Causal Order, Temporal Order, and the Asymmetry of Time

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I confirm that the work presented in this thesis is my own and the work of other persons is appropriately acknowledged.

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Abstract

Upon denying the A-theory construal of temporal relations, the question arises as to what temporal asymmetry should be taken to consist in. This paper is an investigation into the prospects of one particular B-theory answer to this question – viz. the causal account. In particular, I examine the prospects for the claim that the asymmetry of time rests on the asymmetry of causation (the causal thesis). I begin with the version of the causal thesis that is proposed by Hugh Mellor in *Real Time II*. I discuss a number of complications that arise on the arguments he gives for his version, and argue that the 'pair' version of the thesis that Mellor employs is too strong to deal with all cases of temporal asymmetry. In response to this situation, I formulate a weaker version of the thesis – viz. the majority version. However, it turns out that this version is also inadequate to the task of accounting for temporal asymmetry. I conclude by suggesting a further version of the thesis, which appears promising in overcoming the further obstacles. Throughout I take temporal asymmetry to be the distinction between the relation 'earlier than' and the relation 'later than'.

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Contents

Chapter One

Despite its noted advantages, rejection of the A-theory of time carries along with it an abundance of loose ends that require attention. Not the least of these is the question of the so-called asymmetry or directedness of time. In this paper, I turn my attention to an account that attempts to deal with this and a number of the other loose ends – viz. Mellor's causal theory of temporal order. My particular interest is in whether we can make something of what I will the 'causal thesis', viz. the general claim that the asymmetry of time rests on the asymmetry of causation (including a denial of the contrary). Now the explicit arguments offered by Mellor for the causal thesis (primarily in his *Real Time II*) are not the most unknotted arguments offered on a subject, and it is not clear that the version of the thesis that Mellor proposes is easily defensible. In this paper I attempt a reformulation of both Mellor's argument and the causal thesis. I begin below by formulating the question which the causal thesis is intended to answer. In Chapter Two, I move on to Mellor's position. I examine the position for the key claims and comb through two of his arguments involving the causal thesis. Finally, in Chapter Three I turn to an attempted reformulation of the causal thesis.

Consider the overall history of the actual world and the series formed by these spatiotemporally-related events. I take the distinction between the so-called A- and B-theories to be at bottom a disagreement over the nature of the temporal relations contained in this series.[1] For ease of reference, I will term the series as described by these differing accounts the 'A' and 'B' series respectively, but it should noted that I mean to refer to only a single series of temporally-related events of which two different accounts are given.

The distinction between the A- and B-series must minimally be taken to consist in a difference in the structure of the temporal relations of the series. Both accounts agree that, for each event in the series, the event is either earlier than, later than, or simultaneous with every other event in the series and has a determinate temporal location in virtue of these relations[2]. The A-theory holds, however, that by considering the series in this way we have abstracted from the present moment, and in so doing have omitted numerous important facts about the series of events – like, for example, the fact that the coronation of King George V *has passed*. The coronation's

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[1] Bourne (2006) defends a sophisticated version of the A-theory. Proponents of the B-theory include Le Poidevin (1991), Mellor (1998), Newton-Smith (1980), and Price (1996).
[2] The special theory of relativity, of course, complicates this somewhat by making the simultaneity relation depend on frame of reference which includes other values in addition to the temporal relation. For the purposes of setting out the distinction, I will ignore the complication here. I will pick it up again a little further on, as it becomes relevant once we give a more substantive account of the distinction.

having passed is, on the A-theory, something over and above its bearing an earlier than/later than/simultaneous with relation to every other event in the series. (And there are, of course, similar omissions in the case of all the rest of the events in the series, past, present, and future.) So, the series of temporally ordered events mentioned constitutes an A-series if the set R of earlier/later/simultaneity relations holds between all events in the series and, *in addition*, the set S of relations holds between all events in the series and a significant moment of the series – the present moment. To clarify, there is a set of relations for each moment in the series (let us label the sets corresponding to each of these moments, M_0... M_n) such that (1) that moment constitutes the present moment, (2) every event in the series is relevantly related to it, and (3) if that moment is the present, then none of the other moments is present. Thus, the set S of additional relations posited by the A-theory is the disjunction of the sets M_0... M_n. The additional relations of the A-series are naturally grasped, as our own temporal experience seems to present itself as an A-series. So, part of the motivation for adopting an A-series view of the time series is its natural agreement with our experience of time.

In contrast, the B-theory denies this additional set of temporal relations, and claims that all facts purportedly capturable by only the A-theory can, with a little bit of work, be adequately captured in B-theory terms. For example, the relations of the present moment can be explained in token reflexive terms (Mellor, 1998, chapter 3). The disagreement, then, between the A- and B-theories lies in whether, in addition to this relational structure posited in set R, the series of events is ordered in terms of set S as well. I take this to be the fundamental distinction between the two theories and, although it is not yet a substantive distinction, all complete A- and B-theory accounts presuppose this difference in relational structure.

Just what this additional set of A-series relations amounts to (or indeed what the B-series relations amount to) depends upon the details of the theory in question. Most commonly, the A-series relations are explicated in terms of existence. The present moment demarcates either all that can properly be said to exist (presentist accounts[3]) or the point of coming into being of that which exists (growing universe theories[4]). On such accounts, the B-series relations hold in virtue of the A-series relations holding. The coronation of George V is earlier than the writing of this paper only because the coronation was present before the writing of this paper. In denying A-series relations of this ontological sort, the B-theory is committed to claiming that there is no sense in which the events of one moment of the series exist and the rest – or some of the rest, in denial of the growing

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[3] See, for example, Bourne (2006).
[4] See Tooley (1997).

universe theory – do not. The entire series exists 'all at once' as it were[5]. Price makes neat work of the distinction in his phrasing, "[The] B-series regards reality as a single entity of which one ingredient is time, not a changeable entity set in time." (1996, p. 12)

There are, I think, primarily two lines of reasoning which recommend the B-theory over the A-theory, and which have led to its being favoured (although by no means universally) within contemporary philosophy. The first of these is an argument originally devised by J. M. E. McTaggart (1908) for the incoherence of the A-theory view. The second is the supposed ramifications of the claims of special relativity on the A-theory. I turn briefly to the latter.

The obstacle presented to the A-theory by the special theory of relativity is a consequence of the latter theory's claimed relativity of temporal relations. According to the theory of relativity, we can no longer understand simultaneity (or being earlier than or later than) as a relation which holds of all events across space for a given moment. Events are only simultaneous relative to a set of coordinates (viz. to a set of coordinates specifying the velocity and spatiotemporal location of the chosen frame of reference). This is problematic insofar as the present moment of the A-theory is constituted by a set of simultaneous events, which is taken to be the set of existing events (or the point of coming into existence of events). Thus, whichever moment is the present is also relative to a set of coordinates, and existence must now also be understood as relativised to a set of coordinates. This is worrying to anyone who finds it implausible that an object or event can exist from the point of view of one spatiotemporal object or event, but not others. In contrast, the B-theory denies from the outset that existence is demarcated by a significant present moment and so avoids the problem of relativised existence in this sense entirely. I do not wish to delve further into the intricacies of these debates here, and will take it that these two lines of reasoning make the B-theory an acceptable assumption when beginning an investigation into time.

(A second assumption which I will be employing in this paper is that of relationalism about space and time. This distinction is at the heart of one of the oldest questions about time (and space)[6], and continues to be discussed[7]. The distinction can be made in a number of ways, but for the purposes of this paper I shall make it as follows: The relationalist claims that space and time depend, in terms of both existence and properties, on spatiotemporal objects. Whatever properties

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[5] Running into the need to speak in terms of a higher-order time frame is hard to avoid in discussions of the A- and B-theory, although I suspect that part of the problem with the A-series is that appeal to such a higher-order time is unavoidable. It is, of course, desirable to eliminate all such reference in a final analysis.

[6] The question was famously argued in the Leibniz-Clarke correspondence (see Alexander, 1956).

[7] See, for example, Newton-Smith (1986) for a discussion of the distinction within the context of modern physics.

are attributed to time, these are had merely in virtue of the temporal objects found in the world. I will make crucial appeal to this assumption in chapter three. I will not attempt to justify the assumption here, but mean merely to call attention to it.)

Now although adoption of the B-theory has the virtues of avoiding the above-mentioned difficulties, there is yet work to be done in making it decidedly palatable. There is the task of showing that all facts purportedly only captured by the A-theory are in fact describable in B-theory terms[8]. There are also difficulties which arise as a result of the lost set of relations. For example, our natural notion of time presents it as being asymmetric or directed – and this in a great number of ways. We are related to the past and future in decidedly different ways. The past appears as determinate in a way that the future is not. We have a different sort of knowledge of the past than we do of the future. We act so as to affect the future but not the past. In marked distinction to this, space seems to bear no analogous asymmetries. The A-theory appears to make sense of this directedness with relative ease. Time, on the A-theory, is itself fundamentally directed. So all these asymmetries can ultimately depend on the asymmetry of time itself. They follow as consequences of the order in which each moment in the time series becomes present. But now, suppose we deny the A-theory. In denying the ordering obtained by such a present moment, we are pressed for some account of the apparent directedness of time. Thus, the basic question involved in the asymmetry of time, as I will here be discussing it, is, what does the distinction between the relation 'earlier than' and the relation 'later than' amount to on the B-theory? And it is this distinction that I mean to invoke with the term 'temporal asymmetry'.

Now, given our commitment to both the B-theory and relationalism, along with the abundance of asymmetries associated with the direction of time[9], there are a number of different ways in which we might attempt to construe the distinction between 'earlier-' and 'later-than'. Some of these accounts render the distinction a merely local one. For example, it has been proposed that the asymmetry of time consists in the direction of increase of entropy[10] (Boltzmann, 1964). Compatible with this is the claim that entropy might one day reach equilibrium and no more such increase will occur. It follows on this account, that for those times, no distinction between 'earlier-' and 'later-than' can be applied. Thus, some accounts force a distinction between

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[8] Mellor (1998), for example, gives a full treatment of this issue.

[9] We find asymmetry of causation across time, asymmetry of counterfactual dependence, of determinacy (events are determinate in the past direction, but not the future direction – this could also be construed as an asymmetry of truth), asymmetry of action, deliberation, asymmetry in type of knowledge, amount of knowledge, asymmetry of explanation, asymmetry in de facto process evolution (that is, we find many processes only occurring in a given order and not the reverse)...

[10] A proposal argued and refined in particular by Boltzmann (1964)

the symmetric relations of temporal simultaneity and betweenness, and the asymmetric relations of earlier- and laterness, and claim that the latter are local relations only (that is, they are found only within certain regions of time, but not others). Indeed, on such accounts it is possible for different regions of time (spacetime) to bear contrary directions of temporal asymmetry.

The question which I will be addressing might be confused with another question, with which it can converge, but which it is different from in principle. Let us stipulate that 't0' designates the point in time furthermost from the writing of the paper in the direction of the big bang, and 'tn' designates the point in time furthermost from the writing of this paper in the direction of the big crunch (or whatever this is going to be)[11]. Now, we might ask the question, how does the series of events as considered in the direction t0 – tn differ from the series of events as considered in the direction tn – t0? If the correct account of temporal asymmetry renders it global, then our two questions will converge. Whatever accounts for the difference between earlier and later will then also account for the difference between considering the universe in the direction t0 – tn and considering it in the direction tn – t0. However, if the correct account renders temporal asymmetry a local phenomenon, then the two questions will come apart.

As already mentioned, there are numerous asymmetries across time, all of which need ultimately to be accounted for in a discussion of the asymmetry of time. Further, numerous and varied responses to the question of the asymmetry of time abound. However, it would be difficult to answer all such questions within the space of a lifetime, not to mention a paper such as this. As such, I will restrict my discussion to one account of the asymmetry (the causal thesis). Thus, I do not mean give a final answer on what constitutes the asymmetry. My aim is to examine the causal account as a proposed account, for its virtues and failings – an account which I believe has some promise.

