CAUSATION

Chapter 10

Non-Humean Reductionism

Humean states of affairs were characterized recursively in chapter 2, the basic idea being that distinct Humean states of affairs cannot stand in logical relations to one another. A reduction can be defined, then, as non-Humean if the reduction base involves non-Humean states of affairs.

What are some possible examples of non-Humean states of affairs? The two that are especially important in the present context are the existence of strong laws -- or, at least, nonprobabilistic ones -- and the possession, by individuals, of irreducible dispositional properties. Thus, as regards the former, strong laws, whether they are conceived of as second-order relations between universals, as by Dretske, Tooley, and Armstrong, or as structureless states of affairs, as by Carroll, are by definition states of affairs that entail the existence of certain Humean states of affairs -- namely, cosmic regularities involving only Humean properties -- which, it appears, they neither are identical with, nor overlap .

The idea that strong laws commit one to logical connections between distinct states of affairs has been especially emphasized by Bas van Fraassen (1989), who views it as a decisive objection to such a conception of laws. But whether strong laws do involve non-Humean states of affairs turns out to depend upon precisely what account is given of the ontology involved, since it can be shown that if transcendent universals are admitted, there are metaphysical hypotheses concerning the existence of such universals that do clearly and straightforwardly entail the existence of corresponding regularities (Tooley, 1987, pp. 123-9).

Secondly, dispositional properties, if they are conceived of as ontologically ultimate, irreducible properties, rather than as being logically supervenient upon non-dispositional properties plus causal laws, enter into non-Humean states of affairs. This can be seen most clearly if one considers a world where time is discrete. In such a world, if water-solubility were an irreducible dispositional property of an object, then an object's having that property at some time *t*, and being in (unsaturated) water at time *t*, together with the existence of the object and the water at the next instant, would logically entail that the object is dissolving at that next instant.

What are the most important types of non-Humean reductionist approaches to causation? I think that there are two. One involves the idea that causal states of affairs are logically supervenient upon non-causal properties and relations - including the earlier than relation - plus strong laws. The other involves an account in which objective chances play a crucial role.

The first of these approaches is closely related, however, to one of the realist accounts of causation that will be considered in chapter 7. In this chapter, accordingly, I shall focus upon accounts of the second sort.

10.1 Causation and Objective Chances

Let us consider, then, the idea that causation is to be analyzed in terms of objective chances, together with non-causal states of affairs. If such an account of causation is to be offered, one needs to hold that objective chances are not to be analyzed in terms of causation, and here there are two main possibilities. The first, and by far the more common view, is that objective chances are themselves ontologically ultimate states of affairs, and so, *a fortiori*, not analyzable in terms of causation. The other, and much less commonly adopted view, is that objective chances, rather than being either ontologically ultimate, or analyzable in causal terms, supervene upon laws, characterized non-causally, together with non-causal states of affairs.

10.2 Causation and Ontologically Ultimate, Objective Chances

A number of philosophers -- such as Edward Madden and Rom Harré (1975), Nancy Cartwright (1989), and C. B. Martin (1993) -- have both advocated an ontology in which irreducible dispositional properties, powers, propensities, chances, and the like occupy a central place, and maintained that such an ontology is relevant to causation. Often, however, the details have been rather sparse. But a clear account of the basic idea of analyzing causation in terms of objective chances was set out in 1986 both by D. H. Mellor and by David Lewis (1986c) and then, more recently, Mellor has offered a very detailed statement and defense of this general approach in his book *The Facts of Causation* (1995).

10.2.1 Lewis's Account: Counterfactuals and Objective Chances

This general approach to causation was briefly sketched by David Lewis in a postscript to his article "Causation":

> . . . there is a second case to be considered: c occurs, e has some chance x of occurring, and as it happens e does occur; if c had not occurred, e would still have had some chance y of occurring, but only a very slight chance since y would have been very much less than x. We cannot quite say that without the cause, the effect would not have occurred; but we can say that without the cause, the effect would have been very much less probable

> than it actually was. In this case also, I think we should say that *e* depends causally on *c*, and that *c* is a cause of *e* (1986, p. 176).

