CAUSATION

Chapter 11

Causation as a Theoretical, Non-Reductionist Relation

Could causation be a theoretical relation between states of affairs? Serious exploration of this idea required two developments -- one semantical, the other epistemological. As regards the former, one needed a non-reductionist account of the meaning of theoretical terms -- something that was provided by R. M. Martin (1966) and David Lewis (1970). Then, as regards the epistemological side, one needed to have reason for thinking that theoretical statements, thus interpreted, could be confirmed. That this could not be done by induction based on instantial generalization had been shown by Hume (1739, Part IV, Section 2), so the question was whether there was some other legitimate form of non-deductive inference. Gradually, the idea of the method of hypothesis (hypothetico-deductive method, abduction, inference to the best explanation) emerged, and, although by no means uncontroversial, this alternative to instantial generalization is widely accepted by contemporary philosophers.

These two developments opened the door to the idea of treating causation as a theoretical relation, and two main accounts have now been advanced. According to the one, all basic laws are causal laws, so that an account of the necessitation involved in basic laws of nature *ipso facto* provides an account of causal necessitation. According to the other account, by contrast, basic laws need not be causal laws, and consequently the relation of causation cannot be identified with a general relation of nomic necessitation How, then, is causation to be defined? The answer offered by the second approach is, first, that causal laws must satisfy certain postulates involving probabilistic relations, and, secondly, that causation can then be defined as the relation that enters into such laws.

11.1 Causation and Nomic Necessitation

The idea that causal necessitation can be identified with nomic necessitation was advanced by David Armstrong and Adrian Heathcote (1991), and then developed in more detail by Armstrong in his book *A World of States of Affairs* (1997, esp. pp. 216-33). As set out by Armstrong and Heathcote, the thought is that the identification of causal necessitation with nomic necessitation is necessary, but *a posteriori*. This presupposes that one has some independent grasp of the concept of causation, and here Armstrong and Heathcote appeal to the idea that causation is directly observable.

As noted earlier, the claim that causation is directly observable in a sense that entails that the concept of causation is semantically basic is open to very strong objections: causation would need to be immediately given in experience, and it is not. However the basic approach here can be reformulated slightly to avoid this problem. The starting point is the idea that laws of nature cannot be identified with cosmic regularities, or any subset thereof: laws -- or, at least, basic laws -- are, instead, atomic states of affairs that involve certain second-order relations between universals. Let us suppose, then, for simplicity, that in the case of non-probabilistic, basic laws, there is one such relation -- call it nomic necessitation. The central thesis can then be formulated as the proposition that causal necessitation is analytically identical with nomic necessitation, either just as a matter of definition, or else in virtue of a theorem -- possibly a rather deep one -- that follows from the correct analysis of causation. Two first-order states of affairs will then stand in the most fundamental causal relation when those two states of affairs are appropriately involved in an instance of a basic law -- that is, when those two states of affairs are connected by the relation of nomic necessitation. The general relation of causation connecting states of affairs can then be defined as the ancestral of that basic relation.

This approach has a number of important advantages. In particular, it does not fall prey to any of the objections to Humean reductionist approaches set out earlier. Thus, neither the fact that causal relations need not supervene on causal laws together with the totality of non-causal states of affairs, nor the possibility of simple worlds, or of 'inverted' worlds, poses any problem.

What objections, then, might be raised? First, this account presupposes the intelligibility of strong laws, in view of the postulation of the second-order relation of nomic necessitation. So one might object -- as Bas van Fraassen (1989) has -- that strong laws are impossible because they involve logical connections between distinct states of affairs. There are, however, good reasons for thinking that van Fraassen's argument is unsound (Tooley, 1987, pp. 123-9).

A second objection turns upon the claim that not all laws of nature need be causal, as is illustrated, for example, by Newton's Third Law of Motion. For one object's exerting a force on another does not cause the other object to exert an equal and opposite force back on the first object. But if causal necessitation just is nomic necessitation, how are non-causal laws possible?

Armstrong's answer to this objection is that non-causal laws are supervenient upon causal laws. The case just mentioned shows, however, that this response will not work. What is true is that it follows, for example, from the Law of Gravitation that if object A exerts a *gravitational* force on object B, then B exerts an equal and opposite *gravitational* force on A, and similarly for forces of electrostatic attraction and repulsion, magnetic attraction and repulsion, and so on. But the obtaining of these specialized, derived laws does not entail Newton's Third Law: the latter is supervenient, not upon the force laws alone, but upon the force laws together with a 'totality fact' to the effect that such and such types of forces are the only ones found in our world. This totality fact, however, is not itself a law, let alone a causal law, and so Newton's Third Law of Motion is not supervenient upon the causal laws found in a Newtonian world.