As a final clarification, I wish to distinguish the question I am concerned with from another question which is often labelled the 'problem of the direction of time'. I am not discussing the 'problem of the direction of time' as many physicists understand it. This is a problem which arises when we consider the apparent conflict between the time-asymmetries witnessed constantly in the world (the main appeal here is to de facto irreversible processes) and the time-symmetry of most of the fundamental laws uncovered by science. This is a problem of accounting for an asymmetry where we apparently shouldn't find one. My problem is no doubt related to this problem in many

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[11] From here on, I will use 't0' and 'tn' in this way.

ways[12], but begins at a different point. I begin with the intuitive asymmetry contained in the distinction between earlierness and laterness, and ask what this amounts to once we have denied the A-theory. I am not beginning with time-symmetric laws and then asking how it is that we find asymmetry within the playing out of those laws. Having set up these caveats, I turn now to Mellor's proposed account of temporal asymmetry.

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[12] Indeed, Horwich (1987) traces both the asymmetry of time as I have construed it and irreversible processes back to a common explanation (that of initial conditions of the universe).

Chapter Two

Describing it variously as 'derivability', 'dependence', 'reduction', 'entailment', inter alia, Mellor argues, in *Real Time II*, for a link between causal order and temporal order. This link is Mellor's account of temporal asymmetry as the notion is introduced in chapter one, and is a version of the causal thesis, viz. the claim that the asymmetry of time rests on the asymmetry of causation[13]. In this chapter, I will examine the nature of this link posited by Mellor, along with the arguments given for it in *Real Time II*. As is clear from the number of labels applied to it, the nature of this link is not made entirely clear by Mellor. Thus, my first task is to try to understand the nature of the link posited. During the course of this discussion, I will bring out what I take to be the two crucial features of this version of the causal thesis. In the second half of the chapter, I will turn to the arguments put forward by Mellor for the link. The aim of the chapter is to detangle the claims and arguments as far as possible, and to establish a background against which I will attempt a different version of the causal thesis – a version which I hope to establish as more promising than Mellor's version.

In the course of his arguments, Mellor provides a clear account of the logical relations obtaining between the two orders. However, even once his arguments have been concluded, the nature and status of the link is ambiguous. My aim will be to ascertain more precisely the nature of the proposed link. I begin with a brief discussion of the arguments within which the link is proposed, after which I expound the puzzle I take to exist in Mellor's account. Finally, and most importantly, I examine potential resolutions of the situation. This last forms the heart of the chapter.

Note that my interest here is not solely interpretive. Mellor's account was proposed and is seriously entertained as a substantive B-theory account of time, complete with responses to difficulties faced by B-theory accounts. Much of its virtue – particularly with respect to the question of the apparent asymmetry of time mentioned above – depends on the successful establishment of a link between causal order and temporal order. Thus, my primary interest is in obtaining the most plausible version of the link. I turn now to the arguments of Chapter 10 of *Real Time II*.

Mellor's argument for the conclusion that causal order "fixes temporal order" (1998, p. 108) has its root in the significantly different relations we, as agents, bear to our past and future. Mellor

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[13] It is worth noting at the outset that, throughout this paper, I hope to remain neutral on the question of what causation consists in, with the exception of one substantive assumption – I will assume that causation is essentially asymmetric. The claims that I make here should be compatible with most accounts of causation.

takes it to be clear that, in considering our experience, the following holds quite generally: For any time t at which we are situated, we can perceive (that is, are able to be affected by) only things earlier than t and can affect only things later than t. This is explained by the fact that, in general, causes precede their effects. In the terms of our initial discussion of the B-series of all actual events, this amounts to the fact that, in general, the asymmetric cause-effect relation is arranged in a uniform direction along the series. We do not find cause-effect pairs scattered in both directions evenly, so that effects precede their causes just as frequently as causes precede their effects. This correlation between the direction of causation and the earlier-later direction is Mellor's primary explanandum.

On offer are two mutually exclusive and seemingly exhaustive explanatory options: The correlation is explicable only if either the temporal order determines the causal order or the causal order determines the temporal order. Mellor obviously favours the latter, primarily in virtue of its ability to explain the additional correlations between explanatory direction, means-end direction, and the earlier-later direction. For purposes of brevity, I will ignore these arguments against the former option here and focus on his conclusion as to the correctness of the latter.

In order to clarify this posited link of determination as far as Mellor does, I turn briefly to a number of potential objections raised against the account, in response to which Mellor complicates and clarifies it. Having arrived at the conclusion that causal order fixes temporal order, Mellor proceeds immediately to a number of potential counterexamples. The first of these is the case in which we find causal ordering, but no temporal ordering – that is, proposed cases of simultaneous causation. To take Kant's well-known example (1781 A203), placing a ball on a cushion (this being the cause) is simultaneous with the effect of the cushion becoming indented. Mellor's response is to reject such cases as genuine cases of simultaneous causation. He claims that the time difference between the successive positions of the ball and the corresponding indentations on the cushion is – even if miniscule – nonetheless existent and we are simply being imprecise when we suppose that the two are simultaneous.

A more significant obstacle for the purposes at hand, however, is presented by cases of temporal ordering without causal ordering, examples of which abound. As per our B-series construal of the series of events, any given event bears a temporal relation to every other event in the series. However, as Mellor notes, "the causes and effects of any such fact or event will include only the minutest fraction of all the world's earlier and later facts or events" (1998, p. 111). For example, the coronation of George V is earlier than my writing of this paper, but it is implausible that there is a chain of causally related events joining the two (even, emphasises Mellor, assuming

that causation is transitive). And the case is the same in countless other instances. Mellor's response to this is to admit the discrepancy between the number of causal and temporal relations between events, but to show that temporal order is *derivable* from causal order nonetheless. More specifically, Mellor claims that, on the basis of a very limited number of obtaining causal relations, we can derive all obtaining temporal relations. This proceeds as follows: A great many facts hold of every spacetime point, (for example, facts about its gravitation, density, curvature, etc.). Given a causal relation holding between spacetime points st_1 (the cause) and st_2 (the effect), we can infer (1) that st_1 is earlier than st_2 and, from this, (2) that all facts holding of st_1 are earlier than all facts st_2[14]. These latter facts mentioned in (2) will themselves be causally related to facts at other spacetime points. Thus, we have acquired additional causal relations on the basis of which to ascribe temporal order, and this process can then be repeated until all temporal relations have been derived. So, although not every event bears a direct causal relation to every other event (that is, although there is temporal ordering where there is no causal ordering), given that spacetime points admit of multiple facts, we can ascribe temporal order to the whole spatiotemporal series on the basis of intermediate causal relations.

Finally, I wish to raise a tentative counterexample, not discussed by Mellor. The counterexample does not invoke an actual discrepancy between temporal and causal ordering, but rather the possibility of a discrepancy. It consists in the possibility of a world containing only random events – thus a world with temporal ordering, but entirely without causal ordering. It seems that we can at least conceive of such a world. Whether such a conception is one of a world that is indeed possible – and not a conception which merely shows our everyday concepts of causation and time to differ – requires further settling. In favour of the possibility of the described world, Smart supposes he can "envisage a universe of purely random events spread out through space-time" (Smart, 1971, p. 70). However, whether or not the possibility of such a world undermines the link between causal and temporal order proposed by Mellor does indeed depend on the precise nature of the link proposed – hence my interest in the counterexample. As I will discuss below, there is some reason to take Mellor to be proposing a link that holds only of the actual world. If this emerges as the best interpretation of Mellor's position, then the mere possibility of such a world will not injure his position.

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[14] Mellor allows for facts as well as events to be causally related to one another. It would take me too far afield to engage in an examination of this position, so I will merely assume it for the course of my discussion.

The details described above – viz. those contained in Mellor's main argument for the determination of temporal order by causal order and his subsequent appeal to derivability – exhaust in all relevant respects the substantive details of the link proposed by Mellor. Now it is clear that a minimum claim of the account is that we can *ascribe* temporal order on the basis of causal order alone. So, epistemologically, complete knowledge of causal relations would allow us complete knowledge of temporal relations, and, logically, the set of causal relations is sufficient for the set of temporal relations (the latter are derivable from the former). However, it is not clear that in the epistemological case the link does us much good (our epistemic access to temporal ordering is plausibly more basic than our access to causal ordering). And, despite the logical dependence, it seems to me that these details are not sufficient to settle the question of the precise nature of the link proposed, in two ways: First, do temporal and causal ordering constitute two distinct relations or does the link allow us to identify them, so that temporal ordering emerges as nothing over and above causal ordering? Secondly, and not unconnected to the former question, what is the modal strength of the link? Must we understand it to hold in all possible cases (and thus to be a substantive account of what the time relation consists in) or does Mellor have the more modest aim of providing an account of what determines the time relation in the actual world?

Commonly in discussions of reduction, determination relations, identity, and suchlike, the relevant relata are properties or particulars. In our case, however, the relata are neither of these. The relata are themselves relations. This means, firstly, that complications may arise in our discussion that are not found in the analogous relations for properties and particulars. Secondly, this constitutes my motivation for labelling Mellor's link between causal relations and temporal relations a 'link' rather than a 'relation'. However, this is due merely to the awkwardness of discussing a 'relation between relations', and so 'link' should be understood as synonymous with the former relation just mentioned and not different in kind from it.

I begin with the case for identity between the two relations – that is, a case for supposing that, given Mellor's account, we must understand temporal ordering just to be causal ordering. This is to understand the link between the two to be as strong as the relation between H_2O and water, or the evening and morning stars. In such cases, despite our having distinct words/concepts available, we have discovered that there is only one thing or type of thing to which the words/concepts apply. A primary advantage of taking Mellor's proposed link to be that of identity is its explanatory power. As discussed, Mellor's intention is to explain the correlation between causal and temporal ordering. He has rejected the position that temporal order determines causal order because it fails to explain

certain additional correlations, and has named the contrary determination relation as the solution and shown it to be consistent (his derivability thesis). However, in itself, it is not clear that this link does much explaining[15]. Logical derivability alone does not guarantee an ontologically satisfying explanation. We need a more substantive account, and identity is a likely candidate. Identity would make light work of why, whenever we find a cause-effect pair, we have found an earlier-later pair, and why, once we have fixed causal order, we have fixed temporal order. It would give an ontological bite to the link that has so far only been given formal powers. Additionally, I take it that identity wherever possible constitutes a desirable ontological conservatism.

Such a picture, however, is not quite so straightforward: First, a previous worry rears its head in a new form. A minimum requirement on identification between x and y, regardless of the nature of x and y, is that something is a case of x if and only if it is a case of y. If we are to identify the relations, it must be the case that they correlate 1:1. And, as noted earlier, cases of a temporal relation without a corresponding causal relation abound (King George's coronation and my typing). It simply is not the case that wherever we find an earlier-later pair, we have found a cause-effect pair. A further symptom of this situation is Mellor's explicit statement of the transitivity of the 'earlier than' relation and the non-transitivity of the 'cause-effect' relation (1998, p. 118). We cannot identify two relations if they diverge in their formal properties. These considerations appear to rule identity out tout court.

Secondly, one might worry – although perhaps not too seriously – about the distinctness of the concepts getting in the way of an identification. If we are going to show two things to be identical on the basis of philosophical considerations alone, then we must surely proceed by showing the concepts to be analysable in terms of each other. In this case, the mentioned possible-world example of a temporally – but not causally – ordered world does more than enough to show a lack of entailment between the two concepts, and thereby eliminates the possibility of identifying the relations. Finally, Mellor begins his derivability argument with some assumptions that appear to be specific to the actual world, viz. that every spacetime point is the "location of many facts, e.g. about density, curvature, pressure, … etc., all of them related causally to some other facts at other points" (1998, p. 113, italics omitted). Assuming that identity is a necessary relation, it might be objectionable to appeal to contingent facts as the foundational premises in our argument.

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[15] Note that I am here focussing on an explanation for the correlation between temporal and causal order *quite generally* and not only the correlation in the case of agents.