Lewis advanced this as an account of probabilistic causation. But, as Lewis notes, by employing chances where the probabilities are exactly one and exactly zero -- as contrasted with infinitesimally close to one and zero -- one can view this as a general account of causation that covers non-probabilistic causation as well as probabilistic causation.

A feature of this account that does not seem especially plausible is the requirement that, in the absence of the cause, the probability of the effect would have been much lower. If one drops that requirement, Lewis's account is as follows:

(1) An event *c* causes an event *e* if and only if there is a chain of causally dependent events linking *e* with *c*;

(2) An event *e* is causally dependent upon an event *c* if and only if events *c* and *e* exist, and there are numbers *x* and *y*, such that (a) if *c* were to occur, the chance of *e* occurring would be equal to *x*; (b) if *c* were not to occur, the chance of *e* occurring would be equal to *y*; and (c) *x* is greater than *y*.

10.2.2 Mellor's Account of Causation: Objective Chances and Strong Laws

A very closely related analysis was set out by D. H. Mellor in his book *The Facts of Causation*, but Mellor's account is much more detailed and wide-ranging, and he offers a host of arguments in support of central aspects of the analysis, including the crucial claim that a cause must raise the probability of its effect. Mellor also diverges from Lewis in rejecting a regularity account of laws in favor of a view according to which even basic laws of nature can exist without having instances.

Mellor's approach, in brief, is as follows. First, Mellor embraces an ontology involving objective chances, where the latter are ultimate properties of states of affairs, rather than being logically supervenient upon causal laws together with non-dispositional properties, plus relations. Secondly, Mellor proposes that chances can be defined as properties that satisfy three conditions: (1) The Necessity Condition: if the chance of *P*'s obtaining is equal to one, then *P* is the case; (2) The Evidence Condition: if one's total evidence concerning *P* is that the chance of *P* is equal to *k*, then one's subjective probability that *P* is the case should be equal to *k*; (3) The Frequency Condition: the chance that *P* is the case is related to the corresponding relative frequency in the limit.[1] Thirdly, chances enter into basic laws of nature. Fourthly, Mellor holds that even basic

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[1]For a precise formulation of the last condition, see (Mellor, 1995, pp. 38-43).

laws of nature need not have instances, thereby rejecting reductionist accounts in favor of a realist view. Fifthly, any chance that *P* is the case must be a property of a state of affairs that temporally precedes the time at which *P* exists, or would exist. Finally, and as a very rough approximation, a state of affairs *C* causes a state of affairs *E* if and only if there are numbers *x* and *y* such that (1) the total state of affairs that exists at the time of *C* -- including laws of nature -- entails that the chance of *E* is *x*, (2) the total state of affairs that would exist at the time of *C*, if C did not exist, entails that the chance of *E* is *y*, and (3) *x* is greater than *y*.[2]

10.3 Objections

Objections to this approach to causation are of three main types. First, this approach employs the Stalnaker-Lewis style of counterfactuals, and it can be objected that such a closest-worlds account of counterfactuals is unsound. Secondly, there are objections that are directed against the view that objective chances are ontologically ultimate properties. Thirdly, there are objections to the effect that, even given this view of objective chances, the resulting account of causation is unsound.

10.3.1 Closest-Worlds Conditionals

The first objection is that an analysis of counterfactuals in terms of similarities across possible worlds is exposed to a number of serious objections. One of the most important is, as we saw in chapter 5, a type of objection originally advanced by philosophers such as Jonathan Bennett (1974) and Kit Fine (1975), who contended that a Stalnaker-Lewis account generates the wrong truth values for counterfactuals in which the consequent could only be true if the world were radically different from the actual world. Thus Fine, for example, argued that the following counterfactual would turn out to be false on a Stalnaker-Lewis approach:

> "If Nixon had pressed the button, there would have been a nuclear holocaust."

