Causation

ABSTRACT

Causation is defined as a relation between facts: C causes E if and only if C and E are nomologically independent facts and C is a necessary part of a nomologically sufficient condition for E. The analysis is applied to problems of overdetermination, preemption, trumping, intransitivity, switching, and double prevention. Preventing and allowing are defined and distinguished from causing. The analysis explains the direction of causation in terms of the logical form of dynamic laws. Even in a universe that is deterministic in both temporal directions, not every fact must have a cause and present facts may have no future causes.

PRELIMINARIES

Philosophical theories of causation are broadly divided along two axes: facts versus events and counterfactual versus "regularity" (law) theories. It's best we begin by locating our position against this background.

On the question of facts versus events: we hold that the fundamental causal relata are facts– states of affairs that obtain. We are happy to speak of events, objects, tropes, or any other sort of items as causes and effects but only on the understanding that this is a way of saying that *facts* about those items are related as cause and effect.

As to what facts are: for our purposes, we need only the simplest version of Correspondence Theory. We suppose that states of affairs are named by propositions and propositions are true or

false depending on whether the states of affairs they name obtain. Some states of affairs obtain—are facts – at some possible worlds and not at others.

We also take it for granted that facts and the propositions that name them are about things. 'Lincoln was assassinated in 1896' is true because it expresses a proposition which names a fact about Lincoln and about a time. We neither have nor require any special theory of aboutness or truthmaking. Nor do we have a theory of how the things facts are facts about might connect to the constituent structure of facts. For our purposes, we are happy to suppose that propositions are identical iff they are true at precisely the same possible worlds.

On the matter of laws versus counterfactuals, our theory straddles the fence. Law theorists of the early part of the last century were hampered by the underdeveloped state of modal logic and of the logic of counterfactuals in particular. All that changed with mid-century advances in modal logic and Lewis and Stalnaker's semantics for counterfactuals. With these powerful resources in hand, Lewis proposed that causation could be defined in terms of counterfactual relations between events without appeal to laws. Many philosophers of causation followed his lead, but we think that was a mistake. Our analysis takes account of both nomological and counterfactual connections between facts.

About laws, we assume only that there are laws of nature and that we can speak of the propositions they entail as "nomologically necessary." It should not have to be said— but probably does have to be said— that this does not commit us to any "necessitarian" or "non-Humean" view of laws.

About counterfactuals, we assume only what we take to be the uncontroversial core of the standard understanding of the logic of counterfactuals.

CAUSE DEFINED

Here is a case to test our intuitions.

> Suzy is fuming about the recent bad behavior of an academic rival. Trying to calm down, she goes for a walk with her friend Billy. They walk aimlessly for a while when, suddenly, Suzy realizes that they are standing in front of her rival's house. Her anger wells up and before Billy can stop her, she picks up a rock and throws it, breaking a window.

Among the facts in this story are:

> SUZY-THROWS: Suzy throws a rock at t_1 .
>
> BREAKS: The window breaks at t_3.

Suzy's throwing the rock caused the window's breaking[1]: BREAKS because SUZY-THROWS.

Of course, SUZY-THROWS is not the only fact that causes BREAKS. There is the fact that Suzy was angry, the fact that she saw her rival's house, the fact that a rock was there to be thrown, and so on. All of these facts are causes too. But there are facts about t_1 that are not causes. There is the fact that somewhere, on the other side of the planet, a bird sang. There is the fact that Paris is the capital of France.

> PARIS: Paris is the capital of France at t_1 .
>
> BIRD: A bird sings at t_1.

And there are the logical compounds and consequences of all of these: *e*.g. the fact that SUZY-THROWS & PARIS, that SUZY-THROWS v BIRD and so on. Why, among all these facts, do we think that SUZY-THROWS is a cause of BREAKS?

Our analysis of causation aims at answering this question. We say:

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[1] Proponents of the idea that the primary causal relata are facts rather than events are sometimes thought to be obliged to frame causal claims in the sometimes awkward "*P* because *Q*" format: "The window broke because Suzy threw the rock". But, as Vendler (1967) and Bennett(2007) have shown, imperfect nominals like "Suzy's throwing the rock" — unlike perfect nominals like "Suzy's throwing of the rock— behave logically and grammatically like the names of facts, not events. We will often use this form.

> *C* causes *E* if and only if:
> (i) *C* and *E* are nomologically independent facts; and
> (ii) *C* is a necessary part of a nomologically sufficient condition for *E*.