The latter two of these concerns are, I think, fairly easily dispelled, and I mention them merely in order to become a little clearer on the kind of identification I think might be made to work for Mellor. They rest on a sharp dichotomy between analytic and synthetic claims and an unreasonably strong understanding of concepts as immutable and immalleable. In the case of the first, we need not fix reference to the things concerned by means of concepts that involve sufficient and/or necessary conditions for identification of the thing. We might, as Kripke (1980) suggests, secure our reference by means of ostention or an associated description. Reference to the relevant things thus secured, we are at liberty to discover subsequently the identity of the things. Further, the concepts initially associated with the things may come to change in light of empirical discovery. It is not necessary – nor, indeed, desirable – to take such conceptual variation to mark out distinct concepts without exception. Such a picture answers the above concerns in three ways: First, it is not necessary for an identification of things that the concepts associated with the things be analysable in terms of each other. Reference can be secured directly. Secondly, given the plausibility of a certain amount of fluidity to concepts, the narrow understanding of conceptual reduction appealed to in the objection is implausible from the outset. And, finally, Mellor's appeal to contingent facts in support of an identity is quite legitimate given the possibility of direct reference. It is the rigidity of the reference that does the work in securing the identity across all possible worlds and not the necessity of the premises involved in showing the identity.

The first obstacle, however, may prove a little more difficult to overcome. It is clear that there is no 1:1 correspondence between the relation 'earlier than' and the causal relation. The need Mellor recognises for the argument for derivability serves only to emphasise this fact. However, given the virtues of identification, I think it is worth seeing whether something can be done about this lack of correspondence. In particular, I propose the following: Instead of taking the relations to be identified to be 'earlier than' and the cause-effect relation, we can describe the relations in light of Mellor's derivability thesis. Recall that Mellor's thesis allowed for all temporal relations to be derivable from the smaller set of causal relations in virtue of multiple facts holding at each spacetime point. So, for example, if (1) facts A, B, and C hold of spacetime point st_1, (2) facts D, E, and F hold of spacetime point st_2, and (3) facts A and D are causally related, then, given the multiple location of facts at the points, we can obtain the relation 'B is earlier than E', while there is no relation 'B causes E'. So although we cannot identify 'x is earlier than y' with 'x causes y', we can identify it with a more complex relation – a relation I will call 'causal antecedence'[16]: x causally

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[16] Note that Mellor does not employ this term.

antecedes *y* iff (i) *x* is located at the same spacetime point as some fact *G*, (ii) *y* is located at the same spacetime point as some fact *H*, and (iii) *G* causes *H*, or (iv) some such chain of causation holds between *x* and *y*. Given the more complicated relation of causal antecedence, it is now true according to Mellor that *x* is earlier than *y* if and only if *x* causally antecedes *y*. By adjusting the relata we have obtained relations which can in fact be identified. If this identification – or something like it – is successful, it will provide an agreeable account of the how causal ordering fixes temporal ordering, and how "time is the causal dimension of spacetime" (1998. p. 115). Further, it coheres naturally with all of Mellor's explicit claims. (Perhaps it is even plausible that he intended to be claiming something like the above, and unintentionally allowed in room for movement in the form of ambiguities.)

Note that the above identification renders the link between temporal and causal ordering necessary. Given this, the afore-mentioned possible-world counterexample is potentially problematic. If a temporally-ordered, but causally-vacuous, world is indeed possible, then this would rule out any construal that takes the link between temporal and causal ordering to be necessary, including the present identification thesis. However, as we will see, this counterexample is problematic for any plausible alternative to identification. I return to a discussion of it below.

A further – and tangibly more worrying – question is whether the reference to spacetime points included in the definition of causal antecedence can be avoided. If such reference is ineliminable, then the notion of a spacetime point (with its implicit reference to the temporal dimension) is doing work in distinguishing causal relations – that is, it is grouping together the facts needed for causal antecedence to go through in the first place. In this case, we can no longer obtain the 1:1 correlations between purely temporal and purely causal relations needed for our identification to go through, and our identity must fail. This is problematic even for an account weaker than identity, however. If the supposedly causal set of relations from which we derive the set of temporal relations (assuming the two not to be identical in this case) itself has ineliminable temporal reference, then we have failed to show temporal relations to be derivable from causal relations. We haven't shown either to be derivable from the other! We may be able to find a way out by unifying the facts holding at a spacetime point by reference to the particulars located at that point, thus eliminating reference to the temporal[17] from Mellor's derivability argument. It is clear that the problem arises due to Mellor's assumptions about spacetime points at the start of his derivability argument, and so perhaps Mellor's account has an answer to it. It is clearly a concern

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[17] This seems plausible when we consider Mellor's emphasis that the "existence and identities of times derive in the end from the existence and time order of facts about other things" (1998, p. 113).

which requires resolution if Mellor's account is to succeed overall. However, as it does not affect the prospects for identification, I will not expand on it further.

The alternative to the above identification thesis is to model the determination relation between causal and temporal ordering on the commonly-invoked determining relation of supervenience. Supervenience is commonly construed as a relation holding between sets of properties (Kim, 1984), where a subset of the base properties is sufficient for some subset of the supervening properties. For example, it has been proposed that moral properties supervene on physical properties. So, if the moral property of wrongness supervenes on the physical act of killing out of anger, then whenever an act has the property of being a case of killing out of anger, it has the supervening property of moral wrongness. The reason that such a determination relation is weaker than reduction is because the opposite entailment does not hold. So, it is not the case that whenever an act has the property of wrongness it has the property of being a case of killing out of anger, and wrongness can supervene on different base properties. There may be some difficulty, however, in specifying a relation in the present case that is analogous to the supervenience relation in other areas. In the case of causation, it is unclear precisely what supervenes on what, as there are no such analogous sets of properties involved.

Assuming that an analogous relation can be obtained, a distinction can be made between strong and weak supervenience (Kim, 1984). Under weak supervenience, the supervening relation holds only within a possible world. So, if the property of wrongness weakly supervenes in the actual world on the property of being an act of killing out of anger, then in some other possible world, we could find a case of killing out of anger which is not wrong. This version of supervenience is generally considered to be too weak to be of much use in explanatory reduction, and is taken to be a sophisticated consistency requirement (Kim, 1984). In our present case, given Mellor's claims that temporal order simply "is the causal dimension of spacetime" (1998, p. 115) and that causal order "fixes" temporal order (1998, p. 108), I take it that Mellor does not mean for the derivability of temporal ordering from causal ordering to be construed merely as a consistency requirement on our ascription of temporal ordering in this world. This is yet more plausible when we consider the explanatory project Mellor is engaged in. So, it appears that, regardless of whether the link turns out to be identification or dependence (as discussed here), it is minimally a link that holds further than the actual world.

Finally, a general problem for supervenience relations (as is often brought against Non-Reductive Materialism[18]), is the seeming explanatory poverty of the relation taken on its own. Supervenience gives us determination of one set by another across possible worlds, such that we will not find the former without the latter (although we may find the latter without the former). Now, unless we give a further account of why these sets, and not some others, are linked in this way, the account does not provide a substantial explanation – analogous to that allowed by identification – of why temporal order is fixed by causal order, and so does not do the explanatory work intended by Mellor. On this construal, the link emerges merely as an embellished restatement of itself.

I conclude, then, that we ought to take the link between temporal and causal order posited by Mellor to be that of identification. The identification thesis has explanatory virtue in places where the dependence thesis has none. Further, as a rule of thumb in the service of ontological conservatism, we should opt for identity over dependence unless we have reason for supposing otherwise. In the present case, I claim that – although there is work to be done in eliminating reference to temporal ordering – thus far we have no reason to conclude otherwise.

To summarise, Mellor's version of the causal thesis involves, as far as I can make out, two crucial elements. The first of these is what I will term the 'pair' thesis. This is the claim that temporal asymmetry rests on causal asymmetry in the following way: For any pair of temporally asymmetric events, their temporal asymmetry is fully determined by their causal asymmetry. This is further detailed in the notion of causal antecedence as I have construed it above.

The second element in Mellor's version of the causal thesis is what I will call the 'constitutivist' thesis. The account is not merely that temporal asymmetry is determined by causal asymmetry for every pair of events. It appears that Mellor is making the stronger claim that causal ordering determines temporal ordering *as such*. That is, that temporal ordering is nothing more than causal ordering. This is apparent in claims like, "time is the causal dimension of spacetime" (1998. p. 115). Now what is interesting here, is not the claim itself, but the implications it has for temporal asymmetry. If we take temporal ordering to consist in causal ordering and causation is essentially an asymmetric relation, then time is necessarily asymmetric, and all the features of causation will come to bear on the nature of time[19]. I turn now to Mellor's arguments for this rather strong position.

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[18] See, for example, Kim (2005), chapter 4.
[19] Indeed, Mellor exploits this precise point when he argues that against the possibility of causal loops (1998, chapter 12), and then points out that this sits well with our natural understanding of time as being linear.

Mellor's argument for the conclusion that causal order "fixes temporal order" (1998, p. 108) has its root in the significantly different relations we, as agents, bear to our past and future. There are striking differences between past and future, and the most striking of these, claims Mellor,

> is that while we can see (or perceive by other senses) what is past, but cannot affect it, with the future it is the other way round: we can affect but not see it. This does not of course mean that we can see everything that is past and affect everything that is future. [There are] contingent and variable [constraints], [but] our inability to see anything in the future or affect anything in the past seems absolute and unchanging...
>
> The fact that most if not all causes and effects are separated in time already marks a difference between time and space that needs explaining, since the fact has no spatial analogue. Causes and effects are often in the same place, as when the unchanging thing *a* of chapter 9.4 is also unmoving. And when an effect is not where its causes are, it may be north or south, west or east, above or below them. The cause-effect relation has no preferred spatial direction. Why then does it have a temporal one?
>
> There are A-theory answers to this question which, having rejected the A-theory on other grounds, I shall not discuss. The question for us is how B-theorists can explain the correlation between causal and temporal order. The answer is that we cannot unless we take the latter to be entailed by the former. For if we take these two orders to be independent, it should be as conceivable that effects generally precede their causes as that causes generally precede their effects. Yet not even those who think that some causes may be later than their effects think that all or even most could be.
>
> But then may not the dependence between the earlier-later and cause-effect relations go the other way? Why, in particular, may we not *define* a cause as the earlier of two causally related facts or events? The answer is that there are at least two other ways of distinguishing causes from effects, with which this definition could then conflict. These follow from the fact that whereas causes both *explain* their effects and provide *means* of bringing them about, effects neither explain nor provide means of bringing about their causes...
>
> So if the general coincidence of causal and temporal order is to be more than a coincidence, it cannot be because time order fixes causal order. It must be the other way round.
>
> <div align="right">1998, p. 106 – 107.</div>

It would seem that Mellor is attempting to offer his version of the causal thesis as the best explanation. Mellor's initial explananda are the temporal asymmetries evident in action and perception: It is, he claims, a "striking feature of time" (1998, p. 105) that insofar as we are able to affect events, our affecting them is constrained to events which have not yet occurred (that is, events

which are in the future). Similarly, insofar as we are able to perceive events, our perception of events is constrained to events which have already occurred (that is, events which are in the past).

A quick remark on Mellor's terminology is necessary: I take it that Mellor does not mean to claim that we can perceive past events in the way in which it is natural to talk of our perceiving present events. I understand Mellor's talk of perceiving past events as the claim that, for any given time, the set of events that have been perceived by us *at some time* consists only in events that are earlier than that time. To clarify, it might be worth reformulating his point in terms of memory – viz. our memory is constrained to events which have already occurred (and this because we have perceived them). These two asymmetric features of us, as agents and epistemic subjects, reduce to a single asymmetric feature of the world – that is, the temporal asymmetry of causes and effects across time. Action, claims Mellor, just is our causing of certain events, and so we find that the temporal asymmetry of action consists in the temporal asymmetry of causes and effects. It is because causes precede their effects that our actions are directed towards the future only. And the same point holds in the case of memory. Perceptions are the effects of external stimuli on our bodies. Thus, our inability to remember the future is a consequence of the causes of our perceptions lying in the past – again, it is a consequence of causes preceding their effects.