But this may not be a decisive objection. Perhaps the Third Law of Motion is correctly viewed, in a Newtonian world, not as a law, but as a regularity that obtains in virtue of all of the force laws, together with the totality fact that there are no other types of forces.

A third objection is this. When causation is identified with nomic necessitation, one is really offering an account of what it is for one state of affairs to be a causally sufficient condition of another state of affairs. But one also needs an account of what it is for one state of affairs (or type of state of affairs) to be a causally *necessary* condition of another, and the thrust of the third objection is that it is not at all clear that a satisfactory account is available, given the Armstrong-Heathcote approach.

What account can be given, then, of the claim that states of affairs of type *C* are causally necessary for states of affairs of type *E*? One possibility is this:

(1) A state of affairs of type *C* is a causally necessary condition of a (corresponding) state of affairs of type *E* if and only if the absence of a state of affairs of type *C* is a causally sufficient condition for the absence of a (corresponding) state of affairs of type *E*.

But Armstrong would not find this approach very appealing, as he is reluctant to allows absences to function as causes.

One could avoid this problem by adopting, instead, the following analysis:

(2) A state of affairs of type *C* is a causally necessary condition of a (corresponding) state of affairs of type *E* if and only if a state of affairs of type *E* is a causally sufficient condition for a (corresponding) state of affairs of type *C*.

But this analysis is even more problematic, since it commits one to the existence of backward causation in situations where there is no warrant at all for such a postulation.

A fourth objection concerns the relation between causation and time, and this has two aspects. On the one hand, the question of whether backward causation is possible is deeply controversial, and a number of philosophers have attempted to prove that causes must precede their effects. But if causal necessitation is simply nomic necessitation, then it would seem that it follows immediately that backward causation is logically possible, since there appears to be nothing impossible about its being a basic law that states of affairs of type *A* are always preceded by states of affairs of *B*. Nor is there any problem about causal loops, where a state of affairs of type *A* causes a state of affairs of type *B*, and the latter causes the earlier state of affairs of type *A*.

The other, and closely related aspect concerns the possibility of simultaneous causation. Given that there does not appear to be any reason for holding the laws of necessary co-existence are impossible, it would seem that Armstrong must allow that causes might be simultaneous with their effects. But if causes and effects can be simultaneous, then causal theories of the direction of time are absolutely precluded - as is not the case with the possibility of backward causation, since the latter is compatible with the view that the local direction of time is given by the direction of local causal processes.

Finally, and most importantly, Armstrong's account fails to forge any connection between causation and probability, and, because of this, it cannot provide an adequate account of the epistemology of causation. This can be illustrated by the following case. Consider some very simple state of affairs *S*, and some very complex state of affairs *T*. (*S* might be a momentary instance of redness, and *T* a state of affairs that is qualitatively identical with the total state of our solar system at the beginning of the present millennium.) In the absence of other evidence, one should surely view events of type *S* as much more likely than events of type *T*. Suppose that one learns, however, that events of type *S* occur when and only when events of type *T* occur, and that this two way connection is nomological. Then one's initial probabilities need to be adjusted, but exactly how this should be done is not clear. But what if one learns, instead, that events of type *S* are causally sufficient and causally necessary for events of type *T*? Then surely what one should do is to adjust the probability that one assigns to events of type *T*, equating it with the probability that one initially assigned to events of type *S*. Conversely, if one learns that events of type *T* are causally sufficient and causally necessary for events of type *S*, then surely what one should do is to adjust the probability that one assigns to events of type *S*, equating it with the probability that one initially assigned to events of type *T*.

If this is right, then in a case where events of type *S* and events of type *T* always occur together, the frequency with which they occur will provide very strong evidence concerning whether events of type *T* are caused by events of type *S*, or vice versa. Armstrong's account, however, can provide no reason why this should be so.

11.2 Causation and Asymmetric Probability Relations

We considered, in sections 5 and 6, two attempts to offer a reductionist, probabilistic analysis of causation, one in terms of relative frequencies, and the other in terms of non-Humean states of affairs involving objective chances, viewed as ontologically ultimate. We have seen that both approaches are open to a large number of very strong objections, and, in the light of that, it seems to me extremely unlikely that either approach is tenable.

Given this, it may well be tempting to conclude that the whole idea that some concept of probability enters into the analysis of causation is mistaken. But that conclusion would be premature at this point. For it may be that the failures of the present accounts are traceable to the fact that they are reductionist approaches. We need to consider, then, whether a satisfactory realist account of causation can be given, and one that involves some concept of probability. In this section I shall argue that that is the case.