In response to this objection, David Lewis, in his article "Counterfactual Dependence and Time's Arrow," argued, as we saw earlier, that by assigning certain weights to big miracles, to perfect matches of particular facts throughout a stretch of time, and to small miracles, one could make it the case that the Nixon-and-the-button counterfactual came out true, rather than false. We also saw, however, that Lewis's escape cannot handle the general problem that Fine, Bennett, and others raised. For Lewis's solution depends upon the fact that Nixon's pressing the button is an event which would have multiple effects, and

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[2]Mellor's own formulation (1995, pp. 175-9) is different, and considerably more complicated.

which thus is such that it would require a very big miracle to remove all traces of that event, and so to achieve a perfect match with the future of the actual world. As a result, one needs merely to construct a case involving an event that has only a single effect. This is easily done, and then Lewis's account of similarity does not block the counterexample.

So the use of closest-words counterfactuals is not satisfactory. However one needs to ask whether the use of such conditionals is an essential feature of any analysis of causation in terms of objective chances. Initially, it might seem that it is. For the analysis must refer not just to the chance, at the time of the cause *C*, of the effect *E*, but also to the chance that *E would* have occurred if *C* had not occurred. Accordingly, counterfactual conditionals are certainly needed, and in the context of giving an analysis of causation, one cannot, of course, adopt a causal account of the truth conditions of counterfactuals. So what alternative is there to a closest-worlds account?

The answer is that there is another alternative -- namely, one that arises out of the idea that the chances that exist at a given time, rather than supervening on categorical states of affairs that exist at that time together with probabilistic causal laws, supervene instead upon categorical states of affairs together with non-probabilistic, non-causal laws linking categorical properties at a time to chances at that time. For if this view can be defended, then rather than asking about the chance that *E* would occur in the closest worlds where *C* does not occur, one can ignore past and future similarities, and ask instead about the chance that *E* would occur in those worlds where *C* does not occur and that are *most similar at the time of C* to the world where *C* occurs.

The idea, in short, is that one can shift from closest-worlds counterfactuals to closest-momentary-slices counterfactuals, thereby avoiding the objections to which the former are exposed.

10.3.2 Logical Connections between Temporally Distinct States of Affairs

The next four objections are directed against the view that objective chances are ontologically ultimate properties of things at a time. First, the postulation of objective chances, understood as intrinsic properties of things, involves the postulation of non-Humean states of affairs, since objective chances, thus understood, enter into logical relations with distinct states of affairs. It is true that those logical relations will, in general, be probabilifying ones, rather than relations of logical entailment, and one might try to argue that while the latter are problematic, the former are not. That line of argument, however, seems to me very dubious. But even if it could be sustained, it would not answer the present objection. For an account of objective chances must also cover the limiting case where the probability in question, rather than being at most infinitesimally close to one, is precisely one.

Consider, for example, the law of conservation of charge, and suppose that the universe contains, at time t, a total net charge of n units. On the present account, objective chances must be present at time t that logically entail that the total net charge of the universe at any later time ($t + \Delta t$) is also equal to n.

David Hume contended that it is logically impossible for there to be logical connections between distinct states of affairs, and this thesis is, I think, very widely accepted today. Thus Bas van Fraassen (1989), for example, views it as a decisive objection to various realist conceptions of laws of nature. For if laws of nature are conceived of as second-order relations between universals -- as by Dretske (1977), Tooley (1977 and 1987), and Armstrong (1983) -- or as structureless states of affairs -- as by Carroll (1994) -- they have to be identified via the fact that they are states of affairs that entail the existence of corresponding cosmic regularities involving only Humean properties -- and so it appears that laws of nature, thus interpreted, entail Humean states of affairs which they neither are identical with nor overlap So it *appears* that one has logical relations between ontologically distinct states of affairs.

It turns out, however, that whether laws of nature, thus conceived, do involve non-Humean states of affairs depends upon precisely what account is given of the ontology involved, since it can be shown that if transcendent universals are admitted, there are metaphysical hypotheses concerning the existence of such universals that do clearly and straightforwardly entail the existence of corresponding regularities (Tooley, 1987, 123-9) -- the basic idea being that if only certain transcendent universals exist, this must limit what states of affairs can exist at the level of particulars, and it will do so without introducing any logical relations between distinct states of affairs.