Thus Mellor arrives at his fundamental explanandum – viz. the fact that causes precede their effects. The force of this fact can be noted if we consider the world in the following way: Take the total set of particular events as given fundamental existents. Of this set of particular events, we find that they are (i) temporally ordered in relation to one another, and (ii) causally ordered in relation to one another. What is striking is that these two ways of ordering the set happen to give them precisely the same ordering. It is this fact which Mellor claims is in need of explanation. Further, if we consider the ordering given to the set of events by the spatial relations between them, this ordering varies dramatically from the causal and temporal ordering. Thus, as Mellor notes, causal ordering is intimately connected to temporal ordering, while it does not bear the same sort of connection to spatial ordering. I will term the general fact appealed to by Mellor that causes precede their effects the 'coincidence' of causal and temporal ordering. It is worth noting that Mellor does not intend the explanandum to be so strong as to rule out backward causation tout court. All he is assuming is that, generally but perhaps not without exception, causes precede their effects.

In response to this, we might, according to Mellor, make one of three moves: First, we might – seemingly unreasonably – take the two orderings to be entirely independent of one another. Secondly, we might suppose the temporal ordering to be the more fundamental of the two and the

causal ordering to be derivative. Finally, and contrary to the second, we could take the causal ordering to determine the temporal ordering. I begin with the first.

In response to the independence thesis, Mellor invokes the claim that independence of the two orders entails the conceivability of them coming apart. If the independence thesis is correct, then, in thinking of the temporal ordering of the total set of particular events, it should be as conceivable to us that we should find the causal ordering bearing no similarity to the temporal ordering as it bearing the similarity it does. We should take it to be conceivable that effects should precede their causes as frequently as causes precede their effects. And yet, claims Mellor, such independence of the two orders is not conceivable. He states, "not even those who think that some causes may be later than their effects think that all or even most could be" (1998, p. 107). Thus Mellor disregards the independence response from the start.

Turning to the second response listed above, we see that this is the so-called and oft-attacked 'Humean' account. The asymmetry is a matter of our defining 'cause' and 'effect' respectively as the earlier and later events of the relevant pairs of determined or conjoined events. Thus, the fact that causes precede their effects becomes a matter of us choosing to use the words 'cause' and 'effect' in the way we happen to. On this account, there are no asymmetric relations of determination among events. There are either symmetric determination relations or no determination relations. We then introduce an asymmetry stipulatively in our use of 'earlier' and 'later', which identify one of a pair of events as nearer to a given end of the block universe.

Mellor's argument against the Humean account runs as follows. The Humean proposes that we explain the coincidence in temporal and causal ordering by defining the latter in terms of the former. However, temporal and causal order are not the only two orderings in which the total set of particular events coincide. If we examine this set of events, we will also find that the order of means-ends pairs coincide with the mentioned orderings, as well as the order of explanandum-explanans between the events. Mellor claims that, as the Humean account is a definitional account, we cannot thereby explain why these additional orderings also coincide with the causal/temporal ordering. He states, "Either of [the] links, between causing something, and explaining and being a means to it, could thus be used to define a cause as that one of two causally related facts which explains or is a means to the other. But then we must ask why these two definitions pick out the same member of each pair of causally related facts, and no definition will tell us that." (1998, p. 107). The basic point seems to be that, if we define three sets of correlations or coincidences in terms of a fourth, this does nothing to tell us why the correlations or coincidences are such in the first place.

Finally we arrive at Mellor's favoured explanation of the coincidence of the two orders - the determination of temporal ordering by causal ordering. Although Mellor puts forward a number of inter-related arguments for the link over the course of the book, within the argument under discussion, he appears to make the following two-fold move: First, I take it that he intends for the possible responses mentioned to constitute an exhaustive range of responses to the explanandum. Thus, having ruled out the former two responses, we can arrive at the favourability of the third simply by means of elimination. A clear statement of his appeal to an argument by elimination can be found on page 108: "If the general coincidence of causal and temporal order is to be more than a coincidence, it cannot be because time order fixes causal order. It must be the other way round." Mellor does not rest solely on this move, however. The proposed explanation is, secondly, shown to have the further advantages of being able to explain the additional temporal asymmetries (viz. the means-end and explanandum-explanans asymmetries) which the second response left mysterious. The precise way in which the causal account does this is not made explicit by Mellor, but presumably runs something like the following: We are able to use certain actions as means to ends because our actions, as causes, are able to bring about certain effects. Thus, the fact that causes precede their effects (and whatever explains this fact) will explain the fact that means precede their ends. Similarly, what does the work in explanations involving spatiotemporal events are the causes of those events. According to the causal account, causal order determines temporal order and so causes precede their effects. Given that actions are special cases of causes and effects, and explananda are the effects of the relevant explanans, it is no surprise that means precede their ends, and explananda are temporally subsequent to their explanans.

For ease of reference, I list the claims involved in Mellor's argument below:

1) There is a notable temporal asymmetry of action and perception.

2) These asymmetries (in 1) are instances of the general fact that causes precede their effects.

3) That causes generally precede their effects could be explained

   (i) by temporal and causal order being independent of one another.

   (ii) by temporal order determining causal order.

   (iii) by causal order determining temporal order.

4) (i) is ruled out because no-one thinks that "all or even most [causes] could be [later than their effects]".

5) (ii) is ruled out because it leaves the additional temporal asymmetries of means-ends and explanandum-explanans mysterious.

6) (iii) is the favourable explanation both by a process of elimination and because it explains the additional temporal asymmetries of means-ends and explanandum-explanans.

As is clear from the above, Mellor's argument overall proceeds quite quickly, but – according to my mind at least – leaves us wanting further clarification. Indeed, part of the reason for there being so much clarificatory work is, I think, the fact that the argument is given in such bare terms. A crucial question that arises in an attempt to understand Mellor's argument is how we are to understand his primary premise – that is, the premise claiming that causes generally precede their effects (premise number 2). If we focus on the premise without taking note of the conclusion to which it leads, it might be quite natural to take it to be an observational or empirical premise. That is, we might construe Mellor as noting a fact about the world as is given by our experience of it thus far. If the premise is an empirical one, then it might be true of the region of spacetime or world we occupy, but it need not be taken to hold of all regions or worlds. It need only be true of regions or worlds sufficiently like this one.

In contradiction to this reading of the premise, Mellor seems clearly to indicate that there is a conceptual compulsion to accept (2). This is evident in his claiming that "no-one thinks that all or most effects *could* precede their causes" (1998, p. 107). As noted, it is this conceivability that rules out the independence of the two orders from the very beginning. If the orders were independent, it should be as conceivable that effects should precede their causes. And Mellor explicitly denies the possibility of conceiving this. Further, it seems methodologically odd to argue for the explanation of a purely contingent empirical fact by means of a priori argument. Thus, an a priori or conceptual reading of (2) squares better with the ensuing argument than does an empirical reading of it.

The trouble on this reading, however, is that it is far from clear that we cannot *conceive* of effects preceding their causes as frequently as they succeed them. Granted, we do unflinchingly take it to be a fact that causes generally precede their effects. However, Mellor's claim seems to be against our even thinking that things *could* be otherwise. It seems to be a claim about what we can conceive to be possible. And it is not clear to me, in the absence of further argument, that I cannot conceive of a world in which causal dependence is scattered evenly in both the earlier-later and the later-earlier directions (a spacetime block universe will do the job nicely, for instance). So it simply

doesn't seem to be the case that we are conceptually compelled in this way – at least not in the absence of further argument.

There are two considerations with regard to the above quandry: First, the strength of the premise is plausibly weaker than it appears in the formulation under discussion. This becomes clear in a statement given by Mellor in Chapter One of *Real Time II*. Secondly, however, Mellor does not need to appeal to the inconceivability of effects preceding their causes just as frequently as causes precede their effects.

To provide some direction in this regard, I turn to chapter one of *Real Time II*. Here Mellor comments on his argumentative strategy generally and on how he conceives of his argument. He states, "To show what time is, I must start by assuming something about it, since even metaphysical bricks need some factual straw." (1998, p. 7) So perhaps Mellor is meaning to appeal in premise (2) to something which we hold to be factually, but not conceptually, true. And his case will then be as strong as these factual assumptions upon which it is based. Indeed, this squares up well with his subsequent comment that he "shall not try to prove that everything I claim is either necessary or undeniable." (1998, p. 7) So, the distinction relevant to premise (2) seems to be one not between conceivability and inconceivability, but that between what we ordinarily take to be true of the world and logically possible ways that the world could be. Mellor does not – at this early stage of the argument – deny that it is logically possible that all or most effects should precede their causes (and thus, squaring with what I claimed earlier, he does not deny that we can thereby conceive of a such a world). Rather, he is denying that we have any reason to take the world to be that way.

So, without argument for the plausibility of the claim that the world is such that effects are found preceding their causes just as frequently as they are found following them, we need not take the mere conceptual possibility of such a world too seriously. Indeed, Mellor states in the introduction to chapter one, "I shall waste no time rebutting merely conceivable objections to what I have to say: doubt and disbelief are not worth trying to dispel unless they are both real and credible." (1998, p. 7) Thus, it seems that the correct construal of Mellor's crucial premise (2) is to understand it as asserted against the backdrop of this turn towards a sort of philosophical temperateness.

In this light, premise (2) is – I feel – far more comprehensible. And what needs doing having established the status of the premise and its ensuing argument is twofold: We must ask whether the causal account is indeed the best explanation available for the coincidence between causal and temporal order (and this will of course involve an examination of other plausible alternatives). But

prior to this, we must ask whether any positive reasons can be given for supposing that the world is not such that in general causes precede their effects. In the absence of such reason, we are, it seems, quite entitled to conclude along with Mellor that the best explanation of the coincidence of causal and temporal ordering is to be taken as true.

If we accept this weakening, however, it threatens to wreak havoc with premise (4). Recall that Mellor's rejection of the independence thesis depended on the inconceivability of the non-coincidence of temporal and causal ordering. If we now allow for such non-coincidence to be conceivable, dialectically Mellor has lost his reason for rejecting the independence thesis. In response to this worry, it seems to me that premise (4) is not to the point in any case. We need not rule out (i) by appealing to the inconceivability of non-coincidence because (i) really lacks explanatory force entirely. It simply is not an explanation of coincidence to claim that there is nothing connecting the two coinciding sets.

With regard to (5), Mellor assumes that the Humean account of the situation must proceed by definition. That is, the only way in which we might understand the causal ordering to be determined by the temporal ordering under this second response is if we link the two definitionally, thereby preventing the one from having any but linguistic status. This is in contrast to his favoured explanation, of which he distinguishes both definitional and non-definitional versions, favouring the latter. (In the case of the former, it is simply a fact of our use of language that we dub causes 'earlier' and effects 'later' and temporal relations emerge as nothing but useful bits of terminology, whereas on the non-definitional version I take it that both temporal and causal ordering emerge as genuine relations, with the one being determined by the other.) Now Mellor does not explicitly mention why he does not consider a non-definitional version of the Humean account. Such a version would allow for both temporal and causal ordering to be genuine relations, but would take the temporal ordering to be fundamental with the causal ordering being determined by the former. This is one way in which (5) might be rejected. Further, it is not clear that there isn't some room for movement here to get the definition to go some way towards explaining the coincidence of these four orderings. Having defined cause and effect in terms of earlier and later, we might then go on to analyse means and ends, and explananda and explanans to be related to cause and effect conceptually. Means and ends might be construed as a narrower, but derivative, concept of cause and effect – viz. the causes and effects of agents. Similarly, explananda and explanans might be construed as causes and effects which we find to be of interest, given a particular area of enquiry. Mellor speaks as if there are independent orderings to be found in the world for each of these

things, but it is not clear that we must construe things in this way. It is worth noting, however, that I do not suppose that the account offered here is *preferable* to Mellor's causal explanation, but invoke it only to show that Mellor might be a little quick in concluding that the Humean account has *no* explanatory force in dealing with the coincidence of the four orderings.