Until relatively recently, realist approaches to causation -- as advanced, for example, by Elizabeth Anscombe (1971) -- almost always involved the idea that causation is directly observable, and, accordingly, the related view that the concept of causation does not stand in need of any analysis: it can be viewed as analytically basic. But as I have argued elsewhere (Tooley, 1990), there are strong arguments against the view that causation is directly observable in any sense that would justify one in holding that the concept of causation is analytically basic.

If that is right, then either the concept of causation -- or some other causal concept, such as that of a causal law -- must be a theoretical concept, and so it is not surprising that this type of realist approach to causation has emerged only relatively recently. For serious exploration of this type of approach required, as I noted earlier, two philosophical advances -- one semantical, the other epistemological. As regards the former, one needed a non-reductionist account of the meaning of theoretical terms. A paper by F. P. Ramsey written in 1929 contained the crucial idea that was needed for a solution to this problem, and the outlines of an account were then set out, albeit very briefly and almost in passing, by R. B. Braithwaite (1953, p. 79). It was, however, still some time before careful and generally satisfactory accounts were provided by R. M. Martin (1966) and David Lewis (1970).

As regards the epistemological issue, one needed to have reason for thinking that theoretical statements, thus interpreted, could be confirmed. That this could not be done via induction based on instantial generalization had in effect been shown by Hume (1739, Part IV, Section 2), so the question was whether there was some other legitimate form of non-deductive inference. Gradually, the idea of the method of hypothesis (hypothetico-deductive method, abduction, inference to the best explanation) emerged, and, although by no means uncontroversial, this alternative to instantial generalization is at least widely accepted by contemporary philosophers.

11.2.1 The Postulates of the Theory

The basic idea that underlies this approach is that there are certain connections between causation, on the one hand, and prior and posterior probabilities on the other, and the connections in question will emerge if one considers the following case. Let *S* be some very simple type of state of affairs, and *T* a very complex one. (*S* might be a momentary instance of redness, and *T* a state of affairs that is qualitatively identical with the total state of our solar system at the beginning of the present millennium.) In the absence of other evidence, one should surely view events of type *S* as much more likely than events of type *T*. Suppose that one learns, however, that events of type *S* are always accompanied by events of type *T*, and vice versa, and that this two-way connection is nomological. Then one's initial probabilities need to be adjusted, but exactly how this should be done is not clear. Should one assign a lower probability to states of affairs of type S, or a higher probability to states of affairs of type T, or both? And precisely how should the two probabilities be changed?

Contrast this with the case where one learns, instead, that events of type *S* are causally sufficient and causally necessary for events of type *T*. In the case, it is surely clear what one should do: one should adjust the probability that one assigns to events of type *T*, equating it with the probability that one initially assigned to events of type *S*. Conversely, if one learns that events of type *T* are causally sufficient and causally necessary for events of type *S*, then the thing to do is to adjust the probability that one assigns to events of type *S*, equating it with the probability that one initially assigned to events of type *T*.

The relationships between prior probabilities and posterior probabilities are very clear in the case where events of one type are both causally sufficient and causally necessary for events of some other type. But to arrive at the desired postulates, we need to shift, first, to the case where events of one type are causally sufficient, but not causally necessary, for events of some other type, and then we need to generalize to the case where, instead of events of one type being causally sufficient for events of another type, there is only a certain probability that an event of the one type will causally give rise to an event of the other type.

In the case where events of type *S* were both causally sufficient and causally necessary for events of type *T*, the idea was that the posterior probability of an event of type *S*, relative to that causal relationship, was equal to the prior probability of an event of type *S*. When one shifts to the case where an event of type S is causally sufficient for an event of type *T*, the relevant postulate giving the posterior probability of an event of type *S* is as follows:

$$(P_1)\ \ \mathrm{Prob}(Sx/L(C, S, T)) = \mathrm{Prob}(Sx)$$

- where '*L(C, S, T)*' says that it is a law that, for any <u>x</u>, *x*'s being *S* causes x to be *T*.