By contrast, when objective chances are conceived of as intrinsic properties of things at a time, the existence of such properties surely does entail, at least in the limiting cases, the existence of logical connections between distinct states of affairs, since one has a logical entailment between things' having intrinsic properties at one time, and things' having intrinsic properties at other times. Accordingly, if Hume's thesis is correct, we have here a decisive objection to the present account of objective chances.

10.3.3 Basic Laws

The first objection leads immediately to a second, which is concerned with the implications that the view that objective chances are ontologically ultimate has with regard to the nature of basic laws. Consider, for example, a Newtonian world. One normally thinks that, in such a world, Newton's Second Law of Motion -- F = MA -- is a basic law that relates the mass of an object at a given time, and the force acting on it at that time, to its acceleration at a later time. (Because time is dense, and there is no next moment, a somewhat more complex formulation in terms of intervals is needed here. But we can ignore that, as it

does not affect the present point.) Suppose, however, that there are ontologically ultimate, objective chances, and that causation is to be analyzed in terms of them. Then we need to think of the relation between force and mass at one time, and acceleration at later time, in a different way. For what one then has are two connections:

(1) There is a basic law of nature that connects up things existing at one and the same time -- namely, on the one hand, force and mass, and, on the other hand, an objective chance equal to one of a later acceleration equal to F/M;

(2) There is a logically necessary connection between an objective chance that exists at one time -- of the object's undergoing a later acceleration equal to F/M -- and the acceleration of the object at that later time.

So rather than having a causal law connecting states of affairs existing at different times, what we have is a law of dependence connecting something existing at one time -- namely, a certain objective chance -- with other things existing at the *very same* time -- namely, an object's having a certain mass, and being acted upon by a certain force. The only laws that there are, accordingly, if causation is analyzed in terms of ontologically ultimate objective chances are laws connecting simultaneous states of affairs, and connections between states of affairs existing at different times, rather than being underwritten by laws of nature, are logically necessary, if the world is deterministic.

As was mentioned earlier, some philosophers have held that there can be both basic laws of co-existence, and basic laws connecting things at different times, while other philosophers have been suspicious of the idea of basic laws of co-existence, and have favored the view that all laws of co-existence are derived from basic causal laws. The argument for the latter view is unclear. Nevertheless, I think that one can see, at least dimly, why one might find basic laws of co-existence somehow less intelligible, or more problematic, than basic causal laws. By contrast, the opposite view seems to have no evident appeal at all. For if there can be basic laws of nature that link together things at one and the same time, why should there be any problem with basic laws of nature that link together states of affairs at different times?

The upshot is that the idea of analyzing causation in terms of objective chances has consequences with regard to the types of basic laws that are possible -- consequences that, on the face of it, do not seem at all plausible.

10.3.4 The Infinite States of Affairs Objection

The third objection to the view that objective chances are ontologically ultimate properties of things at a time can be put as follows. Imagine that the world is deterministic, that every temporal interval is divisible, and that all causation involves continuous processes. Suppose that x at time t has an objective chance equal to 1 of being C at time $(t + \Delta t)$. Then there are an infinite

number of moments between t and $(t + \Delta t)$, and for every such moment, t^*, it must be the case either that x at time t has an objective chance equal to 1 of being C at time t^*, or that x at time t has an objective chance equal to 1 of not being C at time t^*. But then, if objective chances are ontologically ultimate, intrinsic properties of things at a time, it follows that x at time t must have an infinite number of intrinsic properties -- indeed, a non-denumerably infinite number of properties.

This view of the nature of objective chances involves, accordingly, a very expansive ontology indeed. By contrast, if objective chances, rather than being ontologically basic, supervene on categorical properties plus causal laws, this infinite set of intrinsic properties of x at time t disappears, and all that one may have is a single, intrinsic, categorical property -- or a small number of such properties -- together with relevant laws of nature.

10.3.5 The Compatibility of Objective Chances Objection

The thrust of the fourth and final objection to the view that objective chances are ontologically ultimate is that there are pairs of objective chances that, intuitively, are perfectly compatible, but that would be logically incompatible on the present view.