Finally, it is worth noting that Mellor's options listed in (3) do not exhaust the logical space. We might also take temporal and causal ordering to be mediated by some third ordering or source of ordering as a common determiner of them both. On such an account, the two orderings may or may not be entirely unrelated to one another, but it would incorrect to say that either ordering determines the other. An example of such an account might even be the so-called process accounts which Mellor attacks in the argument following the one presently under discussion. I will discuss such views in more detail below, but the basic idea is that the ultimate explanation for both temporal and causal ordering of events lies in a combination of the contingent initial conditions of the universe and time-symmetric physical laws.

I conclude, then, that Mellor's argument for the causal thesis as it is explicitly given in *Real Time II* is by no means conclusive. If we are to retain the causal thesis, we are going to need to find some other support for the position.

Next, I turn to Mellor's argument against so-called process accounts – what I have called the 'clock argument'. As is the case with many of Mellor's arguments, it is expressed in relatively simple terms. This simplicity is deceiving, however. Thus, again my first task in this discussion is to try to render the argument on paper with a little more clarity that it displays in *Real Time II*. Secondly, I will try to uncover the flaws in the argument. Finally, I will try to show that Mellor's argument is not sufficiently general to cover all process accounts. As the argument in Mellor's words is not unmanageably long, I repeat it here for ease of reference:

> First, let us call processes that link events with incompatible properties *F* and *G* '*FG*-processes' and divide them into *F*-processes, where *F*-events precede *G*-events, and *G*-processes, where *G*-events precede *F*-events. Then *FG*-processes are reversible if processes of both *F*- and *G*-types occur, and irreversible if only *F*- or only *G*-processes occur.
>
> An example of an *FG*-process is our clock hand of chapter 1.5 moving past '1' (an *F*-event) and '2' (a *G*-event) in a single circuit starting at '12'. Let us call the clock *c*. Then these processes in *c* are irreversible, since *c*'s hands always move one way, so that *F*-events always precede *G*-events. So suppose we use this fact to define the direction of time, as that from *F*-events to *G*-events, i.e. from a clock hand's passing '1' to its passing '2'. Then if ever the time order of events of these kinds seems reversed, i.e. if a clock hand seems to move anti-clockwise, as it would if a clock – call it *c'* – were travelling back

in time, we must take this to be a local reversal of the direction of time. And so indeed we would in that case.

But not in the case of a clock *c″* whose hands are *made* to move anti-clockwise: so there must be more to backward time travel than that. But what more? How must *c″* differ from *c*? The answer is that its *clockwork* must differ. *c* and *c′* have the same clockwork, the same causal mechanism, which makes their *FG*-processes irreversible by letting *F*-events affect *G*-events, but not *vice versa*. Thus, on either *c* or *c′*, bending the hand as it passes '1' will make it bent as it passes '2', but not *vice versa*. Whereas on *c″*, where the causal order of *F*- and *G*-events is reversed, bending the hand as it passes '1' will *not* make it bent as it passes '2'.

...[A]s our causal theory of time order asserts, reversing the direction of time means reversing the time order of *token* causes and effects, as the time-travelling clock *c'* does. Reversing the time order of events or facts of different *types*, like *F* and *G*, as the anti-clockwise clock *c"* does, is irrelevant. But then it is irrelevant whether any processes are irreversible. This is why the direction of time does not need, and cannot be defined by, any irreversible processes, neither those of (a) – (c) nor any others.

1998, p. 120 – 121.

The argument is intended to show the superiority of the causal account over process accounts of temporal asymmetry. 'Process' accounts, as Mellor terms them, are accounts of what constitutes the asymmetry of the temporal relation. Such accounts claim that the asymmetry of time consists in the contingent fact that certain relevant processes typically evolve in a given order, and never in the reverse order. The direction of time from earlier to later just is this the order displayed by the typical evolution of the relevant processes. As Mellor notes, a number of different processes are often invoked – increase in entropy, the outward expansion of radiation, and others. Thus, on such accounts, the asymmetry of time is given by the order of properties along the temporal dimension (that is, in terms of types instantiated).

Now we might wonder what the relation of the Clock Argument is to the argument just discussed. Mellor emphasises this argument as an argument for the *asymmetry* or "direction" (1998, p. 118) of time and not merely as an argument for the determination of temporal order by causal order. The reason for this, I think, arises out of its also being an argument against process accounts of the asymmetry of time. Such accounts can differ crucially from Mellor's account in two ways: First, they might take symmetric temporal ordering to be an irreducible relation between events, one independent of temporal asymmetry. That is, contrary to Mellor, they do not include the claim that the temporal relation is reducible to or determined by some other relation. (The entropic account, for example, makes ineliminable reference to the temporal ordering of events across spacetime in order to examine these events for an increase in entropy). Secondly, they take the

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temporal relation itself to be a symmetric one. Thus, process accounts are not aiming to give an account of temporal ordering *as such* (as Mellor's first argument attempts to do). As mentioned, they are rather only intending to account for the *asymmetry* of time

Now what Mellor means for the above argument to show is that, *regardless of the processes appealed to*, irreversible processes do not determine the direction of time's asymmetry. That is, the difference between earlier and later does not consist in the variation of properties across the series of events. What we need is for the point to generalise successfully from the case of the clock. But before turning to this, it will be of some use to reconstruct the argument.
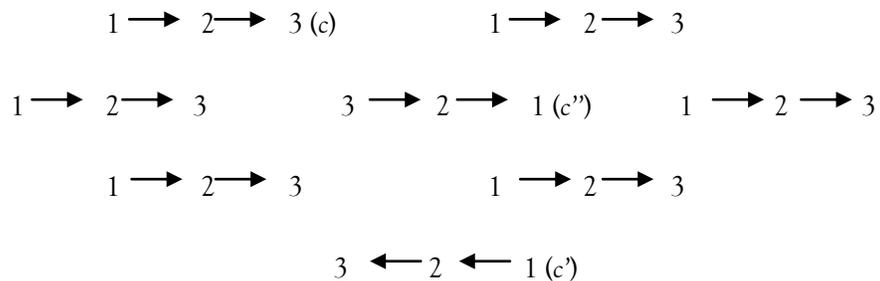
There are a number of important conclusions present in the extract cited. First, Mellor denies the relevance of variation in properties across a series of events in determining the direction of time for that series of events (we shall see in a moment that this consists of a denial of both the sufficiency and the necessity of such variation). Secondly, Mellor asserts the dependence of temporal direction on causal direction. Third is the claimed relevance of tokens – as opposed to the irrelevance of types – in determining the direction of time. I begin with the first conclusion mentioned. I take the argument to look something like the following in standard form:

1) *FG*-processes$_{DEF}$: Processes that link events with incompatible properties *F* and G
2) *F*-processes$_{DEF}$: Processes in which *F*-events precede G-events
3) G-processes$_{DEF}$: Processes in which G-events precede *F*-events
4) *FG*-processes are reversible if both *F*-processes and G-processes occur
5) *FG*-processes are irreversible if only *F*-processes or only G-processes occur
6) Let us arbitrarily take the *F*-event to be the moving of a clock hand past '1' within a single circuit starting at '12'.
7) Let us arbitrarily take the G-event to be the moving of a clock hand past '2' within a single circuit starting at '12'.
8) In clock *c*, the hands always move clockwise.
9) Thus, the processes in *c* are irreversible.
10) Let us, then, take the direction of time$_{DEF}$ to consist in the direction from *F*-events to G-events – that is, the direction from the moving of a clock hand past '1' to the moving of the clock hand past '2'.
11) If the direction of time is the direction from '1' to '2', then any case of a clock hand moving past '2' and then past '1' must be a case of a local reversal of the direction of time.
12) The hands of clock *c'*, a time-travelling clock, move past '2' and then past '1'.
13) Thus, clock *c'* is a case of the local reversal of the direction of time.

14) The hands of clock c'', an anti-clockwise clock, move past '2' and then past '1'.

15) However, clock c'' is not an instance of the local reversal of the direction of time.

16) Thus, the direction of time cannot consist in the direction from '1' to '2'.

Premises (1) – (5) are Mellor's express definitions. To begin with, it seems to me that Mellor's bare construal of irreversible processes as a kind is adequate. (9) follows of course from the definition of irreversibility and from the conjunction of (5) – (8). Premise (10) is the point of entry of process accounts. I take it that this premise is ultimately meant to be representative of all definitions of the direction of time in terms of processes. (11) is intended to follow, I take it, from the stipulative definition of the direction of time given in (10). In order to understand how it and (12) – (16) follow from it, we need to examine the clocks, and their involving notions, a little more closely.

Now Mellor speaks of a "clock hand seem[ing] to move anti-clockwise" (1998, p. 120). This apparent direction must be from the point of view of ordinary processes. So, we consider the events according to the direction of time defined and taken in this order, a time-travelling clock would display the opposing order of process. The backward-running clock is analogous – that is, the order of process seems to be reversed when considering the series in the order used to define the direction of time. A diagram might help to make this a little clearer:

$$1 \longrightarrow 2 \longrightarrow 3\ (c) \qquad\qquad 1 \longrightarrow 2 \longrightarrow 3$$

$$1 \longrightarrow 2 \longrightarrow 3 \qquad\qquad 3 \longrightarrow 2 \longrightarrow 1\ (c'') \qquad 1 \longrightarrow 2 \longrightarrow 3$$

$$1 \longrightarrow 2 \longrightarrow 3 \qquad\qquad 1 \longrightarrow 2 \longrightarrow 3$$

$$3 \longleftarrow 2 \longleftarrow 1\ (c')$$

The various chains represent a number of different clocks. We have decided to define the direction of time according to the irreversible processes of clock c. The direction of time is represented by the arrows. Now the sense in which c' and c'' display reverse order of process should be apparent. If we consider the overall system in the order given by c, we find that the hands of c' and c'' point to 3 and then 2 and then 1, which is the reverse of the hands of clock c and the rest of the clocks. So, we find a reversed order of process if we hold fixed the order as per our definition

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(consider the series in the order given by *c*) and examine the properties or processes of the time-travelling and backward-running clocks under this order. The 'appearance' of a reversal of the time order of these event-types just is this contrast between the defined direction and the reverse of the order of process found in this direction.

With regard to Mellor's invoking the "local reversal of the direction of time" (1998, p. 120), it must be noted that the only sort of time reversal that can coherently be appealed to by a B-theorist is a local time reversal. The notion of a reversal of any sort is a relational notion. So there must be a contrastive case – a 'non-reversed' version of whatever is under consideration. On the A-theory, this 'non-reversed' direction can be given by the direction of the present along the series. However, in the case of the B-theory, on which we admit the ontological equality of all events at all times, we cannot make any such appeal. Thus, any reversal in the direction of time must consist in a region of spacetime bearing the contrasting direction to the direction of time displayed by spacetime more generally, and so can only be local.

Finally, in the case of a 'time-travelling clock' like *c'*, the direction of time is contrary to the direction of time for other objects. So, for clock *c'*, we must take the direction of time to go from its passing '1' to its passing '2'. Further, if we consider the events along the history line of the clock in the direction of its local time (that is, in the direction of the arrows on the above diagram), we will find that the processes are proceeding quite normally. That is, from the point of view of the clock, things would be running normally – but in the t_n - t_0 direction. It is worth noting that this coheres with an intuitive notion we might have of time travel. For example, in the hypothetical case of the time travel of a person, their processes are running normally from the perspective of their history line. They are reversed relative to the processes going on in the non-time-reversed people.

Now Mellor's argument thus far does – it seems to me – have a clear intuitive appeal. The point which Mellor pushes here is that merely reversing the order of evolution of a process in some system does not constitute a reversal of time. Under the proposed definition of the direction of time in terms of irreversible processes, there is a case in which we would not say that the direction of process evolution aligns with the direction we would attribute to time. This is the case of the clock made to run anti-clockwise. Here we have the opposite of the usual processes, but it could be fitted in to a perfectly normal construal of the direction of time. Thus, the typical evolution of a process or processes cannot be enough to determine the direction of time.