What about the posterior probability of an event of type *T*? The postulate covering this can be arrived at by starting from the following analytic truth:

$$\begin{aligned}\mathrm{Prob}(Tx/L(C, S, T)) = {} & \mathrm{Prob}(Tx/Sx \,\&\, L(C, S, T)) \times \mathrm{Prob}(Sx/L(C, S, T)) + \\ & \mathrm{Prob}(Tx/{\sim}Sx \,\&\, L(C, S, T)) \times \mathrm{Prob}({\sim}Sx/ L(C, S, T))\end{aligned}$$

This then simplifies to:

$$\begin{aligned}\mathrm{Prob}(Tx/L(C, S, T)) = {} & \mathrm{Prob}(Tx/Sx \,\&\, L(C, S, T)) \times \mathrm{Prob}(Sx) + \\ & \mathrm{Prob}(Tx/{\sim}Sx \,\&\, L(C, S, T)) \times \mathrm{Prob}({\sim}Sx)\end{aligned}$$

in view of ($P1$), plus an immediate corollary of ($P1$), namely, Prob($\sim Sx/L(C, S, T)$) = Prob($\sim Sx$)

In addition, it is clearly an analytic truth that Prob(Tx/Sx & $L(C, S, T)$) = 1, so that we can simplify further to:

$$\text{Prob}(Tx\ L(C, S, T)) = \text{Prob}(Sx) + \text{Prob}(Tx/{\sim}Sx \ \&\ L(C, S, T)) \times \text{Prob}({\sim}Sx)$$

It would seem, however, that if there is no event of type S, then the probability of an event of type T should not be altered by its being a law that events of type S cause events of type T. So the following would seem to be a reasonable postulate:

$$(P2)\quad \text{Prob}(Tx/{\sim}Sx \ \&\ L(C, S, T)) = \text{Prob}(Tx/{\sim}Sx).$$

If that is right, one can then move on to the following formula for Prob($Tx/L(C, S, T)$):

$$(P3)\quad \text{Prob}(Tx/L(C, S, T)) = \text{Prob}(Sx) + \text{Prob}(Tx/{\sim}Sx) \times \text{Prob}({\sim}Sx)$$

The idea, in short, is that in the case of non -probabilistic causal laws, the relations between prior and posterior probabilities are expressed by the two basic principles -- ($P1$) and (($P2$) -- along with the derived principle ($P3$).

The final step involves generalizing these principles to cover the case of probabilistic causal laws. In the case of ($P1$) and ($P2$), we need merely replace '$L(C, S, T)$' by '$M(C, S, T, k)$', where the latter says that it is a law that, given an event of type S, the probability that that event causes an event of type T is equal to k. So we have the following two postulates:

$$(Q1)\quad \text{Prob}(Sx/M(C, S, T, k)) = \text{Prob}(Sx)$$

$$(Q2)\quad \text{Prob}(Tx/{\sim}Sx \ \&\ M(C, S, T, k)) = \text{Prob}(Tx/{\sim}Sx).$$

The principle that is the probabilistic analogue of ($P3$) can then be derived as follows. First, given that it is a logical truth that

$$M(C, S, T, k)) \Leftrightarrow Sx \ \&\ C(Sx, Tx) \ \&\ M(C, S, T, k) \text{ or } Sx \ \&\ {\sim}C(Sx, Tx) \ \&\ M(C, S, T, k) \text{ or } {\sim}Sx \ \&\ C(Sx, Tx) \ \&\ M(C, S, T, k) \text{ or } {\sim}Sx \ \&\ {\sim}C(Sx, Tx) \ \&\ M(C, S, T, k)$$

-- where '$C(Sx, Tx)$' says that Sx causes Tx -- and given that the disjuncts are all mutually exclusive, it must be an analytic truth that

$$\text{Prob}(Tx/M(C, S, T, k)) = [\text{Prob}(Tx/Sx \ \&\ C(Sx, Tx) \ \&\ M(C, S, T, k)) \times \text{Prob}(Sx \ \&\ C(Sx, Tx)/M(C, S, T, k))] + [\text{Prob}(Tx/Sx \ \&\ {\sim}C(Sx, Tx) \ \&\ M(C, S, T, k)) \times \text{Prob}(Sx \ \&\ {\sim}C(Sx, Tx)/M(C, S, T, k))] + [\text{Prob}(Tx/{\sim}Sx \ \&\ C(Sx, Tx) \ \&\ M(C, S, T, k)) \times \text{Prob}({\sim}Sx \ \&\ C(Sx, Tx)/M(C, S, T, k))] + [\text{Prob}(Tx/{\sim}Sx \ \&\ {\sim}C(Sx, Tx) \ \&\ M(C, S, T, k) \times \text{Prob}({\sim}Sx \ \&\ {\sim}C(Sx, Tx)/M(C, S, T, k))]$$

This can then be simplified by making use of ($Q1$) and ($Q2$) together with the following relationships:

(1) $\text{Prob}(Tx/Sx \,\&\, C(Sx, Tx) \,\&\, M(C, S, T, k)) = 1$

since $C(Sx, Tx) \Rightarrow Tx$;

