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The Causal Connective

1 Preamble

Davidson (1967) distinguishes two conceivable ways of construing singular causal statements. An analysis in terms of a sentential connective, which he illustrates by

(1) *The fact that* there was a short-circuit *caused it to be the case that* the house burned,

is contrasted with one in terms of a dyadic predicate, illustrated by

(2) The short-circuit *caused* the burning of the house.

Davidson argued against an older formulation of the former view, due to Burks (1951), and came down in favour of the latter approach. But this must now be judged in the light of his accepting the circularity charge against his same causes and effects criterion of event individuation (Davidson 1985) and the absence of any clearer account of causal relata. Interest falls once more on the connective view, and this will be the topic of the present paper. A connective account of causation might even be of interest to the proponent of events as the basis of a non-circular causal account of events. No such development is undertaken here, however.

Statements of the kind (1) I write in the schematic form $C(\varphi,\psi)$, where C is the categorical causal connective expressed by the italicised words in (1) and φ and ψ are place-holders for sentences. The italicised expression in (1) is susceptible to tense inflexion—we can say things of the kind 'The fact that φ was causing it to be the case that ψ all day yesterday', and so on—which suggests that the connective should be provided with a time index, C_t. This feature should be treated within a broader framework allowing quantification over time variables in sentences flanking the causal

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connective. But it lies beyond the scope of the present paper, and reference to time is suppressed as far as possible. Now, categorical causal statements C(φ,ψ) I take to be defined in terms of a conditional causal connective, ©→, as $\varphi \wedge .\ \varphi$ ©→ ψ. Sentences of the kind φ ©→ ψ will usually be read simply as 'φ would cause ψ', although this is itself to be taken as a convenient abbreviation of 'If φ were the case, then ψ would be caused to be the case', where it is clear that φ and ψ are place-holders for sentences and not denoting terms. Finally, 'would cause' conditionals are themselves to be defined in terms of a subjunctive conditional, written →, which is the modal primitive for which a suitable modal logic will have to be developed. The procedure will be to develop an intended interpretation of the ordinary subjunctive conditional → in the course of motivating a definition of 'would cause', and draw attention to some of the more unusual axioms. What are called uncontroversial axioms are made explicit and some of their consequences summarised in the appendix.

2 The Connection Thesis

A basic requirement on the analysis is that the ordinary conditional be used to express a connection of the kind involved in hypothetical causal statements. Any such idea would definitely be precluded in the presence of the thesis

(3) $\varphi \wedge \psi\ .\supset\ \varphi \rightarrow \psi$,

according to which 'If Russell were to have died in 1970 then Socrates would have drunk hemlock in 399 BC', and conversely, are each true merely because antecedent and consequent both are. (3) was accepted as a thesis by Stalnaker (1968) and (with some reservations) Lewis (1973), but opinions have varied on what has come to be called the connection thesis. It is definitely rejected here, however, where a form of the connection thesis is maintained and 'φ would cause ψ' is said to entail $\varphi \rightarrow \psi$ as an expression of φ's causal sufficiency for bringing about ψ. More specifically, the idea of sufficiency a sentence of the kind $\varphi \rightarrow \psi$ is to capture is that of the antecedent φ, together with relevant conditions determined by φ, being sufficient for ψ. In the metaphorical terms of possible world semantics, $\varphi \rightarrow \psi$ is true provided ψ is true in every world which might be called a φ-neighbour of the actual world, where φ and its associated conditions obtain. So φ along with its logical consequences, its associated conditions and their logical consequences are all true in the φ-neighbours. But that is the extent of what they have in common. Irrelevant conditions are not common to all the antecedent-neighbours, and if φ-neighbours are similar to the actual world, the notion of similarity is not that of *overall* similarity as Stalnaker and Lewis elaborate the idea. The development of the intended interpretation of → in the following discussion will not appeal to ideas of possible world semantics, however, and a formal model theory is not presented.

Some qualifications are called for in order that $\rightarrow$ fulfil the role of expressing a connection, but a minimal requirement is that instead of (3), only the weaker

(4) $\varphi \wedge \psi .\supset \varphi / \psi$

is upheld, where φ / ψ, read 'If φ were the case, ψ might be', is defined as $\sim(\varphi \rightarrow \sim\psi)$.

The conditional doesn't itself say whether the antecedent actually is true or false; in particular, it is not necessarily counterfactual. A counterfactual is understood to be a conditional whose antecedent is actually false (cf. Anderson 1951). If the conditional itself is true, then the relevant conditions do on the whole obtain; the consequent is not also conditional on all the relevant conditions obtaining. This is more or less the informal interpretation Goodman proposed in his famous 1947 paper (reprinted as Ch. 1 of Goodman 1973). The project he set himself was to explicitly define such conditionals in the spirit of the regularity theory. The problem here is rather that of reflecting in a modal logic how the antecedent of a conditional has the force of more than it explicitly states—how it carries the weight of its relevant conditions.

This reference to Goodman suggests another reading for the weaker connective ' / ' introduced in (4). The reading he gives to the expression defined as φ / ψ above is 'ψ is cotenable with φ', which is to convey that ψ is not merely logically consistent with φ but compatible with φ taken together with all the relevant associated conditions, and which also explains why φ / ψ is not equivalent with ψ / φ. So although $\varphi / \psi \supset \Diamond(\varphi \wedge \psi)$ is a theorem, its converse is not.[1]

Now the conditional $\rightarrow$ as developed here will be subject to certain kinds of degeneracy which might seem to unfit it for the task of expressing the appropriate notion of causal sufficiency. For sentences of the kind $\varphi \rightarrow \psi$ will sometimes be true where a causal connection couldn't obtain between antecedent and consequent. This sort of thing is sometimes taken to threaten the connection thesis, but that, I think, is a mistake. On the contrary, the manipulation of a certain kind of degeneracy will be essential in arriving at a reasonable account of 'would cause'.

A simple illustration of degeneracy is the case where φ entails ψ. For example, I cause Jill to be ill by giving her one of my curries, but surely not that Jill is ill or not. Yet tautologies are entailed by every sentence. More generally, we will have to reckon with the thesis

(5) $\Box(\varphi \supset \psi) \supset \varphi \rightarrow \psi$

[1] This reading suggests more directly what is at issue when the weaker connective is used to express restrictions on principles such as that of transitivity which hold for material and strict implication; cf A6 and T9 of the appendix.

Again, where ψ entails χ and $\varphi \rightarrow \psi$, then $\varphi \rightarrow \chi$; i.e.

(6) $$\varphi \rightarrow \psi \;\wedge\; \Box(\psi \supset \chi) \;.\!\supset\; \varphi \rightarrow \chi$$

is a theorem. But this too leads to cases where no causal connection obtains. If Jill is ill then someone is (at some time) ill—there is illness. But is my giving her the curry the cause of that? Shouldn't we look further afield, to human frailty, or God? Am I the cause of evil? Suppose I buy the last copy of *Spycatcher* in stock; then the other copies would have been sold, but my causing the last to be sold doesn't cause the others to have been sold. Finally, an example of Pollock's: were I to press the doorbell, it would (be caused to) ring; and its ringing entails it exists; but my pressing the doorbell wouldn't cause it to exist.