I take it that this first part of the argument – the part dealing with the conclusion against process accounts – is a case of proposing a general principle, and thereafter refuting the principle by

counterexample. (Part of the problem as we will soon see is that the principle is not sufficiently general.) We are presented with a case which seems to confirm the account, which is then contrasted with a counterexample intended to falsify the principle. In the case of the second conclusion, however (viz. the conclusion that causal direction determines temporal direction), the logical form of the argument is a little more difficult to discern. If we understand it along the lines of the previous argument, as below,

1) Let us take the direction of time$_{DEF}$ to consist in the direction of causation.
2) If the direction of time is the direction of causation, then any case of a reversed causal order must be a case of the local reversal of the direction of time, and the absence of a reversed causal order must be a case of the normal direction of time.
3) Clock c' has a reversed causal order.
4) Thus, clock c' is a case of the local reversal of the direction of time.
5) Clock c'' does not have a reversed causal order.
6) Thus, clock c'' is not a case of the local reversal of the direction of time.
7) Thus, the direction of time consists in the direction of causation.

we have only a case of affirming the consequent. That is, we have found a correlation between causal and temporal order (and even a general correlation if the argument successfully generalises from the arbitrarily-chosen example), but we have not found any support for the conclusion. Given that Mellor has presented a number of arguments for the claim that causal ordering determines temporal ordering, and that a causal account of temporal direction falls out of this claim, we can take these arguments to support the causal account of temporal direction too. And we can then simply take this argument to be confirmatory argument. It doesn't give us very strong reason for taking the direction of time to consist in the direction of causation, but rather only shows that the causation account doesn't stumble over the same obstacles as process accounts.

I turn back now to the first formal argument above, viz. the argument against process accounts, in order to raise what I take to be the most worrying concern with the argument. This problem is made apparent by my formulation of the final conclusion. If we end the argument there, I take it that no process theorist will take issue with the claims made. No-one has proposed that the direction of time has anything to do with the order in which the hands of a clock pass the numbers. The conclusion is straightforwardly true, and was never in dispute. What we really need is the

conclusion that no process whatsoever is adequate to account for the direction of time, and this second conclusion is harder to achieve.

Mellor presumably intends for the arbitrarily chosen F- and G-events to be representative of any events. I take it that the arbitrariness of the events is meant to do the work in getting us from the conclusion about clock hands to the conclusion that no process is relevant to the direction. Indeed, later on he says, "Reversing the time order of events or facts of different types, like F and G, as the anti-clockwise clock c'' does, is irrelevant. *But then* it is irrelevant whether any processes are irreversible." (1998, p. 121, my italics) However, arbitrarily choosing a set of events runs the risk of missing the details thought by process theorists to be relevant to the direction of time. Indeed, the sets of events, or processes, appealed to by process theorists are not simply those that satisfy the single criterion of irreversibility (or typical irreversibility). There are loads of processes fulfilling this criterion – biological processes, chemical and physical processes – but which aren't appealed to by process theorists. It is not the mere irreversibility of the processes that does the work. If this were the rationale, we could choose any irreversible process we like as a reference for the direction of time. There is an explanatory reason that some processes and not others are chosen. It is not a case of mere definition as Mellor has here portrayed it.

Further, and more importantly, if we re-examine Mellor's invoked examples, we find that not all processes are in fact found in the reverse order in the case of clock c''. In fact, it is due to his very appeal to a change in clockwork that this is so. In the case of clock c'', the anti-clockwise clock, we will still find that entropy is increasing in the direction t1 – tn and that an ordinary exchange of energy is taking place. So at the level of description of *different* processes (namely, entropic processes), we do not find a reversal as Mellor suggests. The apparent reversal in process direction is superficial. Similarly, in the case of the time-travelling clock c', not only is the direction of causation reversed, but the direction of entropy is reversed relative to other directions as well. Hence neither of these examples are adequate to show that direction of time and direction of process come apart. What Mellor must do is to show this for entropy –increase (or perhaps some of the other proposed cases).

Now it may be that Mellor can show this stronger claim too, and this is a question I take up in further discussion in chapter three. However, I hope to have shown thus far that the examples Mellor provides do not serve as counterexamples to proposed process accounts. The processes considered are not the relevant ones, and the general principle tested is thus too weak.

To summarise, in this chapter I have examined Mellor's arguments for the entailment of temporal order by causal order, and for the direction of time as consisting in the direction of causation. I have raised a number of complications and worries which render Mellor's arguments for the causal theory of time order somewhat insecure. Can the causal thesis be salvaged, if these arguments are as knotty as I have construed them above? This is the question I take up in the next chapter, with the aim of showing that the causal thesis – although not Mellor's version of it – can indeed be salvaged.

Chapter Three

In this chapter, I intend to bring a number of considerations to bear on the details of Mellor's version of the causal thesis. I begin with the resurrection of an objection that Mellor takes himself to have adequately dealt with, viz. backward causation. It is in response to this objection that I attempt to reformulate his appeal to the agential asymmetry. This reformulation it turns out supports a somewhat different version of the causal thesis – the 'majority' version. This version, although promising, is subject to a number of worries. I conclude with a suggestion to overcoming these worries, which I think shows some promise.

Now, a well-trodden consideration brought against the causal thesis and its corollary – viz. the Humean account - is that they run the risk of ruling out backward causation by fiat, as it were. It is thought that if an analysis of causal asymmetry in terms of temporal asymmetry or vice versa entails the impossibility of backward causation without a substantiation of this impossibility, the analysis is unwarrantedly strong.

Mellor takes it to be a virtue of his account that it is not subject to this objection (1998, 113)[20]. I hope to show, though, that this is in fact not straightforwardly true, and if it is to avoid the objection, some retuning is going to be needed. Mellor claims that – in abstraction from his independent argument against backward causation – his account is compatible with the possibility of backward causation. The way in which it is so is not immediately apparent, for Mellor's analysi is a pair analysis, and is in this respect analogous to (the standardly-attacked, simplistic version of) the Humean analysis. The unit of analysis on these accounts is the event (or in Mellor's case, fact) *pair*. The Humean account analyses the relation 'X causes Y' as 'X is earlier than Y (and conditions C)' (the reference here to conditions C being intended to capture whatever further complicating conditions the account might appeal to). The concern put to the Humean upon this proposal is that, since the analysis holds for every possible pair, it seems to entail that in no case can we have X causing Y and being later than it. Similarly, it seems that the Mellorian account, with its analysis of 'X is earlier than Y' as 'X causally antecedes Y', is subject to the same concern. However, the Mellorian account involves some additional claims which allow it to sidestep the concern in the following way: Mellor's view of causal relata is of a pluralist bent. It is pluralist insofar as he allows both facts and events to enter into causal relations, but also insofar as any spacetime point is the location of a number of different facts, variously related to the abundance of other facts obtaining

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[20] Ultimately Mellor does claim to rule out backward causation on the basis of an a priori argument (1998, chapter 12). This argument, however, is independent of his account of temporal asymmetry and the latter is meant to display the virtue of being compatible with backward causation.

at other spacetime points. Thus, for any given bounded spacetime region (for example, the region occupied by my black cat as she sits looking out the window), there are a number of causally-relevant facts bearing the same location (the fact that she is looking out the window, the fact that her tail is curled around her legs in a cat-like fashion, the fact that her body temperature is at its given value). It is these two pluralist components that do the work in arriving at the compatibility of the account with backward causation. Although in the case of every pair the direction of earlier-later unflinchingly goes with the direction of causal antecedence, the account allows for two spacetime points to be both earlier and later than each other.[21] Mellor states, "if C at *t* can cause E at *t'*, a fact Q at *t'* should be able to cause a fact R at *t*." (1998, p. 113)[22] Thus, the account is compatible with cases of pairs in which the direction of causal antecedence is contrary to that of ordinary causal antecedence.

I turn now to two cases of backward causation present in the literature; the one somewhat more imaginative than the other. The former is Dummett's (1964) much-loved dancing chief example.[23] In it, we are presented with the story of the chief of a tribe who is under the – arguably correct – impression that his dancing over four days causes the young men of the tribe to be brave during their initiation ritual (two of which days of dancing are done once the men are returning and the opportunity for bravery has passed). Let us constrain our discussion to a particular case of bravery shown by the young men while on a particular hunt and the case of dancing performed by the chief on day four while the men were returning from this hunt. Now under Mellor's construal, this case of bravery is to be analysed in the following way: There is some fact (or facts) coincident with the men's bravery (or some part thereof[24]), not identical to the men's bravery, and causally

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[21] I suspect that this is the primary respect in which it differs from the Humean account. I take it that one of the assumptions on the latter account is that 'earlier' and 'later' are mutually exclusive.

[22] The multiplicity of facts at each spacetime point, while perhaps not avoiding causal loops entirely, does allow us to avoid the most worrying sort of causal loop – viz. one with only two links, each of which causes the other.

[23] It might be objected that the use of hypothetical merely imagined examples does no work in establishing anything of significance. And as much as I often agree that imagined examples can lead to pie in the sky notions, I suspect that they may be warranted in this case. The point is that we are trying to discover what our notion of earlier-later amounts to. And part of this process (I do not think all) is to test its application in extreme cases. In what follows, I will rely on a distinction between backward causation and time-travelling objects. In addition, I will assume that their impossibility has not been satisfactorily established. Thus, while I am not in a position to demonstrate their possibility, I will take it to be a virtue if an account can retain compatibility with backward causation and time-travelling objects.

[24] Mellor gives an analysis of the duration of a B-time and its parts (1998, chapter one). All we need here is that some fact shares part of its spatial and temporal location with the fact of the men's bravery, and that it is causally antecedent to some fact that share part of its spatial and temporal location with the fact of the chief's dancing. I guess a wind blowing some dust from the site of the bravery to the site of the dancing would do the trick.

antecedent to the chief's dancing. Given this, we can conclude that the other facts bearing the same spatiotemporal location as the bravery are earlier than the facts bearing the same spatiotemporal location as the dancing, and it is thus in virtue of this that we can understand the bravery as earlier than the dancing (as indeed the story tells us it is). However, in addition, the dancing is directly causally antecedent to the bravery (it causes the bravery). Thus, in virtue of this second causal direction, the dancing must be understood to be earlier than the bravery as well.

The second of these is a less magical example – an interpretation of experimental results which has actually been proposed by physicists. The most compelling of these results are – according to de Beauregard (1977) – those gleaned from the Delayed Choice Quantum Eraser experiment. The experiment is, of course, a complicated one, but the gist of it for our purposes is as follows: Two photons (let us creatively tag them 'A' and 'B') are put into an entangled quantum state. The state or behaviour detected in photon A is dependent on the detection of its entangled twin photon B. However, the detection of A's behaviour occurs some nanoseconds *before* the detection of photon B. Thus, it would seem that the detection of photon B has a (nonlocal) effect on the behaviour of photon A which is temporally prior to it, and so can potentially be interpreted as a case of backward causation. Again, according to Mellor's account the situation is to be analysed as follows: There is some fact partially coincident with photon A's mentioned behaviour, and this fact is causally antecedent to some fact partially coincident with the detection of B. This allows us to interpret the situation as one in which the behaviour of photon A is earlier than the detection of photon B (thus, rendering it a case of backward causation). And again, in virtue of the direct causal relation between the detection of B and the behaviour of A, the detection of B emerges as earlier than the behaviour of A as well.

Now it seems to me that there are three ways in which the analysis above doesn't sit quite comfortably with what we might expect of an analysis of backward causation. Take Dummett's example. The unfolding of the events involving the dancing chief and the brave young men does not seem to be a case in which the direction of time is affected, that is, in which the earlier-later relations within the course of events are affected by the backward causation. We can understand the story perfectly well without assuming the temporal priority of the dancing. Indeed, putting Mellor's analysis aside for a moment, there is no immediately intelligible sense in which the dancing over the last two days is earlier than the bravery shown on the second day. The dancing is straightforwardly later than the bravery. There is no sign of the bravery being earlier than the dancing other than its causing the dancing. The case is the same, although perhaps less obvious, in the example from

physics. On Mellor's account, the only thing which might be called on to factor in our interpreting the detection of photon B as earlier than the behaviour of photon A is the causal relation running from B to A.