Some terminological clarifications. When we say that *C* and *E* are nomologically independent, we mean that the laws of nature allow one to be true or false regardless of whether the other is true or false. By a "condition", we just mean a conjunction of facts about a particular time.[2] By "part", we just mean *entailment*: *Q* is a part of *P* if and only if $P \rightarrow Q$.

When we speak of a "nomologically sufficient condition for *E*" we mean a fact *S* such that:

$$\Box_L(S \supset E)$$

When we say a fact, *C*, is a "necessary part of a sufficient condition *S* for *E*", we do not mean that *C* is nomologically necessary for *E*, but rather that *C* is necessary for *S* to be sufficient for *E*. We will spell this out formally as we proceed.

DETERMINING

Our account begins by assuming determinism in the sense of Lewis:

> A deterministic system of laws is one such that, whenever two possible worlds both obey the laws perfectly, then either they are exactly alike throughout all of time or else they are not exactly alike throughout all of time, or else they are not exactly alike through any stretch of time. They are alike always or never. They do not diverge, matching perfectly in their initial segments but not thereafter: neither do they converge. Let us assume, for the sake of the argument, that the laws of nature of our actual world are in this sense deterministic.[3]

[2] It will not matter to our analysis how precise the times are — to the year or to the second— the relevant granularity will be determined by the intervals that figure in natural laws.
[3] Lewis, 1979.

We assume determinism not because our analysis requires it but because any plausible account of causation must be at least consistent with determinism. It is this requirement that motivates the first clause of our analysis— the one about nomological independence. Determinism has no temporal direction. Causation does. If nomological sufficiency entailed causation, then backwards causation would be everywhere since determinism entails that the total state of the universe at any moment in the future is nomologically sufficient for every fact about the past.

Determinism also entails, though this may be less obvious, that there are facts about the future which are nomologically *necessary* for every fact about the past. To see why this is so, take any proposition *F* which names a fact about some time t_i. If *F* is nomologically contingent, then there will be some nomologically possible worlds where it is true and some where it is not. Take all the nomologically possible worlds where *F* is true and describe the total state of each such world at some other time, t_j. If we now disjoin the propositions expressed by all those descriptions, we get a proposition, *NS*, which is true at every and only those nomologically possible worlds where *F* is true. NS then is nomologically sufficient and necessary for *F*.

More generally, given determinism, there must be a function, $\mathcal{NS}(F,t_n)$, from facts and times onto facts such that for every fact and every time.

$$\Box\ (\mathcal{NS}(F,t_n) \equiv F)$$

Where $\mathcal{NS}(F,t_n)$ will be the disjunction of every possible condition of the world at t_n nomologically sufficient for *F* to be true at whatever time *F* is about.

With all this in mind, let's return to our story. Our question was, why do we want to say that SUZY-THROWS is a cause of BREAKS? Part of the explanation must be that we suppose that SUZY-THROWS is part of a nomologically sufficient condition for BREAKS. And that must be

true if determinism is true since determinism guarantees that there are facts at every time which are nomologically sufficient for every fact about every other time. But being a part of a sufficient condition for BREAKS cannot be enough to make SUZY-THROWS a cause. *Every* truth about t_1 must be part of *some* sufficient condition for BREAKS. If is true that:

$$\Box_L(\ldots \,\&\, \text{SUZY-THROWS} \,\&\, \ldots \;.\supset \text{BREAKS})$$

elementary logic guarantees that it will also be true that

$$\Box_L\ (\ldots \,\&\, \text{SUZY-THROWS} \,\&\, \text{PARIS} \,\&\, \text{BIRD} \,\&\ldots\; .\supset \text{BREAKS})$$

To exclude causally irrelevant facts like BIRD and PARIS, we need to capture the intuition that the throwing was in some sense *necessary* for the breaking even though it clearly isn't, by itself, *nomologically* necessary for it.

Historically, it was on just this point that attempts to give "regularity theories" of causation foundered. J.L.Mackie said that a cause is a *non-redundant* part of a nomologically sufficient condition. He tried to define non-redundancy in linguistic terms. His idea was that a redundant condition is one which does not have to be named in a formal deduction of the effect from some canonical expression of the laws. There were technical reasons[4] why this could never be made to work, but in any case, the idea seems fundamentally wrong-headed: what causes what should not depend on what language we use to describe it.