Burks (1951) proposed to get around some such problems with his logic of causal propositions by defining a notion of φ's being nomologically but non-logically necessary. This might inspire the thought of labouring with a connective of the kind

$$\varphi \rightarrow \psi \;\wedge\; \sim\Box(\varphi \supset \psi).$$

But apart from the problem of logical consequences of what is caused, there are still other degenerate cases, to be discussed shortly, where the antecedent doesn't cause the consequent and which are not accounted for by proposals of this kind. A better way to account for degeneracy of the sort entailed by (5) and (6) is to note that their analogues for 'would cause' can be blocked by imposing a sine qua non condition. It is not true, for example, that were I not to press the doorbell, the bell wouldn't exist, nor that were I not to have given Jill the curry, she wouldn't be either ill or not. 'φ would cause ψ' should, then, be at least as strong as

$$\varphi \rightarrow \psi \;\wedge\; \sim\varphi \rightarrow \sim\psi.$$

What matters is that the analogues of (5) and (6) don't hold for 'would cause', not that they don't hold as they stand. They raise no problem because, in the presence of the sine qua non condition, the sort of degeneracy to which they give rise is precluded.

Contraposition, it has been widely recognised, doesn't hold for subjunctive conditionals. Certainly it doesn't hold for $\rightarrow$ because it can't be inferred from the fact that the conditions associated with the antecedent obtain that those associated with the negation of the consequent do. So when expressing that φ is a necessary condition for ψ we have to choose between the non-equivalent forms $\psi \rightarrow \varphi$ and $\sim\varphi \rightarrow \sim\psi$. Each of these forms plays a role in the ensuing discussion; but our immediate concern is that if $\varphi \rightarrow \psi$ is to express the causal sufficiency of φ for ψ (in a non-degenerate case), then we wouldn't want to say $\psi \rightarrow \varphi$—i.e. that ψ is also causally sufficient for φ. Choosing the second and not the first of the two non-equivalent forms to express the necessity of φ for ψ is not sufficient to capture the notion of the causal priority of cause over effect. But it is in line with the idea that this notion should be given some expression, whereas the former seems to preclude this. More will be said about this notion presently, but first some doubts about the sine qua non condition must be discussed.

3 Overdetermination and the Sine Qua Non Condition

The sine qua non condition is a classical constraint on causality, expressed for example by Hume in one of his definitions of a cause as "an object, followed by another, ... where, if the first had not been, the second never had existed" (*Enquires,* p. 60). The condition with all its modal import can be more convincingly attributed to Blanshard and Taylor (see e.g. Taylor 1980 and Blanshard's reply). But the condition might be thought too strong. Surely something else might cause the effect if the antecedent at issue were absent—particularly where there is overdetermination—and the weaker 'But for φ, ψ *might* not have been the case' would seem to be more appropriate than 'But for φ, ψ *would* not have been the case'. Moreover, replacing $\sim\varphi \rightarrow \sim\psi$ by the weaker condition $\sim\varphi$ / $\sim\psi$ suffices to block the analogues of (5) and (6) for 'φ would cause ψ'. Nevertheless, appeal to overdetermination doesn't speak as clearly in favour of the weaker condition as might at first appear, and the more elaborate cases call for a different kind of modification. Indeterminism, on the other hand, does seem to provide the weaker condition with some motivation.

Of course, something that is or would be caused by something might be caused by something else, too, in some sense. But as Blanshard and Taylor make clear, the sine qua non condition is understood to mean that under those conditions something does or would cause something, nothing else could have *under the same circumstances*. In a favourable (non-degenerate) case, $\varphi \rightarrow \psi$ holds in virtue of relevant conditions which, it was said, together with the antecedent are sufficient for ψ. The sine qua non condition $\sim\varphi \rightarrow \sim\psi$ must be understood as holding under roughly those same conditions which were relevant for $\varphi \rightarrow \psi$ being true. ('Roughly', because $\sim\varphi$ won't be true under precisely the same conditions φ is.) One of the major issues that must be addressed by the modal logic for $\rightarrow$ is how to reflect this connection between conditionals with a positive and those with the corresponding negative antecedent. A minimal prerequisite is that sentences featuring in conditionals be understood with a very pronounced contextual element. Any time or times referred to will serve partly to fix the content of sentences, as well as other explicit referring terms. But implicit features of the context must also be considered to play a very substantial role. Davidson (1963, 1970) makes essentially the same kind of appeal to implicit features of the context when alluding to alternative descriptions (not actually produced) of events in his devious interpretation of Hume's thesis. Just how this understanding of the sine qua non condition might be reflected in suitable axioms is discussed in §4.

Merely attending to the requirement of consistent relevant conditions doesn't obviously rule out overdetermination altogether, however. Consider the classic case of the firing squad, where several bullets deal a mortal blow simultaneously. The firing of any one of the bullets would have caused the death, it seems, and so it is not true that, had that bullet not been fired, the prisoner wouldn't have died. It is doubtful that someone willing to say this could reasonably maintain the weaker condition, for even if a particular bullet hadn't been fired, the prisoner would have died; it is not possible that he wouldn't. Even if a particular bullet which did in fact hit the victim's heart had not done so and missed his body completely, he would still have died as a result of the other bullets. So appeal to actual overdetermination does not serve to motivate the weaker condition. This is not to deny that we can envisage a situation in which one bullet would do the job, and use a counterfactual to express it. But this counterfactual would involve a conditional with a complex antecedent, something like 'If all but one of the bullets hadn't been fired and this one particular bullet had been fired, then it would have killed the prisoner', which is of no help in motivating the weaker condition.

Overdetermination doesn't motivate the weaker condition, then. But is this really a case of overdetermination? As described, the cause is the firing of all the bullets by the firing squad. The reason we talk about overdetermination is that we can imagine a different occasion on which one bullet would do to achieve the same end. Perhaps this reconstrual of the situation is encouraged by a relational view of causation where distinct events are thought of as determined by the actions of distinct individuals. But the present conception provides no basis for this train of thought. Firing squads are unusual, but relevantly similar cases are by no means uncommon. I apply more force than necessary to crack a nut, and more heat than necessary to boil a kettle; more votes were cast for the winning party than was necessary to elect them; and so forth. But the additional resources and superfluous energy make their mark—the nut is crushed along with the shell, more water boils away as steam, the winning party won convincingly, which might allow them to do what just scraping in wouldn't. And so too with the superfluous bullets. When confronted with the killing of a human being some details pale into insignificance, however, and an apparent overdetermination may be largely a matter of how our interests give rise to a description of less than the whole effect, merely of the relevant end or goal. What is important is the fact that the man died, not that his dying was one in which his body was torn by several bullets. But if superfluous effort is irrelevant to what is of most interest to us, it doesn't follow that it is irrelevant to what actually happens. Practical interests may well not run parallel with what is salient for the purposes of describing nature. Apparent overdetermination in the sense that we wouldn't distinguish between many other possible descriptions, some mutually incompatible, which specify some aspect of the phenomenon more precisely (even when what Davidson would call psychological descriptions are not at issue), is familiar enough. It remains to see whether there is any real overdetermination.

Other lines of criticism of the sine qua non condition remain to be considered. But before turning to these, some of the points of interpretation of the primitive conditional developed above will be consolidated in the form of definite axioms.

4 Relevant and Ancillary Conditions

A formula of the kind $\varphi \rightarrow \psi$ is to be used to say that φ would be sufficient, in the circumstances, for ψ. The task of specifying all such relevant conditions constituting the circumstances can't in general be carried out (cf. Anscombe 1971, p. 69). Sometimes we can't ourselves make the distinctions our usage presupposes, but rely on experts being able to supply the necessary descriptions. As Putnam says, there is a division of linguistic labour. But then as Cartwright has so convincingly argued, the experts can't always be relied upon to produce the goods. It just isn't true that the fundamental laws are strictly true generalisations with antecedents carefully circumscribed to meet all eventualities. Rather, the ordinary notion of cause is primary in the formulating of models in terms of which the laws can be made applicable to real phenomena, the criteria of adequacy of the models being the production of relatively consistent results. Føllesdal uses a metaphor of an iceberg in outlining his conception of Husserl's *Lebenswelt* which is applicable here. What appears above the surface, our articulated or articulatable thoughts, rests on an enormous submerged body of unarticulated, unstructured presupposed conditions which we only dimly penetrate as amateurs in trying to put two thoughts together—and even as experts trying to apply general principles to the individual case.