The argument is as follows. Consider the following three objective chances:

(1) P = an objective chance of 0.7 of property C in Δt

(2) Q = an objective chance of 0.2 of property D in Δt

(3) R = an objective chance of 0.7 of property C in Δt and an objective chance of 0.2 of property D in Δt

Clearly, something might have both property P and property Q. Suppose, then, that it is a non-causal law that anything that comes to have the categorical property A also acquires both property P and property Q at the same time. Then the probability that something that acquired property A would acquire certain combinations of properties in Δt would be as follows:

Both C and D: $(0.7)(0.2) = 0.14$

C, but not D: $(0.7)(0.8) = 0.56$

D, but not C: $(0.3)(0.2) = 0.06$

Neither C nor D: $(0.3)(0.8) = 0.24$

Propensity R, as defined above, is just a combination of propensities P and Q, and the probabilities that something with propensity R will acquire the various combinations of properties just listed would be precisely the probabilities associated with the joint possession of propensities P and Q.

Consider, now, a propensity, *S*, that can be described in ordinary language as follows: Propensity *S* gives rise either to property *C* or to property *D*, but never to both, and the probability of its giving rise to *C* is 0.7, while the probability of its giving rise to *D* is 0.2. Clearly, *S* is not identical with the conjunction of *P* and *Q*, nor with *R*, since, given *S*, there are different probabilities associated with the combinations of properties considered above, namely:

Both *C* and *D*:	0.0
C, but not *D*:	0.7
D, but not *C*:	0.2
Neither *C* nor *D*:	0.1

If objective chances are ontologically ultimate, how is *S* to be defined? The answer will depend upon precisely what the correct account is of objective chances, so understood. Earlier, I mentioned Mellor's proposed analysis. But one of its clauses involves the term "should", and, as it seems inappropriate for a characterization of objective chances to incorporate any normative language, Mellor's account seems problematic.

The type of account that seems to me preferable can be illustrated by the following analysis of what it is to have propensity *R*:

x has propensity *R* at time *t*

means the same as

> There is some intrinsic property *P* such that, first, *x* has property *P* at time *t*; secondly, *x*'s having property *P* at time *t* does not logically supervene upon a state of affairs that involves either the existence of certain laws of nature, causal or otherwise, or *x*'s having some relevant categorical property, either at time *t*, or at any other time; and, thirdly, the logical probability that *x* has property *C* at time *t**, given that *x* has property *P* at time *t*, and regardless of whatever other intrinsic properties *x* has at time *t*, is equal to 0.7, while the logical probability that *x* has property *D* at time *t**, given that *x* has property *P* at time *t*, and regardless of whatever other intrinsic properties *x* has at time *t*, is equal to 0.2.

With this as a model, let us now consider how the possession of propensity *S* is to be analyzed. In the case of propensity *R*, probabilities are assigned to each of the two 'effect' properties -- *C* and *D*. Obviously this cannot be done in the case of propensity *S*, since there the probability that the thing in question will acquire both property *C* and property *D* is equal to zero, and this can be generated by an assignment of probabilities to each of *C* and *D* only if at least one of those probabilities is equal to zero, which is not the case.

What is needed, accordingly, is an analysis in which probabilities are assigned to at least three of the four relevant combinations of possibilities:

x has propensity *S* at time *t*

means the same as

> There is some intrinsic property *P* such that, first, *x* has property *P* at time *t*; secondly, *x*'s having property *P* at time *t* does not logically supervene upon a state of affairs that involves either the existence of certain laws of nature, causal or otherwise, or *x*'s having some relevant categorical property, either at time *t*, or at any other time; and, thirdly, the logical probability that *x* has property *C*, but not property *D*, at time *t**, given that *x* has property *P* at time *t*, and regardless of whatever other intrinsic properties *x* has at time *t*, is equal to 0.7, while the logical probability that *x* has property *D*, but not property *C*, at time *t**, given that *x* has property *P* at time *t*, and regardless of whatever other intrinsic properties *x* has at time *t*, is equal to 0.2, and, finally, the logical probability that *x* has neither property *C*, nor property *D*, at time *t**, given that *x* has property *P* at time *t*, and regardless of whatever other intrinsic properties *x* has at time *t*, is equal to 0.1.