(2) $\text{Prob}(Sx \,\&\, C(Sx, Tx)/M(C, S, T, k)) = \text{Prob}(C(Sx, Tx)/Sx \,\&\, M(C, S, T, k)) \times \text{Prob}(Sx\ /M(C, S, T, k))$;

(3) $\text{Prob}(C(Sx, Tx)/Sx \,\&\, M(C, S, T, k)) = \text{k}$;

(4) $\text{Prob}(Sx \,\&\, {\sim}C(Sx, Tx)/M(C, S, T, k)) = \text{Prob}({\sim}C(Sx, Tx)/Sx \,\&\, M(C, S, T, k)) \times \text{Prob}(Sx\ /M(C, S, T, k))$;

(5) $\text{Prob}({\sim}C(Sx, Tx)/Sx \,\&\, M(C, S, T, k)) = (1 - \text{k})$;

(6) $\text{Prob}({\sim}Sx \,\&\, C(Sx, Tx)/M(C, S, T, k))] = 0$

since $C(Sx, Tx) \Rightarrow Sx$;

(7) $\text{Prob}(Tx/{\sim}Sx \,\&\, {\sim}C(Sx, Tx) \,\&\, M(C, S, T, k) = \text{Prob}(Tx/{\sim}Sx \,\&\, M(C, S, T, k)$

since ${\sim}Sx \Leftrightarrow {\sim}Sx \,\&\, {\sim}C(Sx, Tx)$;

(8) $\text{Prob}({\sim}Sx \,\&\, {\sim}C(Sx, Tx)/M(C, S, T, k)) = \text{Prob}({\sim}C(Sx, Tx)/{\sim}Sx \,\&\, M(C, S, T, k)) \times \text{Prob}({\sim}Sx/M(C, S, T, k))$;

(9) $\text{Prob}({\sim}C(Sx, Tx)/{\sim}Sx \,\&\, M(C, S, T, k)) = 1$.

The result of making the relevant substitutions is then as follows:

$$\begin{aligned}\text{Prob}(Tx/M(C, S, T, k)) &= [1 \times \text{k} \times \text{Prob}(Sx)] + [\text{Prob}(Tx/Sx \,\&\, {\sim}C(Sx, Tx) \\ &\quad \&\, M(C, S, T, k)) \times (1 - \text{k}) \times \text{Prob}(Sx)] + \\ &\quad [\text{Prob}(Tx/{\sim}Sx \,\&\, M(C, S, T, k) \times 0] + [\text{Prob}(Tx/{\sim}Sx \\ &\quad \&\, {\sim}C(Sx, Tx) \,\&\, M(C, S, T, k) \times 1 \times \text{Prob}({\sim}Sx)] \\ &= [\text{k} \times \text{Prob}(Sx)] + [\text{Prob}(Tx/Sx \,\&\, {\sim}C(Sx, Tx)\,\& \\ &\quad M(C, S, T, k)) \times (1 - \text{k}) \times \text{Prob}(Sx)] + \\ &\quad [\text{Prob}(Tx/{\sim}Sx) \times \text{Prob}({\sim}Sx)]\end{aligned}$$

Then, to arrive at the final proposition, we need a principle which says that the probability that Tx is the case, given that Sx is the case, and that $M(C, S, T, k)$) is the case, but that Sx does not cause it to be the case that Tx, is just equal to the probability of Tx given Sx alone. So let us introduce the following postulate:

$$(Q3)\quad \text{Prob}(Tx/\text{Sx} \,\&\, {\sim}C(Sx, Tx) \,\&\, M(C, S, T, k)) = \text{Prob}(Tx/Sx).$$

This allows us to arrive at the following important, derived proposition:

$$\begin{aligned}(Q4)\quad \text{Prob}(Tx/M(C, S, T, k)) &= [\text{k} \times \text{Prob}(Sx)] + [(1 - \text{k}) \times \text{Prob}(Tx/Sx) \times \\ &\quad \text{Prob}(Sx)] + [\text{Prob}(Tx/{\sim}Sx) \times \text{Prob}({\sim}Sx)]\end{aligned}$$

The idea is then that postulates ($Q1$) through ($Q4$) -- or simply ($Q1$) through ($Q3$), given that ($Q4$) is derivable from the other three -- serve to define implicitly the relation of causation. That implicit definition can then be converted into an explicit one by using one's preferred approach to the definition of theoretical terms. So, for example, if one adopted a Ramsey/Lewis approach, one would first replace the three descriptive terms '*C*', '*S*', and '*T*' by variables ranging over properties and relations. Next, since it is only '*C*' that one wants to define, one affixes two universal quantifiers to the front of the resulting open sentence containing the variables that one put in place of '*S*' and '*T*', so that one has an open sentence with only the one free variable -- namely, the one that was used to replace all occurrences of '*C*'. The relation of causation can then be defined as that unique relation between states of affairs that satisfies the open sentence in question.