These conditions are degenerately implied, in the sense of the conditional, by the antecedent with which they are associated. The point can be put as follows. Suppose χ is a condition we are able to articulate which is one of those in virtue of which some conditional $\varphi \rightarrow \psi$ is true; it is thus a necessary condition: $(\varphi \rightarrow \psi) \rightarrow \chi$. But now suppose the conditional $\varphi \rightarrow \psi$ is true. On the intended interpretation, the conditions associated with the conditional are those associated with the antecedent. I.e., where the conditional is true, the conditions associated with it are those associated with the antecedent. Where $\varphi \rightarrow \psi$ is false, the circumstances necessary for $\varphi \rightarrow \psi$—comprising conditions χ such that $(\varphi \rightarrow \psi) \rightarrow \chi$—wouldn't all be associated with φ since if they were, $\varphi \rightarrow \psi$ would be true after all. The conditions associated with the antecedent are those which would be true if it were, and include the consequences of all true conditionals with this antecedent. A condition which is a necessary condition for $\varphi \rightarrow \psi$

will thus also be a necessary condition for φ where $\varphi \rightarrow \psi$ is true. It will be an axiom for this interpretation of $\rightarrow$, then, that

A8 $\varphi \rightarrow \psi \;\wedge\; (\varphi \rightarrow \psi) \rightarrow \chi \;.\!\supset\; \varphi \rightarrow \chi.$

(The numbering accords with that in the appendix.) To illustrate, suppose φ is 'The match is struck', ψ is 'It lights' and χ 'It is made of wood' or 'Oxygen is present' or 'It is not made of metal', etc. The antecedents of the material implication are then both true, and the consequent, 'If the match were struck, it would not be made of metal', etc., is also true.[2]

A notable feature of the associated conditions is their *underdetermination* by the cause, particularly in the counterfactual case. Where the counterfactual 'If I were to strike the match, it would light' is true, for example, there are innumerable possible ways of moving my wrist and bringing the match to the matchbox in an appropriate orientation and with a force sufficient to light it but not too strong to break it. This may seem to offer scope for arguments of the sort Lewis (1973, pp. 20-1) brings to bear in support of the claim that there may, on his overall similarity view of the relevant possible worlds, be no closest antecedent world. But such finer points of difference in the manner of achieving the antecedent state of affairs have no bearing on the relevant conditions associated with the antecedent and may well vary from one antecedent-neighbour to another along with all the totally irrelevant conditions. This kind of underdetermination of the antecedent is one aspect of the vagueness of the relevant conditions, and it would be a mistake to allow truth conditions of conditionals to turn on artificial questions of precision. Two over-precise, incompatible specifications of (i.e. each entailing) a relevant condition might each be cotenable with the antecedent of a particular true conditional.

As with other cases of degeneracy, the antecedent of a conditional fails as a sine qua non condition of its subjunctively implied relevant conditions. It is not true that, were the match not struck, there would not be oxygen present. But the import of this feature depends on how the general idea that the sine qua non condition $\sim\varphi \rightarrow \sim\psi$ obtains *under the same conditions as* the conditional $\varphi \rightarrow \psi$ is explicated. It seems that two constraints have to be met, that of preserving the conditions relevant for $\varphi \rightarrow \psi$, and that

[2] Despite allusions earlier to possible world semantics, I've no idea how this might be developed into a satisfactory model theory. If φ-neighbours to world α (having in common the φ-relevant conditions) are worlds β standing in the relation $\Re(\varphi,\alpha,\beta)$ included in models $\mathcal{M} = \langle W, \Re, V \rangle$, where W is a set of worlds and V a valuation of atomic formulas over W, with the basic truth condition $\mathcal{M} \models \varphi \rightarrow \psi\,[\alpha]$ iff $\mathcal{M} \models \psi\,[\beta]$ for all β such that $\Re(\varphi,\alpha,\beta)$, then semantic conditions corresponding to the axioms of the basic system described in the appendix can be easily formulated. But iteration of the kind involved in A8 corresponds to the condition

$$\mathcal{M} \models \varphi \rightarrow \psi\,[\alpha] \;\&\; \Re(\varphi,\alpha,\beta) \;.\!\Rightarrow\; \Re(\varphi \rightarrow \psi,\alpha,\beta),$$

which seems to be just circular as a semantic account of $\rightarrow$.

of precluding some other cause (sufficient condition) χ of ψ appearing out of the blue when it isn't actually true and making the sine qua non condition false.

The first of these constraints can be captured by laying down, by analogy with A8, an axiom

A9 $\varphi \rightarrow \psi \ \wedge\ (\varphi \rightarrow \psi) \rightarrow \chi\ .\supset\ {\sim}\varphi \rightarrow \chi.$

Since there doesn't seem to be any reason for holding $\varphi \rightarrow \psi \supset (\varphi \rightarrow \psi) \rightarrow \psi$ as a theorem, this won't lead to $\varphi \rightarrow \psi \supset {\sim}\varphi \rightarrow \psi$.[3] Taking χ as $\varphi \rightarrow \psi$, the second conjunct of the antecedent becomes an instance of $\varphi \rightarrow \varphi$, which is an uncontroversial axiom. From A8 and A9 respectively, then, we obtain the theorems

(7) $\varphi \rightarrow \psi \ \supset\ \varphi \rightarrow (\varphi \rightarrow \psi)$

(8) $\varphi \rightarrow \psi \ \supset\ {\sim}\varphi \rightarrow (\varphi \rightarrow \psi)$,

which might at first seem odd; but these are really just further examples of degenerate implication, in line with the present interpretation. A9 shows why degenerately subjunctively implied relevant conditions don't satisfy the sine qua non condition. Even if I were not to strike the match, oxygen would still be present according to A9, which is inconsistent with its not being present if I were not to strike the match (given the antecedent is possible. But this is always so for the negation of antecedents of 'would cause' statements of interest as live candidates for truth.)

So much for the first of the two constraints. The second would be met by laying down the axiom

A10 $\chi \wedge {\sim}(\varphi \rightarrow \chi)\ .\supset\ {\sim}\varphi \rightarrow \chi.$

${\sim}(\varphi \rightarrow \chi)$ means that χ is not among those conditions associated with φ (including those for which φ and its associated conditions is sufficient); i.e. χ is irrelevant for φ's efficacy, and so ${\sim}\chi$ would come 'out of the blue'. Its raining on Easter Island in 1066, for example, is no doubt irrelevant to the white ball's now colliding with the red causing it (the red) to move off. If χ is in addition actually true, then it remains true in the possible worlds relevant for the sine qua non antecedent ${\sim}\varphi$. So if my striking the match would cause it to light, then the sine qua non conditional 'If I don't strike the match, it won't light' can't be counted false on the grounds that a red hot poker might, in some sense, light the match instead. The absence of proximate red hot pokers remains a fact as part of the conditions associated with the negative antecedent of the sine qua non conditional. We might say that the Stalnaker-Lewis notion of minimal difference and

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[3] The Stalnaker-Lewis axiom (3) together with $\varphi \rightarrow \varphi$ yields the thesis (†) $\varphi \supset (\varphi \rightarrow \varphi) \rightarrow \varphi$, and so we could from A9 infer $\varphi \supset {\sim}\varphi \rightarrow \varphi$, which is the disastrous $\varphi \supset \Box\varphi$ (Df. $\Box$, appendix). But there seems to be no reason to accept (†).

overall similarity (at least up to a certain degree of underdetermination, or causal equivalence) enters the picture in connection with negations of antecedents.

