opposite true. The following figure illustrates how causality in Ω would seem to somebody living in Ψ.



The first section supports the claim that Growing Block Theory is a consistent causal analysis of time which describes change, truthmakers, and underdetermined determinate events more completely than alternative theories. From this we get the idea that the present is whatever is earlier than the future. The present is also later than, and counterfactually dependent on, past events. The next section focused on D.H. Mellor's argument from causal loops against retrocausation. Mellor's argument is that if retrocausation is possible, then causal loops would exist. Causal loops do not exist because the contrary position leads to an absurdity. From this it follows that retrocausation is not possible. But the example of Ebenezer Scrooge, who backward time-travels but cannot affect the past world around him, is a refutation of the premise that if retrocausation is possible, then causal loops exist. Scrooge would be initiating a private retrocausal process, relative to the outside world, by backward time-travelling as a ghost. The counterexample is no more incredible than the case of backward time-travelling, so Mellor's argument does not succeed in proving the point intended. The next section was about Bem's precognition experiments and reasons why precognition of the sort proposed by Bem is logically impossible. These reasons depend on the notions of counterfactual dependence, bilking, and the analysis of time covered in previous sections. The final section was about the asymmetry of causation and retrocausation in terms of current physics paradigms. The asymmetry of causation is a contingent fact of reality that is logically independent of the deliberative nature of human cognition. A possible picture of retrocausation emerges, according to which earlier states of causal processes are determined by later states of a causal process relative to observations made in terms of an oppositely directed causal process. From this it follows that the possibility of retrocausation is not an incoherent notion.

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