Consider, now, another propensity, *T*, that can be described in ordinary language as follows: Propensity *T* gives rise either to property *C* or to property *D*, but never to both, and the probability of its giving rise to *C* is 0.5, while the probability of its giving rise to *D* is 0.3. The crucial question now is whether an object at one and the same time could possess both property *S* and property T, and the answer is that this is certainly possible. For that would just mean that there would be different routes by which the object in question might acquire property *C* - in one case, in virtue of having property *S*, and, in the other case, in virtue of having property T.

The problem is that the above analysis of what it is to have propensity *S*, together with a parallel analysis of what it is to have propensity T, entails that it is logically impossible for any object to have both of those properties at the same time. For the definition of propensity *S* entails that if something has propensity *S* at time *t*, together with any other intrinsic properties whatever -- including propensity *T* -- then the probability that *x* has property *C* at time *t** is equal to 0.7, whereas the corresponding definition of propensity *T* entails that if something has propensity *T* at time *t*, together with any other intrinsic properties whatever -- including propensity *S* -- then the probability that *x* has property *C* at time *t** is equal to 0.5.

How do things compare if objective chances, rather than being viewed as ontologically ultimate, are analyzed along causal lines? To answer that question, we need to have a causal account in front of us. Such an account can easily be arrived at by generalizing upon a causal analysis of dispositional properties. So

consider, for example, water-solubility. According to a familiar type of account, the statement that *x* is water-soluble is to be analyzed as saying that *x* possesses some categorical property, *P*, such that there is a law of nature, *L*, that entails that, for any *y*, the state of affairs that consists of *y*'s possessing property *P* at any time *t*, and *y*'s being in water at time *t*, immediately causes *y* to dissolve.

This account of dispositional properties is easily converted into an account of objective chances. Precisely how the latter should be formulated depends upon the correct account of the logical form of probabilistic causal laws, but one natural formulation runs as follows:

x at time *t* has an objective chance equal to *k* of being *C* at time *t**

means the same as

> There is some intrinsic, categorical property, *P*, such that, first, *x* has property *P* at time *t*, and, secondly, there is a law of nature, *L*, to the effect that for any *y*, and any time *u*, the probability that *y*'s having property *P* at time *u* causes *y*'s having property *C* at time *u**, given that *y* has property *P* at time *u*, is equal to *k*.

The point now is that, given this type of account, something can have both propensity *S* and propensity *T* at the same time. The reason is that the probabilities that enter into the causal analysis are not probabilities, for example, that *x* will have property *C* at time *t**; they are, rather, probabilities that a certain intrinsic property of *x* at time *t* will cause *x* to have property *C* at time *t**, and there is no incompatibility involved if *x* has two intrinsic properties, *P* and *Q*, at time *t*, where the probability that possession of property *P* at time *t* will give rise to *x*'s possessing property *C* at time *t** is equal to 0.7, while the probability that possession of property *Q* at time *t* will give rise to *x*'s possessing property *C* at time *t** is equal to 0.5.

In short, there are sets of objective chances that are, intuitively, perfectly compatible, and that are compatible given a causal analysis, but that would be logically incompatible if chances were ontologically ultimate properties of a thing at a time.

10.3.6 Underdetermination Objections

Suppose, now, that one could somehow overcome the four objections just set out against the thesis that objective chances are ontologically ultimate. There would still be at least three very strong reasons for holding that causation cannot be analyzed in terms of objective chances, so understood.

First, there are underdetermination objections. For recall the argument set out in section 3.2.7 for the conclusion that there can be situations that differ causally, even though they do not differ with respect to relevant non-causal properties and relations, nor with respect to causal or non-causal laws, nor with respect to the direction of causation in any potential causal relations. Given this

conclusion, if objective chances are logically supervenient upon causal laws plus non-causal states of affairs, then the cases do not differ with respect to objective chances either. But even if one rejected the latter supervenience claim, and held that objective chances were ultimate, irreducible properties, that would not alter things, since the relevant objective chances would still be the same in both cases. The earlier argument supports, accordingly, the following, stronger conclusion that applies to any attempt to analyze causal relations in terms of objective chances: causal relations between events are not logically supervenient upon the totality of states of affairs involving non-causal properties of, and relations between, events, all of the laws, both causal and non-causal, all of the dispositional properties, propensities, and objective chances, and, finally, the direction of causation for all possible causal relations that might obtain.