On this last point, note that A10 can be equivalently written

$$\chi \supset. \ \varphi \rightarrow \chi \ \vee \ {\sim}\varphi \rightarrow \chi,$$

which might seem unreasonably strong if $\rightarrow$ is to express a connection. But on the connection thesis as maintained here, the interpretation of $\rightarrow$ is not that it always expresses, or holds true in virtue of, a connection. In particular, if $\rightarrow$ with antecedent φ is true in virtue of a connection, then $\rightarrow$ with antecedent ${\sim}\varphi$ isn't. So where 'φ would cause ψ' is true and counterfactual, we have ${\sim}\varphi \wedge \chi \ .\supset \ {\sim}\varphi \rightarrow \chi$, and the idea behind the Stalnaker-Lewis axiom (3) seems to have at least a restricted range of applicability.

Nevertheless, it will transpire that A10 is a mixed blessing, and may have to be rejected. This prompts the thought that a weaker form of the second constraint might be more appropriate, perhaps

A10* $\quad \varphi \rightarrow \psi \ \wedge \ \chi \ \wedge \ {\sim}(\varphi \rightarrow \chi) \ .\supset \ ({\sim}\varphi \rightarrow {\sim}\psi) \rightarrow \chi.$

Note that where ${\sim}\varphi \rightarrow {\sim}\psi$ is true the material consequent will yield ${\sim}\varphi \rightarrow \chi$ via A8; i.e.

(*) $\quad \varphi \rightarrow \psi \ \wedge \ {\sim}\varphi \rightarrow {\sim}\psi \ \wedge \ \chi \ \wedge \ {\sim}(\varphi \rightarrow \chi) \ .\supset \ {\sim}\varphi \rightarrow \chi$

becomes provable.

5 'Even if' Conditionals

Given what was said above in connection with A8 about the associated conditions including those subjunctively implied by all true conditionals with the antecedent in question, the totally irrelevant conditions are those irrelevant for any true conditional with the antecedent in question. But if an irrelevant condition χ is not subjunctively implied by antecedent φ, doesn't this conflict with the intuition that we should say 'Even if φ, still χ' and take this to entail the ordinary subjunctive conditional $\varphi \rightarrow \chi$? Stalnaker (1968, pp. 167-8) maintained that

(a) If the Chinese were to enter the Vietnam conflict, the United States would use nuclear weapons

is true, not only if the Chinese involvement would trigger U.S. nuclear retaliation, but also if the U.S. would use nuclear weapons anyway, for domestic reasons, whatever the Chinese might do. The latter circumstances are a case in point, of a subjunctively implied irrelevant condition. Butcher (1983, pp. 102-3) doesn't find Stalnaker's intuitions at all appealing, however, and objects that (a) is false if the U.S. were to use nuclear weapons anyway. What we would say in that case, he argues, is not (a) but rather

(b) Even if the Chinese didn't enter the conflict, the U.S. would (still) use nuclear weapons.

I agree with Butcher here, although not with his further conclusion that 'Even if $\sim\varphi$, still ψ' entails $\sim(\varphi \rightarrow \psi)$. Butcher wants to say that we affirm (b) in order to deny the connection asserted by (a). Again, I agree, but take this to mean that (a) should be interpreted as expressing a 'would cause' conditional if it is to express a connection, which is in turn denied by denying the sine qua non condition. That is, to deny φ ©→ ψ, $\sim\varphi \rightarrow \sim\psi$ is denied by asserting $\sim\varphi \rightarrow \psi$, which entails $\sim\varphi$ / ψ (given $\sim\varphi$ is possible; A2, appendix), and the latter is just $\sim(\sim\varphi \rightarrow \sim\psi)$. In cases of interest, it has already been noted, φ is contingent.

In the special case where ψ is necessary and $\Box(\varphi \supset \psi)$, $\varphi \rightarrow \psi$ follows in accordance with (5). There is no causal connection and the sine qua non condition fails. 'Even if $\sim\varphi$, still ψ' is appropriate here, denying the causal connection by denying the sine qua non condition. The discussion of pre-emption in the next section provides a further kind of example where an 'Even if' statement is used to assert $\sim\varphi \rightarrow \psi$ where $\varphi \rightarrow \psi$ is true.

6. Further Objections to the Sine Qua Non Condition

The firing squad case can be compared with another familiar example. Smith sets out to cross the desert with what he believes is a can full of fresh drinking water. But his wife has poisoned the water. Moreover, unbeknown to her, Jones has punctured the can with a tiny hole. Some time later Smith is found to have died in the desert of dehydration. Who killed him? Neither Jones' nor Smith's wife's action was a sine qua non condition of Smith's death: even if Jones hadn't punctured the can, Smith would have died from poisoning; and even if his wife hadn't poisoned the water, Smith would have died for lack of water. So if we were to argue that Smith's death was due to dehydration, and Jones caused this, then Jones' action would be a cause which wasn't a sine qua non condition of the effect. (Again, the weaker condition offers no solution.) The cause might be construed along the lines of the firing squad case, as the joint action of Jones and Smith's wife. Whereas in the firing squad case the cause is spread over space, the cause in the present example on this construal is spread over time. But this difference is not itself sufficient to upset the analogy, which could be improved by considering a firing squad whose members are positioned at various distances from the victim, the bullets being shot at different times in order to arrive simultaneously.

Nevertheless, this interpretation seems unnecessarily artificial. The difficulty lies with the fact that Smith didn't consume the poison. Jones' action deprived Smith of the water he needed and thereby saved him from the poison! It might more reasonably be said in the present case that the putative constituents of the total cause don't in fact add, but rather the action of the one interferes with, or *pre-empts,* the action of the other. A similar case would be one where Sally is startled by a loud clap of thunder and the telephone rings at the same time. Sally is of such a nervous disposition that the telephone's ringing would have been quite enough to startle her, but was, as it happens, completely drowned by the thunder.

It seems that we have a state of affairs, ψ, actually caused by φ, where

(9) $\varphi \rightarrow \psi \;\wedge\; {\sim}\varphi \rightarrow \psi$

is true because even if φ were not true, ψ would be anyway in view of some actual circumstances χ for which it also seems to be true that

(10) $\chi \rightarrow \psi \;\wedge\; {\sim}\chi \rightarrow \psi.$

But this is not quite right. χ (the telephone rings, Smith's wife poisons the water) is not sufficient, *under the circumstances,* for ψ (Sally is startled, Smith dies) because φ (there is a loud clap of thunder, Jones punctured the can) is actually true and was sufficient. If the noise of the telephone doesn't appear above the background noise, Sally wouldn't even notice it, and a condition of the telephone's startling Sally is blocked out by the thunder. Otherwise, there is no pre-emption and the situation is as in the firing squad case. So we have ${\sim}\chi \rightarrow \psi$, but ${\sim}\varphi \rightarrow (\chi \rightarrow \psi)$ rather than $\chi \rightarrow \psi$. (Since the latter is not true, the former shouldn't, in accordance with what was said in the last section, be expressed as 'Even if ${\sim}\varphi$, still $\chi \rightarrow \psi$'.) There is some asymmetry, then, which goes some way towards explaining the intuition that φ and not χ is the cause of ψ, although both are actually true. But so long as it can be maintained as a genuine case of pre-emption it constitutes a counterexample to the sine qua non requirement.