11.2.2 The Merits of this Account

11.2.2.1 In Comparison to an Analysis in terms of Relative Frequencies

The advantages of the analysis of causation just set out emerge very clearly if one considers the problems that confronted the two reductionist approaches. Let us begin, then, with the objections directed against an account in terms of relative frequencies. First of all, a number of problems for the latter account arise from the fact that, according to it, the direction of causation supervenes upon patterns in events -- specifically, upon the direction of open forks. Because of this, that account could not handle such possibilities as accidental and non-accidental open forks involving common effects, temporally inverted, twin universes, and simple, temporally symmetric worlds that contain causally related events. By contrast, when causation is viewed as a theoretically defined relation between states of affairs, the different relationships that are set out in (Q_1) and (Q_4) between posterior probabilities and prior probabilities, in the case of causes and effects, ensure that the relation of causation possesses an *intrinsic* direction, rather than a direction supervening upon any patterns in events. Because of this, neither accidental nor non-accidental open forks involving common effects pose any problem. Similarly, nothing precludes there being either temporally inverted, twin universes, or simple, temporally symmetric worlds that contain causally related events.

The same is true in the case of simple, probabilistic, temporally non-symmetric worlds, but here there is the additional advantage that (Q_1) and (Q_4) provide the basis for a justification of one's intuitive judgements about the likely direction of causation in such worlds, since one can show that it is much more likely that the direction of causation runs from the very simple events to the extremely complex ones, rather than in the opposite direction.

Secondly, there were underdetermination objections, based on situations that are, as far as patterns in events go, causally ambiguous -- such as the case where there are excellent theoretical grounds for holding that the probability that an event of type *P* will give rise, directly, to an event of type Q is 0.75, where one finds that events of type *P* are directly followed by events of type *Q* with a probability of about 0.76, and where one knows that events of type *Q* occur uncaused with just the frequency that would make it likely, given a law that events of type *P* cause events of type *Q* with a probability of 0.75, that events are type *P* will be immediately followed by events of type *Q* with a probability of about 0.76. If one attempts to analyze causation in terms of relative frequencies, one is forced to the unintuitive conclusion that such cases are logically impossible, since there are no non-causal states of affairs that can distinguish between the cases where an event of type *Q* has been caused by an event of type *P*, and the cases where the event of type *Q* has followed an event of type *P*, but has not been caused by it. By contrast, if causation is a theoretically defined relation between states of affairs, this possibility poses no problem at all.

Finally, there was the most central and crucial objection of all, namely, that directed against the claim that causes -- or, at least direct causes -- must raise the probabilities of their effects. Here the problem was that an event of type *C* might have caused an event of type *E*, but there might have been another type of event, *D*, such that, first, the probability of the occurrence of an event of type *E* is greater, given an event of type *D*, than given an event of type *C*, and, secondly, if the event of type *C* had not been present, an event of type *D* would have been.

The view that causation is a theoretically defined relation between states of affairs is, by contrast, perfectly compatible with the idea that, had a certain cause been absent, a more efficacious cause would have been present, since this approach to causation does not entail that a direct cause must raise the probability of its effect in the way claimed by probabilistic, reductionist analyses of causation.

In response, it might be objected that there is surely something intuitively very appealing about the idea that a cause makes it effect more likely. The answer to this, however, is simply that causes do make their effects more likely, but not in the way claimed by reductionist analyses.

The correct account of probability-raising by causes follows very quickly, in fact, from the important principle that we saw was entailed by ($Q1$) through ($Q3$), namely:

$$(Q4)\quad \text{Prob}(Tx, M(C, S, T, k)) = [\text{k} \times \text{Prob}(Sx)] + [(1 - \text{k}) \times \text{Prob}(Tx/Sx) \times \text{Prob}(Sx)] + [\text{Prob}(Tx/{\sim}Sx) \times \text{Prob}({\sim}Sx)]$$

The derivation is as follows:

First, it is a theorem of probability theory that

$$(1)\quad \text{Prob}(Tx) = [\text{Prob}(Tx/Sx) \times \text{Prob}(Sx)] + [\text{Prob}(Tx/{\sim}Sx) \times \text{Prob}({\sim}Sx)]$$

Secondly, for the '*Tx*' that we are considering here, '*Tx*' is not logically entailed by '*Sx*', nor is it the case that it is logically necessary that *Tx*.