Is backward causation not precisely a cause which is later than its effect? Mellor's account allows for this only by making the cause earlier than its effect as well. I grant that in certain cases we might want to claim that backward causation involves a reversal of temporal asymmetry. But my point is that for any given case in which X is the retroactive-cause of Y, there *need not* be a sense in which X is earlier than Y. Mellor's account entails that there is. This surely highlights what we should want from an account genuinely compatible with backward causation. We want at the least the possibility of an analysis of backward causation on which we aren't thereby compelled to understand the later cause as *also earlier*. (That is, we can at least make some sense of incorporating backward causation into a perfectly ordinary understanding of the direction of time.) And Mellor has not yet provided this. This is the first and most prominent worry.

A related worry is the following: What we want is that a *later* cause brings about an *earlier* effect. As noted, Mellor achieves this indirectly by appeal to the causal relations between multiple facts. Given this appeal to multiple facts, the facts in virtue of which the cause is counted as later than the effect are not the cause and the effect involved in the backward causation themselves. So while the retro-active cause does emerge as later than its effect upon final analysis, it is only such in virtue of its coincidence with an opposing causal chain.

Also, as it stands, the analysis seems to have the implication that all events simultaneous with the dancing are also earlier than the bravery. The baby crying in the hut nearby, the buck rummaging in the grass just over the hill, the little boy running down the road in a country far away – all these are thereby both earlier (and, as already specified, later) than the bravery. Now this may be a signpost pointing in the direction of the incoherence of the notion of backward causation. It might also, however, indicate a need for a reworking of the causal thesis. We must not bypass the implications of interpreting the retro-active cause as earlier for the surrounding network of events. (This problem seems to rule out the interpretation of a retro-active cause as earlier than its effect altogether – a conclusion stronger than the position I took above.)

It seems to me that what needs doing is either a loosening of the analysis, so that not *every pair* of causally-related events is thereby temporally-related, or a tightening of it, so that not every pair of *causally-related events* is thereby temporally-related. It might be objected that these solutions only deny the claim essential to the causal account – viz. that causal ordering determines temporal

ordering. I think, however, that each can be made to work in such a way that this basic claim can be more or less salvaged. In order to introduce these variations on Mellor's version of the causal thesis, however, I return to his argument appealing to agential asymmetry.

Recall that Mellor's initial explanandum was an appeal to our asymmetry as agents – viz. that, at any given point in time, we are able to remember only earlier events and bring about only later events. Mellor employed this as a restricting case of the more general fact that causes precede their effects, and explained this latter fact by the causal thesis. I raised a number of worries against this argument in chapter two. However, it seems to me that the agential asymmetry, with its roots firmly in causal asymmetry as we shall see, should still be put to work in the service of the causal thesis[25]. Suppose, then, that we formulate the appeal to the agential asymmetry as follows: Let us examine the block universe as it is construed under the B-theory. Let assume that causation across the block is uniformly arranged in terms of its asymmetry, with all causation running from t_0 to t_n. This can be taken as a straightforwardly contingent feature of our world. We then note the necessary relations between causation and action, and causation and memories.

One account of the relation between memories and causation is found in *The Structure of Time* in which Newton-Smith distinguishes memories as the impressions which give us non-inferential reliable knowledge of the past. Thus, a hypothetical situation involving an analogous relation to the future would consist in precognition, i.e. reliable non-inferential knowledge of the future. For example, he supposes that acquiring more and more 'mories' (these being analogous to memories, only in relation to the future) would consist in acquiring more and more reliable beliefs about the future (1980, p. 207). Now, while it is correct that judgements formed on the basis of memories are generally more reliable than judgements formed on the basis of prediction, this is by no means a feature in every case. It seems to me that the distinguishing feature of memories is not their certainty or reliability (although this is a typical feature) but the following: If something is to be counted as a memory it must involve causal interaction with the thing remembered. If there is no such interaction, we would not count it as a memory. I might have been told that there was a robbery at the café by the river, but unless I was there I remember only the telling, and not the robbery. Thus, false memories are not merely false beliefs about the past, but false beliefs about our causal interactions. I might take myself to remember giving you ten pounds, but I cannot take

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[25] This argument that I present here is partly inspired by Papineau's formulation of Mellor's argument as found in (1985, p. 274) Whether Papineau had something like this argument in mind (which is indeed an argument for a rather different conclusion to Mellor's), I am not sure.

myself to remember the first performance of Händel's Messiah. Thus, I have a memory of *x* only if I have had unmediated causal contact with the particular *x*. So, contra Newton-Smith, 'mories' are not correctly analogous to memories. And it isn't mere ignorance of the future that gives the appearance of an asymmetry. Memories do not just involve degree of certainty or reliability of something like this. It is lack of causal contact with the future. (If this seems to conflict with our ordinary talk of remembering, it is worth noting that the use of 'remember' is fairly loose. If someone describes a happening to us, we might thereafter loosely say that we remember the happening. But 'remember' is broader than 'memory', for we wouldn't say that we *had a memory of* the happening.)

In the case of action, I take it that the relation to causation is even more straightforward. To act is at least to cause something (another essential factor, but one which is irrelevant to our purposes is probably intention). Of course, one might fail to cause what one means to cause. But if one has not caused anything at all, one has not acted[26].

So, we have assumed that across the block causal asymmetries are uniformly arranged in relation to one another, and that memories are essentially effects of the causal interaction with the thing remembered, and actions are essentially causes. These two assumptions then entail the contingent fact of agential asymmetry. Given that agents are (at least) a combination of memories and actions, agents (as a contingent fact entailed by these two assumptions) are asymmetrically oriented in terms of the two. At any given point in the causal network at which the agent is located, memories will lie causally prior to that point, and the results of actions will lie causally subsequent to that point. Or, at any give point, memories will be of events lying towards t0 and the effects of actions will be events lying towards tn.

So, we have got as far as causal/agential asymmetry, but we've yet to involve temporal asymmetry in the argument. The point here then, is this: *For an agent that is so oriented*, at any given point in time, the past will be the events lying in the direction of memories and the future will be the events lying in the direction of potential action. Or, in B-theory terms, an event is earlier than the agent's temporal location if lies in the direction of remembered events, and an event is later than the agent's temporal location if it lies in the direction of events that are the result of potential actions. It is important to note the condition here. The claim does not apply to cases of agents who do not bear the agential asymmetry. It is merely the claim that, *if an agent does bear this asymmetric*

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[26] The case of mental acts is a little more tricky, and I don't mean to be covering mental acts within the bounds of this discussion, although – ultimately – they would have to be dealt with as well.

orientation to their memories and actions, then earlier events must be taken to lie in the direction of remembered events, and later events in the direction of potential actions. And it seems to me that this is a hard claim to deny.

Does this not leave us, though, with an unhappily anthropocentric account of temporal asymmetry (for we have arrived at the claim that the earlier-later distinction rests in the memory-action distinction)?[27] Is this enough - this talk of agents? We need not be alarmed, however. We must note just what is at work here. Given the necessary connection between causation and memories, and causation and action, the agential asymmetry (as already noted) depends on the asymmetry of causation. There is no distinction to be drawn between the direction of memories and that of potential action if there is no collective uniformity in causal asymmetry. It is because of this collective uniformity, that we have the agential asymmetry at all. Thus, our conclusion amounts to the claim that, insofar as there is collective uniformity of causal asymmetry, we must, for any given temporal location, take the earlier direction to be the direction of (collective) causal antecedence and the later direction to be the direction of (collective) causal subsequence. Thus, for a given temporal location, an event is earlier than that temporal location if it lies in the direction of causal antecedence, and it is later than that temporal location if it lies in the direction of causal subsequence. Given that on this account temporal direction is resting on collective causal asymmetry, the distinction between earlier and later does not emerge as an anthropocentric notion. It extends to cover all universes, regions, cases in which there is such collective causal asymmetry, agents or none. The point is that, *given what the distinction between earlier-later turns out to be in the case of an* agent, it can be applied to worlds without agents. If causes and effects were scattered in both directions equally we would lose the agential asymmetry. As noted, it is a contingent fact that we are so oriented. Thus, time emerges as contingently asymmetric – ultimately on the basis of the contingent uniformity displayed by causation[28].

All we have arrived at for what I've said so far is that the collective uniformity must be complete uniformity. As emphasised, the argument turns on the entailment of agential asymmetry by causal asymmetry. Now it is clear in the case of complete uniformity in causal asymmetry that the agential asymmetry is entailed. This is because, regardless of where the agent is located within the causal network, its potential memories will lie in only one of the causal directions and its potential

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[27] ...Unhappy for some. Indeed, some writers favour a merely anthropocentric account of temporal (and causal) asymmetry. E.g. Price (1996). For our purposes, however, this would not be a welcome conclusion, so let us push on...

[28] If it turns out – as Mellor suggests (1998, chapter 12) – that the uniformity in causal asymmetry is not contingent, then our account has the implication that temporal asymmetry is similarly necessary.

actions will lie in the other. But might agential asymmetry be entailed by something weaker than this? Recall Dummett's dancing chief or the quantum eraser experiment. It seems that even in circumstances like these we can understand the agents to be asymmetric in the relevant sense – indeed, even when they themselves are involved in the deviant causal chain, like Dummett's chief. So what is it about the uniformity that permits some deviant causal chains, but nonetheless allows for the retention of the agential asymmetry? The point required to make sense of this situation is that, at any given time, agents (agents that are rich enough in experience to employ a distinction between earlier and later) are complexes made up of many memories and actions (and thus many causes and effects). Thus, all that is needed in order for our causal network to retain its implication of agential asymmetry is that, at any given point[29], the bulk of causation (antecedent and subsequent) linked to that point is uniformly oriented. So, even if there are some deviant causal chains which run the opposite way, as long as the bulk of the causation linked to each point in the causal network is uniform in arrangement, we would still have an overall asymmetry sufficient for the network to entail the agential asymmetry.[30] (The corollary of this is that causation which is scattered randomly throughout the block universe will entail a lack of agential asymmetry, and so a lack of temporal asymmetry.) Thus, the collective causal asymmetry appealed to in my formulation need only be that of enough uniformity to ensure that, at any given point within the causal network, the bulk of the causation is uniformly aligned (and this must of course hold for every point in the network in the same direction).

So, in contrast to the definition involved in Mellor's analysis (viz. that E is earlier than F iff E is causally antecedent[31] to F), what is doing the work in my definition is the appeal to the *direction of collective* causal antecedence/subsequence. E is, on my account, earlier than F iff E lies in the direction of collective causal antecedence relative to F. This does not entail that E itself is causally antecedent to F. As we have seen, this is compatible with F being causally antecedent to E – as long as the direction of collective causal antecedence lies in the direction of E relative to F. That is, the following four claims are compatible on this account; (i) that F causes E (or some fact co-located with F causes some fact co-located with E, or a uniformly-directed chain of such causation joins F to E), (ii) that E may or may not be causally antecedent to F, (iii) that E is earlier than F, and (iv) that F

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[29] By 'point' here I understand 'causal relatum' within the network, which in this case are facts.

[30] It is important, here, to bear in mind the reason that we want the causal asymmetry to entail the agential asymmetry. The agential asymmetry depends on causal asymmetry, and if entailed by the causal network ensures that the distinction between 'earlier' and 'later' can be applied to network.

[31] Recall that causal antecedence is a more complicated relation that straightforward causation, but minimally if E is causally antecedent to F, then there is some fact co-located with E that causes some fact co-located with F (or there is some chain composed of such causal relations linking E and F).

is not earlier than E. So the account I propose is not a pair analysis. It is an analysis that is possible only in virtue of the collective patterning of the causal asymmetry involved. The temporal ordering of E and F need not coincide with the causal ordering of E and F for all E and F. This being so, it is in principle possible for us to deny the pair thesis without denying the causal thesis entirely. Thus, we have now arrived at a version of the causal thesis which is genuinely compatible with backward causation – that is, which permits some backward causation without thereby entailing that the cause precedes the effect in addition to succeeding it. This is the first virtue of this version (a version which I will call the 'majority' version).