But how, exactly, is the preclusion of the sine qua non condition to be explained when φ pre-empts χ in causing ψ? The following, at least, seem clearly to be involved:

i. φ,

ii. χ,

iii. $\varphi \rightarrow \psi$,

and

iv. ${\sim}\varphi \rightarrow (\chi \rightarrow \psi)$.

If we add that the alternative cause, χ, is independent of the real cause φ, in the sense that (v) ${\sim}(\varphi \rightarrow \chi)$, then in view of A10, (ii) and (v) imply ${\sim}\varphi \rightarrow \chi$. Now this latter condition together with (iv) uncontroversially entails ${\sim}\varphi \rightarrow \psi$ (T11, appendix), and this in turn uncontroversially entails $\sim\varphi \mathbin{/} \psi$ given φ is contingent (A2, appendix), which is just $\sim(\sim\varphi \rightarrow \sim\psi)$. So A10, introduced to secure the sine qua non condition against the objection that an alternative cause might appear out of the blue, is now seen to sustain another objection. (Matters are not improved by adopting A10* since (*) just means that the assumption that the sine qua non condition holds leads to a contradiction.) It might be said that both conjuncts of (9) should be accepted from the outset as part of the characterisation of the pre-emption situation, and the discussion made independent of A10. But why beg the question when this particularly strong case can be made out against the sine qua non condition?

This is a fair account, I think, of the pre-emption objection to the sine qua non condition. But a reply is possible along broadly the same lines as that in the overdetermination objection. What was important were the contextual features concerning what actually happened, over and above the aspects of immediate interest to us, which are involved in the truth conditions of the singular statements at issue on the occasion in question. In the present case we might say that the effect at issue is Smith's dehydration, or death by dehydration, since that is how he actually died. Imagining another death, by poisoning, is to imagine another example. It is now true to say that Jones' puncturing the can was a sine qua non condition of Smith's dehydration (and Smith's wife's poisoning the water would have been a sine qua non of Smith's being poisoned). Were it the case that there was so little water left in the can (and correspondingly little poison) that Smith failed to survive what would not normally have been a lethal dose because of his weakened condition due to scarcity of water, we would have a genuine case of joint action as in the firing squad case. The ploy seems less plausible in the second example, but that, I think, is because Sally's being startled by thunder and by the telephone's ringing don't seem to involve such radically different physical processes as do dehydration and poisoning. But on reflection, they do seem analogous to alternative scenarios in the firing squad and kettle boiling cases.

In addition to cases of pre-emption of an actual, independent alternative cause, the sine qua non condition also fails, apparently, in cases involving non-actual alternative causes like that described by Loeb (1974, p. 540). If the objection is to stick, the alternative cause, though non-actual, shouldn't be just a possibility appearing out of the blue but one firmly tied to the circumstances. Suppose, then, that Harry has both white and brown mushrooms at his disposal, each equally lethal. He decides which to put into Harriet's soup by tossing a coin, as a result of which he uses the white ones (φ) and causes her death (ψ). Under the circumstances, if Harry hadn't used the white mushrooms, he would have used the brown ones: $\sim\varphi \rightarrow \chi$. It can be assumed that the white and brown mushrooms are lethal under the same conditions—that the poisonous substance each contains is the same, that it is stored in the structure of the mushrooms in ways which make it equally susceptible to entry into the blood stream after ingestion, etc.—defeating the ploy of distinguishing between kinds of death. So it seems reasonable that the sine qua non condition fails in this case, although as Loeb says, "Intuitively, ... Harry's using the white mushrooms *was* a *cause* of Harriet's death".

$\sim\varphi \rightarrow \chi$ is not derived via A10 this time, but is assumed outright as part of what is involved in Harry's determination to act on the outcome of the toss. Together with $\sim\varphi \rightarrow (\chi \rightarrow \psi)$, as in the pre-emption case, it yields $\sim\varphi \rightarrow \psi$ and so precludes the sine qua non condition. But there is another view of the matter. Until Harry makes and acts on his choice, each of φ and χ would cause ψ. Intuitively, there seems to be a good sense in which the two sine qua non conditionals both hold. For if a sine qua non condition preserves the ancillary conditions invoked by the sufficiency conditional, *together with* the completely irrelevant circumstances which actually obtain, then each sine qua non conditional is true. The negation of what might disrupt it is part of the completely irrelevant circumstances. And by the same count, when Harry makes his choice and uses the white mushrooms, it is no longer true that the sine qua non conditional for the alternative cause, $\sim\chi \rightarrow \sim\psi$, holds because $\sim\varphi$ is no longer true and so not preserved among the irrelevant circumstances. But the sine qua non condition for the actual cause continues to hold and Loeb's intuition that Harry's using the white mushrooms caused Harriet's death is sustained. It seemed at first as though Harry's determination to act on the outcome of the toss means that $\varphi \rightarrow \sim\chi$ and $\sim\varphi \rightarrow \chi$ both hold. But $\sim\varphi \rightarrow \chi$ here must mean that, prior to the toss, if (shortly thereafter) Harry were not going to use the white mushrooms, then he would use the brown mushrooms, whereas neither of the two 'would cause' statements initially upheld on the second version of the story make any reference to the future. And when Harry uses the white mushrooms, the sine qua non conditional 'Were Harry not to use the white mushrooms, Harriet wouldn't die' is true, the fact that if Harry hadn't chosen to use the white mushrooms, he would have chosen to use the brown mushrooms notwithstanding.

This reply stresses the temporal determination of conditionals, a feature I said at the beginning would be suppressed. It is obviously a feature to be reckoned with, however, although its systematic incorporation into conditional logic raises many issues which can't be pursued here. Another observation is that rebuffing the objection in this way presents something of a dilemma. For this line of argument seems to presuppose A10, sanctioning the preservation of irrelevant conditions. Thus, in order to save the sine qua non condition from the non-actual alternative cause objection, appeal is made to the principle which supports the pre-emption objection. But since an additional argument was found for rejecting the pre-emption objection, the balance lies in favour of A10. This axiom will exact a price later, however.

Again, these are equally good counterexamples to the weaker condition, and no help is to be had from that quarter. $\sim\varphi \rightarrow \psi$, which is what rules out the sine qua non condition given $\Diamond\sim\varphi$, is also inconsistent with $\sim\varphi / \sim\psi$ (cf. T7 of the appendix).

Arguments have been given against these two lines of objection, but a standby position should, perhaps, be mentioned. Where $\varphi \rightarrow \psi$ and no corresponding sine qua non condition distinguishes this from merely degenerate subjunctive implication, what does? The obvious suggestion is an extended sine qua non condition of the kind $(\sim\varphi \wedge \sim\chi) \rightarrow \sim\psi$. If, for example, ξ is some subjunctively necessary relevant condition for $\varphi \rightarrow \psi$ in the sense of A8, say some feature of Sally's or Harriet's anatomy or metabolism, as the case may be, then it is not true that $(\sim\varphi \wedge \sim\chi) \rightarrow \sim\xi$. So the suggestion suffices to exclude ψ's being degenerately related to φ. Once started on this path, it seems that in general there might be any number of alternative sine qua non refuting causes $\chi_1,...,\chi_n$ to φ of ψ, and we have to reckon with some general schema for the extended sine qua non condition: $(\sim\varphi \wedge \sim\chi_1 \wedge ... \wedge \sim\chi_n) \rightarrow \sim\psi$. Where ψ is a phenomenon which interferes with some project or procedure we want to carry out, like the existence of background noise or the perturbance of a steady temperature, it might take some considerable thought and effort to eliminate all its alternative sources after the principal one has been eliminated. Or the effect might be so vaguely specified—Why doesn't the experiment work?—that any number of causes might be involved. This sort of uncertainty is, perhaps, a realistic feature of our concept of causation, reflected by writing the extended sine qua non requirement as a schema.