Thirdly, if '*Tx*' is not logically entailed by '*Sx*', and it is not the case that it is logically necessary that *Tx*, then the following is true:

(2) $\text{Prob}(Tx/Sx) < 1$.

(Here it is crucial that a distinction is drawn between probabilities that are precisely equal to one, and probabilities that are merely infinitesimally close to one.)

Fourthly, if *k* were precisely equal to zero in '$M(C, S, T, k)$', so that events of type *S* causally give rise with probability zero to events of type *T*, then it would not be true that events of type *S* cause events of type *T*. So we can assume that

(3) $k > 0$

It then follows from (2) and (3) that

(4) $[\text{k} \times \text{Prob}(Sx)] + [(1 - \text{k}) \times \text{Prob}(Tx/Sx) \times \text{Prob}(Sx)] > [\text{k} \times \text{Prob}(Tx/Sx) \times \text{Prob}(Sx)] + [(1 - \text{k}) \times \text{Prob}(Tx/Sx) \times \text{Prob}(Sx)]$

It is also true, however, that

(5) $[\text{k} \times \text{Prob}(Tx/Sx) \times \text{Prob}(Sx)] + [(1 - \text{k}) \times \text{Prob}(Tx/Sx) \times \text{Prob}(Sx)] = [\text{Prob}(Tx/Sx) \times \text{Prob}(Sx)]$

Statements (4) and (5) together then give us:

(6) $[\text{k} \times \text{Prob}(Sx)] + [(1 - \text{k}) \times \text{Prob}(Tx/Sx) \times \text{Prob}(Sx)] > [\text{Prob}(Tx/Sx) \times \text{Prob}(Sx)]$.

This, in turn, together with (*Q*4), yields:

(7) $\text{Prob}(Tx, M(C, S, T, k)) > [\text{Prob}(Tx/Sx) \times \text{Prob}(Sx)] + [\text{Prob}(Tx/{\sim}Sx) \times \text{Prob}({\sim}Sx)]$.

Finally, (7), together with (1), gives us the following result:

(*Q*5) $\text{Prob}(Tx, M(C, S, T, k)) > \text{Prob}(Tx)$, provided $k > 0$

This says that causes do raise the probabilities of their effects, in the following way: the probability of *Tx*, given only that it is a law that events of type *S* give rise, with some non-zero probability *k* to events of type *T*, is greater than the *a priori* probability of *Tx*.

My basic thesis concerning the raising of the probabilities of effects by their causes is, accordingly, that this is the case only in the sense stated by principle (*Q*5).

11.2.2.2 In Comparison to an Analysis in terms of Objective Chances

Next, let us consider how the approach according to which causation is a theoretically defined relation between states of affairs compares with an analysis of causation in terms of objective chances. To begin with, then, we saw that the idea that objective chances were ontologically ultimate was exposed to at least four serious objections. First, that idea entails that there can be relations of logical entailment between temporally distinct, intrinsic states of affairs. By contrast, when one defines the relation of causation in the manner indicated above, one can then go on, first, to define causal laws as laws that involve the relation of causation, and then, secondly, to define objective chances in terms of causal laws plus non-causal properties and relations. When this is done, the existence of objective chances does not entail any logical relations between temporally distinct states of affairs.

A second and related objection was that when causation is analyzed in terms of objective chances, it turns out that rather than laws connecting states of affairs existing at different times, what one has are laws connecting states of affairs at one and the same time, plus logical connections between temporally distinct states of affairs. This means that one is confronted with the puzzle of why, if there can be laws of nature connecting simultaneous states of affairs, it should be impossible for there to be laws connecting states of affairs that exist at different times.

When causation is analyzed as a theoretically defined relation between states of affairs, this problem does not arise: both basic causal laws linking states of affairs at different times, and basic laws of co-existence linking states of affairs at a single time, are logically possible.

A third objection was that a state of affairs at a single instant may involve a non-denumerable infinity of objective chances. If objective chances are ontologically ultimate, that means that the momentary state of affairs involves an infinite number of distinct, intrinsic properties. But if objective chances, instead, supervene on non-causal properties and relations plus causal laws, then there is no need for any infinity of properties. Indeed, an infinity of objective chances may even supervene upon a single intrinsic property plus a single causal law.