A second virtue of this account, I take it, is that it allows temporal asymmetry to emerge either contingent or necessary – depending on whether uniform causal asymmetry is a necessary property of causal networks or whether it isn't. A consequence of this possibility of contingent temporal asymmetry is that the account is now compatible with worlds in which events are temporally but not causally ordered – an obstacle which, as mentioned earlier, was not overcome by Mellor's pair thesis.

It might be worthwhile for us to compare very briefly the majority version of the causal thesis with Mellor's pair version. It has already been noted that the majority version replaces the analysis in terms of pairs with an analysis in terms of networks. So, temporal asymmetry must be taken to be a feature of causal patterning rather than of individual causal relations. In relation to our discussion of chapter two, the majority version is a supervenience claim – temporal asymmetry supervenes on uniformity of causal asymmetry. Secondly, the account allows some causal asymmetry to be at odds with the temporal asymmetry it determines, and as such cannot be constitutive of temporal ordering. Thus, on this account, we require independent symmetric temporal ordering, and the account is merely one of what temporal asymmetry consists in.

Despite its advantages, the majority account, as it stands, might invite a worry: The account sits quite comfortably when we restrict our attention to (this region of) the actual world where there are no established cases of backward causation or to a world in which there is very little backward causation. Similarly, it sits well with worlds in which causation is so lacking in uniform arrangement as to be scattered randomly across the world (assuming that this is a coherent notion). So, given that complete or near-complete uniformity is sufficient for temporal asymmetry and randomly scattered causation is sufficient for a lack of temporal asymmetry, it seems that there would be some degree of uniformity beyond which temporal asymmetry would arise. And while this is not an incoherent view, it certainly is strange. What is worrying here is that temporal asymmetry doesn't seem to be a

matter of degree. Even if merely local, we either have it or we don't. There isn't any intelligible notion of degree of temporal asymmetry. We cannot have a region or world in which things are earlier than each other, but to a greater degree than some other region or world. So once we move away from the pair analysis (which ensures that this determinateness is at least retained in the case of pairs) to the majority analysis, we must make intelligible the notion of a determinate relation (earlier-later) supervening on a vague one (majority uniformity).

Related to this worry is that we are still ignorant of just how much uniformity within a network *is* sufficient. Is there a degree of uniformity after which temporal asymmetry arises, as the above line of reasoning suggests? And if so, what point is this? If we are allowing some deviant causation, which should it be? And how much? Indeed, it is not clear what it is about *mere* majority that should make the difference, such that if we only just scrape majority uniformity – or pass a certain degree of uniformity – the network is thereby temporally asymmetric. The account, as it stands, is somewhat unprincipled.

I wish to make a suggestion in this regard, which might at first appear a little odd, and which certainly requires a more extensive examination than I will give it here. But I do think it is a promising line. In order to introduce the suggestion, I begin with a case of backward causation of a different sort – the sort in which we'd be more inclined to allow that the asymmetry of time *is* affected by the deviant causation. This is the case of time-travelling objects.[32]

In the case of time travel, like that of backward causation, the majority of causation runs in the t0 – tn direction while some minimal number of chains run in the opposing direction. Unlike the case of backward causation, however, there *is* a sense in which the earlier-later direction coincides with the direction of causation in the deviant chain(s). I will begin with an old-fashioned example of time travel in order to illustrate the point more clearly. I will then transpose these claims into a more general form which should hold for less imaginative cases of time travel. Let us begin then by considering the case of time-travelling Mellor: Time-travelling Mellor has lived an ordinary existence up until a fateful Thursday in 2014 when he steps into a time-machine. Upon the initiation of the time machine, Mellor travels back in time. Let us stipulate that the time travel we are considering involves an alteration in the *relation* between courses of events which are otherwise as they normally would be. Everything within the time machine (Mellor and his stowed accoutrement) proceeds as it normally would, while everything outside of the time machine too proceeds as it normally would.

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[32] I will not delve here into a discussion of the paradoxes of time travel. Many authors consider these paradoxes to be tractable and this is enough for me to use the notion of time travel to test out the account of the asymmetry of time I have proposed.

Mellor gets a little older; we get a little older. Mellor makes himself some tea; we make ourselves a little tea as well. However, in relation to each other, these two sets of proceedings are occurring in opposed directions. Thus, the events and processes constituting Mellor's world line do an about-turn and proceed in the opposite direction to that in which they were proceeding. While our hair grows longer as we consider the temporal series in the $t_0 - t_n$ direction, Mellor's hair grows longer as we consider the temporal series in the $t_n - t_0$ direction[33]. If we were to look through the hypothetical window of Mellor's time machine as he travelled from outside the machine, we would find that as our own facial hair went from stubble to beard, Mellor's facial hair would go from beard to stubble. (These opposing directions will of course be found at times prior to Mellor's climbing into the time machine, given the about-turn of his line.) This appeal is akin to Mellor's in the case of the time-travelling clocks and similarly involves a reversal of the direction of local time. The point here then is that there is a sense in which Mellor's stubble is earlier than his beard – viz. if we consider the course of events as it is proceeding inside the time machine.

Let us generalise the case: Let us take Mellor to be a particular case of the more general time-travelling object X, and let us call a state which depends on a state lying at an earlier point in the object's world line (like the state of Mellor being bearded) t and the state upon which it causally depends (like the state of Mellor being stubbled) s. I take it that even less fictitious examples of time travel involve at least these four basic elements; (i) an object X, (ii) a state t of the object that is later than s along the object's world-line, but which is earlier than s by the direction of temporal asymmetry determined by non-time-travelling objects, (iii) a state s of the object that is earlier than t along the object's world-line, but which is later than t by the direction of temporal asymmetry determined by non-time-travelling objects, and (iv) s is causally antecedent to t, but not vice-versa.

Now according to the majority view as it stands, we seem to get the wrong analysis of such cases. Let us call a universe which is very similar to our own, but which contains a few cases of time-travelling objects, 'U'. Depending on the details of the causal relations in which the time-travelling object is involved, we obtain one of two analyses of the temporal asymmetry of U using the majority account advanced thus far. Either the causal relata involved in the world-line of the time-travelling object are such that the bulk of causation in which they are involved is opposed in its asymmetry to that of the non-time-travelling objects or every causal relatum in U is such that the bulk of

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[33] The situation is of course complicated by the relativity of simultaneity.

causation[34] in which it is involved is uniformly aligned (in the direction associated with the non-time-travelling objects). (I remain neutral on this point as the causal boundaries between a time-travelling object and the other objects are unclear, and I do not wish to delve into their intricacies here. And, as we shall see, on either construal our majority account gives the wrong analysis.) In the case of the former, U is entirely lacking in temporal asymmetry. And in the latter, U turns out to be temporally asymmetric in the direction of the non-deviant causation. (This is akin to the case of backward causation discussed above.) And on this construal, s is later than t, contrary to our judgement above.

Now the former conclusion is surely wrong – for physicists have entertained the possibility of time-travelling objects within our universe (de Beauregard, 1977), and we take our universe (or at the very least this region of it) to be temporally asymmetric. But why should we be inclined to deny the latter conclusion? Why should we not simply accept the result offered by our account, that the direction of the majority of causation determines the direction of temporal asymmetry and there put an end to it? An answer to this highlights the problem involved in an unprincipled appeal to mere majority: Returning briefly to Mellor's time machine, let us abstract from what is going on inside and focus on what is outside the machine – viz. the rest of us (that is, all objects and processes involved in the world as we take it to be outside the machine). Bearing in mind the commitment made in chapter one to relationalism about space and time, what is the 'rest of us' but a collection of objects of the same sort as Mellor? Upon what basis might we nominate the direction of time asymmetry as it is determined by our set of objects as 'the' direction rather than the direction determined by Mellor and his accoutrement in the time machine?

Well, if we could appeal to the temporal relations posited by the A-theory, we would have a basis. On the A-theory[35], even if an object travelled back in time, we would not want to equate the earlier-later distinction as it applies along the world-line of the object with the earlier-later distinction as it applies to the rest of the non-time-travelling objects. 'The' direction of temporal asymmetry would be the direction of growth of the universe, and so ours would indeed be the direction of time whereas the direction determined by the course of events in the time machine must be taken to be a direction in some other subsidiary sense (a merely apparent 'earlier-later'). But, for better or worse, we have for the purposes of this paper given up any involvement with the

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[34] Here again to be understood as the complicated relation of causal antecedence and subsequence, and not simply two-place causation (includes chains).

[35] Assuming that time travel is even compatible with an A-theory account, it would only be compatible with a growing universe account and not with a presentist account.

A-theory. Alternatively, if we had taken on the B-theory but had come upon time asymmetric laws (which might point to time itself bearing certain properties), we might appeal to the properties of time itself to distinguish a direction. In this case, something like a substantivalist account of time might account for ours being 'the' direction of temporal asymmetry as opposed to Mellor's. But again, we have relinquished this possibility in our taking on relationalism.

We might point out that the direction determined by Mellor's course of events is *surrounded by* the direction determined by the rest of us. But all this amounts to is an appeal to sheer numbers. It does not lessen the sense in which the course of events involving the time-travelling object are intrinsically akin to ours, except opposed in causal direction. The point I am trying to make is akin to the point about the relativity of motion that arises on a relationalist account of space: Given that we can't appeal to spatial points in order to establish which of two objects is moving and which is at rest, we might justifiably take either of the objects to be at rest. Thus, what we need is a refinement in our appeal to the direction of collective causal asymmetry so that it doesn't entail the overriding of perfectly respectable cases of the earlier-later distinction.

It turns out that our account, which trades the pair analysis for the network analysis is still too broad. We haven't yet constrained the notion of a network nor found a principled way of distinguishing how much of a majority is sufficient. And so even when deviant causation is local and contained to a small, continuous region, the entire universe emerges either as lacking temporal asymmetry entirely (that is, no distinction between earlier-later whatsoever applies) or this asymmetry is overridden by the greater collective asymmetry. The question then is this: In virtue of what is state s of X earlier than state t when the network in which it is embedded considered in its entirety collectively determines no direction of temporal asymmetry (as analysed in terms of the majority account)? In virtue of what do we want to say that the course of events involving the time-travelling object form a temporally asymmetric network and the course of events involving the rest of the objects form an opposing temporally asymmetric network, rather than simply concluding that the entire network has no temporal asymmetry or the majority asymmetry?

What seems to be the difference between the case of backward causation in which the direction of temporal asymmetry is unaffected and the case of time-travelling objects in which the direction of temporal asymmetry is affected is that the latter involves *objects* in a special way. This suggests a solution then. When we are assessing a network for temporal asymmetry, not all causation linked to an arbitrary point is relevant to assessing temporal asymmetry. Only the causation that is essential to the objects involved is relevant. By this I mean the causal processes

which are essential to the object being the sort of object it is. In the case of U as described above, the causation relevant to assessing temporal asymmetry is the causation involved in the essential processes of the time-travelling object, and of each of the non-deviant objects. And if we limit our considerations to these causal processes, we find that for each point in the world-line of the time-travelling object, the relevant causation *is* uniformly arranged *and no other causation is relevant* to the determination of the temporal direction for these points. Whereas in the case of backward causation, the causation is not essential to the processes of the object's involved (the chief's dancing does not constitute part of an essential causal process), and so it is not relevant in determining the direction of temporal asymmetry for the objects involved.

As a last consideration, it is interesting to compare what the majority account and this latter version of the causal thesis imply about the role of processes (or order of properties) in the asymmetry of time. The majority account – being an account which abstracts from the causal relata entirely – of course rules processes out of a determination of the direction of temporal asymmetry entirely. This latter account, however, if correct, gives us reason to suppose that processes do have some bearing on the asymmetry of time. Where ordinary process accounts go wrong, however, is in specifying particular processes on which the direction of temporal asymmetry depends. Temporal asymmetry as such does depend on processes, but – being a notion which carries over to worlds with different processes and different objects – does not depend on any particular processes as process accounts suggest. Further, process accounts leave out any appeal to causation entirely, and – if my suggestion above turns out to have some weight – causation is precisely the ingredient which allows for the temporal *asymmetry*.

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