But counterexamples are still forthcoming. Atoms in a lump of uranium disintegrate spontaneously, we are told, with the emission of several neutrons at a rate proportional to the mass of the lump. For lumps above a certain critical size, the neutrons tend not to escape but collide with other atoms, inducing their disintegration with the emission of more neutrons, and so on. Fixing on a particular neutron heading towards a particular uranium atom, we want to say that it would cause the disintegration of the uranium atom. We can imagine alternative cause situations involving other neutrons; but there is another possibility to be reckoned with here. The particular uranium atom might disintegrate spontaneously, before the particular neutron we have our eye on gets to it. And so even if our particular neutron were not to collide with our atom, it might disintegrate anyway. It is not true that if there were no collision, there would be no disintegration.

This, I take it, is the sort of description we have to give quantum phenomena if they are to provide the sort of probabilistic counterexample Otte (1987) offers to the sine qua non condition. Waiving the question of whether the description is justifiable, it seems we have at last a case where the weaker condition, but for the cause, the effect might not have been, has some bite. Cases where φ would cause ψ but ψ might occur anyway (but only might) bring this condition into play.

Another sort of probabilistic counterexample Otte offers, according to which φ couldn't be a sine qua non condition of ψ because an alternative cause χ of ψ might spontaneously occur anyway, is distinctly less plausible. His grounds are that it is possible that $\sim\varphi \wedge \chi$ (p. 50). But as we have already seen, this doesn't entail $\sim\varphi \rightarrow \chi$. Even so, the weaker condition could be called upon here too.

That Otte and others regard counterexamples to the sine qua non condition as such triumphs over the modal conditional approach is largely due to the prominence of the condition in Lewis's 1973 paper. Given the thesis (3), all the substance of Lewis's account is to be found in the sine qua non condition. By emphasising the sufficiency of the cause and the connection thesis, on the other hand, the present account is not so sensitive to minor hiccups in the sine qua non condition. Even if the extended sine qua non condition were admitted, precluding a neat, perfectly general definition of 'would cause', still the same general pattern would apply, expressed with the same primitive concepts, and the proposal would be a far cry from abandoning a uniform concept of causation. But our talk of causation is usually talk of *the* cause, in the sense of a feature around which innumerable causal factors, as they are called, are gathered as relevant conditions, and excluding alternative such causes. On the present view causes are not primarily entities that can be counted. Such sense as there is to be found in the definite article is to be found in the sine qua non condition. It certainly won't be generally misleading to understand 'would cause' with the sine qua non requirement, bearing in mind that special cases may call for special modifications which we've not as yet seen any reason for thinking can't be expressed within the present apparatus. Perhaps the generalised sine qua non condition may sometimes be called for, and the probability of spontaneous effects calls for the weaker condition; but usually, 'unique' causation is at issue.

7 The Causal Priority Condition

The discussion of degeneracy was opened by blocking the analogue of (5) for 'would cause' by the introduction of the sine qua non condition. But this falls short of actually maintaining the thesis

(11) $\varphi \text{©}\!\!\rightarrow \psi \;\supset\; \sim\Box(\varphi \supset \psi)$.

In particular, blocking (5) doesn't exclude the case φ would cause φ, which is certainly not universally valid, and I venture to say never true. A further condition is therefore required. Now we saw that contraposition is not valid for the subjunctive conditional. In the case of 'would cause' we can go further: the contraposition of a true 'would cause' conditional is actually false. Davidson has given a nice counterexample:

My tickling Jones would cause him to laugh, but his not laughing would not cause it to be the case that I didn't tickle him" (1967, p. 152).

Let us consider the proposal, then, that 'would cause' be defined by

$$\varphi \copyright\!\!\rightarrow \psi \;\; \equiv. \;\; \varphi \rightarrow \psi \;\;\wedge\;\; {\sim}\varphi \rightarrow {\sim}\psi \;\;\wedge\;\; {\sim}\psi \,/\, \varphi.$$

Note that this last conjunct, which is equivalent with ${\sim}({\sim}\psi \rightarrow {\sim}\varphi)$, could not be maintained in the counterfactual case on the Stalnaker-Lewis interpretation of conditionals according to which the consequent is said to be true in all worlds where the antecedent is true and which differ minimally from the actual world in accommodating it.[4]

As well as ruling out the contrapositive, the final conjunct of the proposed definition also ensures the validity of

(12) $\varphi \copyright\!\!\rightarrow \psi \;\supset\; {\sim}(\psi \copyright\!\!\rightarrow \varphi)$,

(of which ${\sim}(\varphi \copyright\!\!\rightarrow \varphi)$ is a special case), in view of which it might reasonably be called the causal priority condition.[5]

(11) and (12) motivate the addition of some such condition to the sufficiency and sine qua non conditions. However, the suggested addition is inadequate, because states of bodies are not causally sustained. Thus, if a red ball maintains the same state of uniform motion during an interval t, and t', t'' are two abutting subintervals of t with t' entirely earlier than t'', the red's motion at t' does not cause its motion at t''. Under the circumstances, however, it would seem to be a sufficient as well as a sine qua non condition of the motion at t''. Since it doesn't cause the motion at t'' there must be some

4 Lewis makes essentially this proposal at the end of his 1973 paper for the special case of categorical causal statements in connection with what he calls the problems of effects and epiphenomena—of the effect also causing the cause, and of the epiphenomenon causing the substantial effect. However, the import of the proposal depends very much on its interpretation. For Lewis, ${\sim}({\sim}\psi \rightarrow {\sim}\varphi)$ is true because ${\sim}\psi \rightarrow \varphi$ is true, and this in turn because it would involve less overall change to alter some laws or circumstances than to change φ. This explains why Lewis can't extend the proposal as he understands it to the counterfactual case: ${\sim}\varphi$ would remain true in all ${\sim}\psi$-worlds overall most similar to the actual one, and so ${\sim}\psi \rightarrow {\sim}\varphi$ couldn't be false.

5 The causal priority condition is vaguely similar—I make no stronger claim—to the third clause in Hausman's (1984) causal priority condition (CP) which he sets out as follows: X causes Y if

(1) X and Y are causally connected,

(2) everything causally connected to X is causally connected to Y,

and

(3) something is causally connected to Y but not to X.

('X' and 'Y' are described as ranging over causal factors which include true causes and factors which are causal conditions.) The causal priority condition ${\sim}\psi/\varphi$ might be thought of as saying that conditions which allow ${\sim}\psi$, and therefore lack a ψ-relevant factor, don't necessarily mean ${\sim}\varphi$. To take one of Hausman's examples, splitting of an amoeba (φ) causes the subsequent existence of two separate amoebas (ψ), and the absence of an amoeba eater just after splitting is a condition whose failure may lead to ${\sim}\psi$, but not thereby to ${\sim}\varphi$. Hausman's second condition is similarly reminiscent of the sufficiency condition $\varphi \rightarrow \psi$ here. But one of the principles from which he derives his (CP) condition is the transitivity of the relation 'causes', as he understands it, standing between factors over which 'X' and 'Y' range, and this principle has no analogue here.

additional condition generally satisfied by causes which fails in this case; but the present proposal doesn't seem to fit the bill. Even if the red's state of motion were not maintained at t'' (because of an earthquake), the red might well still move at the prescribed velocity for t'.