A fourth objection to ontologically ultimate, objective chances was that there are objective chances that are, intuitively, perfectly compatible, but that would be incompatible if objective chances were ontologically ultimate. We also saw that the objective chances in question are perfectly compatible when one analyzes objective chances in terms of causal laws plus non-causal properties and relations.

Next, there were two objections that arose in the case of a relative frequencies approach to causation that also apply to an analysis of causation in terms of objective chances. First, the latter approach is also exposed to underdetermination objections, since the arguments that show that causal relations between states of affairs do not supervene upon causal laws plus non-causal properties and relations also show that the situation is not changed if one adds objective chances to the proposed supervenience base. Secondly, an analysis of causation in terms of objective chances incorporates the requirement that at least a direct cause of an effect must raise the objective probability of its effect, and so this approach is also exposed to the objection that there are situations where if a certain cause had been absent, a more efficacious cause would have been present. By contrast, as we have just seen, neither of these two objections poses any problem at all for the view that causation is a theoretically defined relation between states of affairs. On the contrary, as regards the second of these objections, it is one of the great strengths of the latter account that it can provide a correct account of the one and only way in which causes do raise the probabilities of their effects.

Finally, there was the objection that an analysis of causation in terms of objective chances *immediately* rules out a causal analysis of the direction of time, since, in general, objective chances of an event of a given type, E, are not chances that the event will occur at some time or other, nor even chances that an event of type E will occur at a certain temporal distance: they are, instead, chances that an event of type E will occur at a certain temporal distance *and* in a certain temporal *direction*. Ontologically ultimate, objective chances presuppose, therefore, the relation of temporal priority, and so if one analyzes causation in terms of such objective chances, a causal analysis of the direction of time is ruled out. By contrast, when causation is viewed as a relation between states of affairs that is to be defined via the theory set out above, the idea of a causal account of the direction of time remains an open possibility.

11.3. Probabilistic Approaches to Causation

In chapters 6 and 10, I have argued against two accounts of the relation between probability and causation, and in favor of another. In particular, I have attempted, first of all, to establish the following claims:

(1) Reductive analyses of causation in terms of relative frequencies are untenable;

(2) Reductive analyses of causation in terms of ontologically ultimate, objective chances are also open to decisive objections.

Secondly, I have also tried to make plausible the following two claims:

(3) There are necessary connections between causation and logical probability, and those connections are captured by postulates ($Q1$) through ($Q3$), and, in a more explicit fashion, by the two derived propositions, ($Q4$) and ($Q5$);

(4) The correct analysis of the relation of causation is given by a theoretical-term style definition based upon the theory that consists of postulates (Q1) through (Q3) -- supplemented, if one prefers, by (Q4) and/or (Q5).

11.4 Summing Up: The Metaphysics of Causation

Traditionally, the main divide between accounts of the nature of causation has been viewed as that between reductionist accounts and realist accounts. We have seen, however, there are also very great gulfs within realist accounts, between direct realism and indirect, theoretical-term realism, and within reductionist accounts, between Humean reductionist accounts and non-Humean ones. Indeed, non-Humean reductionist approaches to causation are, in some respects, closer to realist accounts than to Humean reductionist accounts.

What are the central advantages and disadvantages of the various approaches, and which seems most promising? As regards non-Humean reductionist accounts, the appeal is quite clear: the introduction of objective chances initially looks as if it may enable one to provide a satisfactory account of probabilistic laws, and of probabilistic causal connections -- something that does not seem possible given a Humean, reductionist approach. The cost, however, appears very high, since the postulation of irreducible, objective chances commits one to the existence of logical connections between states of affairs that are distinct in the very strong sense of occupying different spatiotemporal locations.

If this latter idea is not acceptable, the choice is then between Humean reductionist approaches, and realist accounts. The former are exposed to a number of objections, some of which vary from one Humean reductionist theory to another, and some of which are general, with the latter including various underdetermination objections, and objections based upon very simple universes, and 'temporally inverted' ones. None of these poses any problem, by contrast, for realist theories, where the most important objections center, in the case of direct realism, upon the claim that the concept of causation is analytically basic, and, in the case of theoretical-term realism, upon the idea of strong laws, and the idea of logical probability.

The central objection to direct causal realism does seem strong. But, as regards the objections to theoretical-term realism, it is, in the first place, not at all clear that strong laws violate the thesis that there can be no logical connections between distinct existences, and, secondly, it can be argued that if the idea of logical probability were unsound, no beliefs at all could be inferentially justified. So there are grounds for thinking that there may very well be satisfactory answers to the crucial objections to the view that causation is a theoretically defined relation. By contrast, both the general objections to Humean, reductionist approaches, and many of the theory-specific objections, seem quite compelling.