10.3.7 The Objection to the Probability-Raising Condition

Next, just as in the case of probabilistic accounts of causation of a Humean, reductionist sort, any analysis of causation in terms of objective chances is also exposed to the objection that causes need not raise the probability of their effects. For although it is possible, by adopting Lewis's distinction between causation and causal dependence, to argue -- as Lewis does -- that an analysis of causation in terms of objective chances does not entail that *causes* always raise the probabilities of their effects, the objection in question still applies, since one can show that a cause need not raise the probability of its effect even in the case of *direct* causation.

To establish that this is so, the argument that was offered earlier to show that a cause need not raise the probability of its effect needs to be modified slightly, so that, first, it deals with direct causal connections, and, secondly, it refers to objective chances, rather than to conditional and unconditional probabilities. This can be done as follows. Suppose that there is a type of atom, *T*, and relevant laws of nature, that entail the following:

(1) Any atom of type *T* must be in one of the four mutually exclusive states -- *A*, *B*, *C* , or *D*;

(2) Any atom of type *T* in state *A* has an objective chance of 0.999 of moving directly into state *D*; an atom in state *B* has an objective chance of 0.99 of moving directly into state *D*; an atom in state *C* has an objective chance of 0 of moving directly into state *D*;

(3) There is a certain type of situation -- *S* -- such that any atom of type *T* in situation *S* must be in either state *A* or state *B*.

Suppose now that *x* is an atom of type *T*, in situation *S*, in state *B*, and that *x* moves directly into state *D*. Given that, for example, shifting an atom of type *T* from state *C* into state *B* would be quite an effective means of getting it into state *D*, it is surely true that *x*'s being in state *D* was probably caused by *x*'s having

been in state *B*. But this would not be so if the above account were correct. For consider what would have been the case if *x* had not been in state *B*. Given that *x* was in situation *S*, *x* would, in view of (3), have been in state *A*. But then *x*'s objective chance of moving directly into state *D* would have been 0.999, and so higher than what it is when the atom is in state B.

The point here, as before, is that a given type of state may be causally efficacious, but not as efficacious as alternative states, and, because of this, it is not true that even a direct cause need raise the probability of its effect, contrary to what is required by the above analysis.

10.3.8 Objective Chances and a Causal Theory of Time

The final objection starts out from the observation that if there is, at location *s* and time *t*, a certain objective chance of a state of affairs of type *E*, this is not, of course, equal to the probability that there is a state of affairs of type *E* somewhere in the universe: it is, rather, the probability that there is a state of affairs of type *E* in a location *appropriately related* to *s* and *t*.

What does this mean in the case of time? If backward causation is logically possible -- as Lewis believes, and as Mellor does not -- then it would seem that there could be an objective chance at location *s* and time *t* that was the chance that there is an event of type *E* at a certain temporal distance either before or after *t*. Such chances would be 'bi-directional'. But let us set those aside, and consider only the cases where a chance of their being an event of type *E* is either a chance of there being an event of type *E* at a later time, or else, a chance of there being an event of type *E* at an earlier time. All such chances, then, would themselves incorporate a temporal direction -- either the later than direction, or the earlier than direction. But this means that if one proceeds to analyze causation in terms of objective chances that are not of a bi-directional sort, one cannot, on pain of circularity, analyze the direction of time in terms of the direction of causation.

Many philosophers, of course, reject a causal analysis of the direction of time, and it may be that they are right in so doing. The problem here, however, is that the impossibility of a causal theory of the direction of time would follow *immediately* from the analysis of causation, and this does not seem right, since then it would be rather puzzling why a substantial number of philosophers have been attracted to a causal theory of the direction of time.