We might still consider what can be said in favour of this further condition. Kim (1973) raises a number of counterexamples specifically aimed at Lewis's modal analysis of categorical causal statements but which have sometimes been taken as obstacles standing in the way of any modal conditional analysis of causation (e.g. by Widerker 1985). One category of problem cases is characterised by Kim as involving "one event 'determining' another without *causally* determining it. The second event depends asymmetrically on the first for its occurrence, but is not a *causal* consequence of it" (p. 193). He illustrates with the example of his sister giving birth to her first child, when he became an uncle.[6] Here we have an example in which φ, $\varphi \rightarrow \psi$ and $\sim\varphi \rightarrow \sim\psi$, i.e.

> If Kim's sister had not given birth at *t,* he wouldn't have become an uncle at *t,*

are all true; but clearly not $C(\varphi,\psi)$. It is not necessary to impose a temporal precedence requirement on 'would cause'. There is no inconsistency on the present account because the condition $\sim\psi$ / φ is not fulfilled—it is not the case that if Kim hadn't become an uncle, his sister might (nevertheless!) have given birth.

Not all of Kim's counterexamples can be dealt with in this way. Cases of what he calls logical or analytical dependency involve conditionals of the kind $\sim\varphi \rightarrow \sim\psi$, such as

> If George had not been born in 1950, he would not have reached the age of 21 in 1971.

Here $\sim\psi$ / φ is true—George might have died at 20. But the sufficiency condition $\varphi \rightarrow \psi$ is clearly not true in this case. The sufficiency condition also fails in another of Kim's counterexamples where it is held that

> If I had not written 'r' twice in succession, I would not have written 'Larry'.

Admittedly, it is a contention of the present analysis that causal antecedents are not in general completely specified. An activity is described in the antecedent of this last example as continuing for only part of the time required for the completion of its action as described by the corresponding causal conditional. If a notion of the time of the antecedent were acceptable, together with a notion of the time of causation (of the

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6 Such cases have been considered problematic by philosophers seeking to define events as changes but unable to accept Xantippe's becoming a widow upon Socrates death as an event. Lombard (1986) proposes to deal with such cases by banishing relational changes altogether from event-generating changes, and thence from the range of the causal relation. But this is too drastic, disqualifying as true causal statements any candidates involving as antecedents interactions such as mutual gravitational, electrostatic or magnetic attraction, and the impressing of one billiard ball on another.

conditional) along the lines hinted at in the first section (Slote 1978 broaches some such idea), then a general requirement that the time of causation be a part of the time of the antecedent might be imposed. But there are difficulties with the former notion, at least, because antecedents may well contain references to more than one time. For example, in the present case, the complex pluperfect tense of ‘I had written’ involves a reference to a reference point in the past before which the writing is said to occur. The intuition that the sufficiency condition fails in this case remains to be fully articulated, then. Some further points remain to be discussed.

It would seem that cases of Kim’s second kind should be diagnosed problems for those who count (3) valid. But this response is not so easily justified on the present account if A10 stands. For by taking χ as ψ in A10, denial of the sufficiency conditional would give us $\sim\varphi \rightarrow \psi$; and this together with $\sim\varphi \rightarrow \sim\psi$ yields $\sim\Diamond\sim\varphi$ (by A2, appendix). Under these conditions, then, the sentence $\sim\varphi \rightarrow \sim\psi$ expressing the s*ine qua non* condition is true only if $\Box\varphi$ is. For contingent φ, $\psi \wedge \sim(\varphi \rightarrow \psi)$ precludes the sine qua condition and so these last two examples of Kim’s are not in fact compatible with the denial of the sufficiency condition. Perhaps this should be seen as an argument against A10. If A10* were adopted instead, substitution of χ by ψ in (*) yields an inconsistent material antecedent, and it cannot be used to rebuff $\sim(\varphi \rightarrow \psi)$. On the other hand, my writing ‘r’ twice can still be counted a necessary condition of my writing ‘Larry’, as is George’s being born in 1950 of his reaching the age of 21 in 1971, in the form $\psi \rightarrow \varphi$, and perhaps this is how analytically necessary consequences should be expressed. But since we also have $\sim\varphi$ / ψ by A10 as just shown, this brings us dangerously close to saying that my writing ‘Larry’ would cause my writing ‘r’ twice. The conditional $\psi \rightarrow \varphi$ is degenerate, however, because it is not true that if I hadn’t written ‘Larry’ I wouldn’t have written ‘r’ twice, like the cases of degeneracy arising from (5) as already discussed.

In another example in which I open the window by turning the knob,

If I had not turned the knob, I would not have opened the window

is said to be true. Kim elucidates: “my turning the knob does not cause my opening the window (although it does cause the window’s being open)” (p. 193). In the sense in which this sine qua non as well as the causal priority condition are true, it is false to say that my turning the knob is sufficient for my opening the window. This seems as clear a case as any of failure of the causal conditional because of failure of the sufficiency condition. A10 puts the spanner in the works again, however, and renders this inconsistent. But the same kind of response is once more possible: replace A10 by A10*, or express the necessity as $\psi \rightarrow \varphi$ rather than $\sim\varphi \rightarrow \sim\psi$.

Joint effects, ψ and χ, of a common cause φ have also been raised as counterexamples to conditional analyses of causation. If one pellet from a shotgun had hit the bull (ψ), then others would at least have hit the target (χ) (because there is so little scattering at such short range). And if the cheese had spoiled (ψ), the milk would have spoiled (χ) (because milk spoils before cheese).[7] In these cases, however, it is not clear that the sine qua non condition $\sim\psi \rightarrow \sim\chi$ is satisfied—the milk might have spoiled and the cheese not because the temperature was quickly restored to normal; and although no pellet hit the bull, one might have hit the outer ring of the target. In other cases it seems that the joint effects are each both sufficient and sine qua non conditions of the other. For example, the fall in pressure causes both the fall in the barometer reading and the rain; and John's piano playing might wake Smith whilst sending Brown to sleep. But here the symmetry between ψ and χ precludes either being causally prior to the other. Thus ψ wouldn't cause χ because at most $\psi \rightarrow \chi$ and $\sim\psi \rightarrow \sim\chi$, for $\sim\chi / \psi$ couldn't be true because $\sim\chi \rightarrow \sim\psi$ is.

The causal priority condition renders the connective ©→ not even transitive in the extended sense expressed by a material conditional whose antecedent contains only connectives flanked by 1st. and 2nd. or by 2nd. and 3rd. links, as it were, and whose consequence contains only connectives flanked by 1st. and 3rd. links (cf. A6, appendix). A traditional line of thought takes non-transitivity as a sign of a restricted notion of 'immediate causation' and seeks to extend it to a more inclusive transitive notion. It is difficult to find good arguments for or against this policy. Suffice it to say that the conception of causal influences petering out rather than extending indefinitely over space or time strikes me as the more plausible approach, but I must plead lack of space to pursue this issue here.

Suppose, contrary to the present proposal, that the causal priority condition were construed as $\sim(\psi \rightarrow \varphi)$ rather than $\sim\psi / \varphi$. This would allow (12) and the negation of the contrapositive to be maintained without (11), although the special case $\sim(\varphi$ ©→ $\varphi)$ would still hold. It wouldn't, however, meet Kim's problem cases, and is therefore not adopted here. If Kim were to become an uncle, then his sister must have given birth; if he has more than one sister, or a brother, the original antecedent 'Kim's sister gives birth' can be changed to 'One of Kim's siblings has a child'. Again, if I were to write 'Larry' then I would have written 'r' twice in succession. Finally, it seems that if George has reached the age of 21 in 1971, then he must have been born in 1950. Some philosophers have objected to such 'backwards looking' conditionals. Lewis (1979), for example, elaborates his semantics for conditionals in such a way as to rule backwards looking conditionals as false, and offers the account as a semantic theory of the direction of time. But it is a virtue of the present account that causal priority can be explained independently of temporal precedence. The arbitrary disqualification of

7 Examples taken from Davis (1988, p. 138).

contemporaneous causation becomes unnecessary, and it offers a hope of explaining temporal direction in terms of causation.[8]

Note that, given the axiom A8 and what was said about the interpretation of the conditional allowing the kind of degeneracy which sanctions it, backwards looking conditionals cannot reasonably be ruled out in principle. Suppose (cf. Bennett 1984, p. 70f) Mr. D'Arcy and Queen Elizabeth quarrelled yesterday and she is still very angry. Then, if D'Arcy were to ask of her a favour today, she wouldn't grant it. But now D'Arcy is too proud a man ever to ask for a favour under such circumstances. So if he were to ask her for a favour, they wouldn't have quarrelled yesterday. If D'Arcy were to ask her for a favour today, then, she would grant it. This, the Downing scare story as Bennett calls it, is used by Lewis (1979) as an argument for generally counting backwards looking conditionals false in order to avoid conflict with the forward looking conditionals which are supposed to be more important. But as Bennett says, the conflict only arises by arbitrarily associating different conditions with different temporal directions, and has nothing to do with the direction of time. We might say that if, if D'Arcy were to ask the Queen for a favour she would refuse, then they must have quarrelled yesterday (i.e. $(\varphi \rightarrow \psi) \rightarrow \chi$). And, if, if D'Arcy were to ask the Queen for a favour she would grant it, then they wouldn't have quarrelled. If $\varphi \rightarrow \psi$ ('If D'Arcy were to ask for a favour, she would refuse') is the true conditional, A8 gives us the backwards looking conditional 'If D'Arcy were to ask a favour, they would have quarrelled yesterday'.

8 Appendix

The basic system MC of modal conditional logic to which the axioms A8-A10 described in the text are considered to be added can be described as follows. With $\rightarrow$ primitive, three defined modal operators are first introduced by

Df / $\varphi / \psi \equiv {\sim}(\varphi \rightarrow {\sim}\psi)$

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8 A relation D of *having the same direction as* between two pairs, t_1, t_2 and t_3, t_4, of times which are pairwise separate (thinking of them as intervals standing in mereological relations, as in Needham (1981); otherwise, as pairwise distinct) can be defined on the basis of a triadic betweenness relation B. Defining first $B(t_1, t_2, t_3, t_4)$ as $B(t_1, t_2, t_3) \wedge B(t_2, t_3, t_4)$, $D(t_1, t_2, t_3, t_4)$ is defined by

$$B(t_1, t_2, t_3, t_4) \vee B(t_1, t_3, t_2, t_4) \vee B(t_1, t_3, t_4, t_2) \vee$$
$$\vee B(t_3, t_1, t_2, t_4) \vee B(t_3, t_1, t_4, t_2) \vee B(t_3, t_4, t_1, t_2).$$

If t_1 and t_2 are thought of as times of antecedent and consequent of a causal statement, $K(t_1,t_2)$, and similarly for t_3 and t_4, then the direction of time might be defined in terms of causation by maintaining that for all (most, or for all of some particular kind of) causal statements $K(t_1,t_2)$ and $K(t_3,t_4)$, where the times are pairwise separate (distinct), t_1, t_2 and t_3, t_4 stand in the relation D of having the same direction.

Df $\Box$ $\Box\varphi \equiv {\sim}\varphi \rightarrow \varphi$

Df $\Diamond$ $\Diamond\varphi \equiv {\sim}\Box{\sim}\varphi$.

In order to reduce the number of brackets, modal operators are assumed to bind more strongly than truth-functional connectives. The axioms and rules of inference are as follows:

A0 The tautologies of truth functional logic

A1 $\varphi \rightarrow (\psi \supset \chi) \;\supset.\; \varphi \rightarrow \psi \supset \varphi \rightarrow \chi$

A2 $\Diamond\varphi \supset.\; \varphi \rightarrow \psi \supset \varphi / \psi$

A3 $\varphi \rightarrow \varphi$

A4 $\Box\varphi \supset \psi \rightarrow \varphi$

A5 $\varphi \rightarrow \psi \supset.\; \varphi \supset \psi$

A6 $\varphi \rightarrow \psi \wedge \psi \rightarrow \chi \wedge \psi / \varphi \;.\!\supset\; \varphi \rightarrow \chi$

A7 $\varphi \rightarrow \chi \wedge \psi \rightarrow \chi \;.\!\supset (\varphi / \psi) \rightarrow \chi$

MP From φ and $\varphi \supset \psi$ to infer ψ

R From $\vdash \varphi$ to infer $\vdash \psi \rightarrow \varphi$

Note that (4) is just the contraposition of A5. Other theses referred to in the text not appearing above are to be found in the following list of derived rules and theorems.

R_n From $\vdash \varphi_1 \wedge ... \wedge \varphi_n \;.\!\supset \psi$ to infer $\vdash \chi \rightarrow \varphi_1 \wedge ... \wedge \chi \rightarrow \varphi_n \;.\!\supset \chi \rightarrow \psi$

N From $\vdash \varphi$ to infer $\vdash \Box\varphi$

T1 $\Box(\varphi \supset \psi) \;\supset.\; \Box\varphi \supset \Box\psi$

T2 $\Box\varphi \supset \varphi$

T3 $\Box(\varphi \supset \psi) \supset \varphi \rightarrow \psi$

T4 $\varphi \rightarrow \psi \wedge \psi \rightarrow \varphi \wedge \varphi \rightarrow \chi \;.\!\supset\; \psi \rightarrow \chi$

T5 $\varphi \rightarrow \psi \wedge \Box(\psi \supset \chi) \;.\!\supset\; \varphi \rightarrow \chi$

T6 $\varphi \rightarrow {\sim}\psi \equiv {\sim}(\varphi / \psi)$

T7 ${\sim}(\varphi \rightarrow \psi) \equiv \varphi / {\sim}\psi$

T8 $\varphi \rightarrow (\psi \wedge \chi) \;\equiv.\; \varphi \rightarrow \psi \wedge \varphi \rightarrow \chi$

T9 $\varphi \rightarrow \chi \wedge \varphi / \psi \;.\!\supset (\varphi \wedge \psi) \rightarrow \chi$

T10 $(\varphi \wedge \psi) \rightarrow \chi \wedge \varphi \rightarrow \psi \;.\!\supset\; \varphi \rightarrow \chi$

T11 $\varphi \rightarrow \psi \wedge \varphi \rightarrow (\psi \rightarrow \chi) \;.\!\supset\; \varphi \rightarrow \chi$

T12 $\varphi \rightarrow \psi \supset \varphi \rightarrow (\varphi \rightarrow \psi)$

The latter theorem requires A8; all the others follow from A0-A6 and the inference rules. The unfortunate consequence of A10 (with A2) mentioned in §7 is

T13 $\psi \wedge {\sim}(\varphi \rightarrow \psi) \wedge {\sim}\Box\varphi \;.\!\supset {\sim}\varphi / \psi$.

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