Mackie dared not appeal to— though he was acutely aware of— the other way in which SUZY-THROWS is necessary for BREAKS: not nomologically but counterfactually:

(1) $\qquad \sim\text{SUZY-THROWS} \;\Box\!\!\rightarrow\; \sim\text{BREAKS}$

Mackie saw the dependence but did not want to rely on it for his analysis because the logic and semantics of counterfactuals were then poorly understood.

[4] Cf. Strevens 2007, Maslen, C. 2012.

This changed with the advent of Lewis and Stalnaker's semantics for counterfactuals. With that in hand Lewis could boldly propose[5] that we "give up" on regularity theories and argue that counterfactual dependence— at least between events— is all there is to causal dependence. This seemed to work well for all sorts of cases. It certainly works for our story about Suzy when we re-describe it in terms of events: the event which is the breaking of the window would not have occurred if the event which is Suzy's throwing of the rock had not occurred.

Following Lewis, counterfactual accounts of causation became the focus of philosophical thinking about causation and law theories went into eclipse. But there were problems: cases where causal and counterfactual dependence seemed to come apart, and cases where causal stories could not be easily translated into talk about events. We will review many of those cases below.

In our view, things would have gone better if philosophers had not been so quick to reject law theories in favor of counterfactual theories.[6] They should never have been seen as mutually exclusive. They are both essential parts of a single story.

To see how this is so, let us reflect for a moment on the connections between nomological and counterfactual dependence.

Theorists of counterfactuals disagree about how we should think about counterfactual situations. What would the world be like if Suzy hadn't thrown that rock at t_1? Some theories say we should imagine a world where some small miracle happens just before t_1 that keeps Suzy

[5] Lewis 1973b.

[6] Lewis is certainly responsible for this. His doctrine of Humean Supervenience requires that the causal facts supervene on matters of particular fact. His account of counterfactuals means that counterfactual propositions are just ways of asserting relations of similarity between our world and other worlds in matters of particular fact. But his Best System theory of laws entails that the laws of nature are no more than heuristic devices for summarizing the particular facts about the actual world. This seems to have led him to think that reference to the laws should play no essential role in the analysis of cause. We think this a strategic mistake; we need to talk about laws to understand causation. However nothing in our account is inconsistent with any theory of laws.

from throwing[7]. Some say we must imagine a world with no miracles, but different initial conditions which lawfully bring it about that Suzy does not throw the rock[8]. Other theories say it doesn't matter how the counterfactual situation comes about so long as what happens in it at t_1 is like what actually happens in all the other respects that we care about.[9] These disagreements are important, but notice that they are disagreements about the *history* of the relevant counterfactual situation. All agree that the relevant situation, however it comes about, will be a nomologically possible one very much like the actual state of the world at t_1 and that the way we figure out what happens in that world— e.g. whether a window breaks— is to assume that events thereafter unfold in accordance with the actual laws of nature.

This means that any theory of counterfactuals[10] is committed to this equivalence:

$$\Box_L(P \supset Q) \equiv \Box_L(P \mathrel{\Box\!\!\rightarrow} Q)$$

If every nomologically possible world where *P* is true is a world where *Q* is true, then the closest nomologically possible *P*-world to every world is a world where Q is true[11]. Conversely: if at every nomologically possible world, the closest worlds where *P* is true are always worlds where *Q* is true, then $P \supset Q$ is true at every nomologically possible world.

Now return to our story. Given that BREAKS is true at t_3, there must be some set of facts about t_1 which are, in conjunction, nomologically sufficient for BREAKS. We know that SUZY-THROWS is a member of such a conjunction since, as we observed above, *every* true

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[7] Lewis 1979.
[8] Bennett 1984.
[9] Maudlin 2004, Paul & Hall 2013, Bennett 2003.
[10] We expect some to object on the grounds that this would make some backtracking counterfactuals true and didn't Lewis forbid backtrackers? No. Lewis only ever argued against backtracking *event* counterfactuals and he would have denied that *P* is ever nomologically sufficient for *Q* when *P* and *Q* assert the occurrence of distinct events.
[11] Lewis would say that the histories of the closest worlds may not be nomologically possible because they contain miracles, but he would agree that at the time of the antecedent and thereafter they must be identical with some nomologically possible world.

proposition about t_1 is part of *some* nomologically sufficient condition for BREAKS. Indeed, determinism means that the total state of the world at t_1— *all* the facts about the world at that time, including PARIS and BIRD— must be nomologically sufficient for BREAKS and every other fact about t_3. Our problem then is to pick out which among all the t_1 facts are *relevant* to BREAKS being true and which are not.

One obvious relevance criterion is the counterfactual dependence expressed by (1). BREAKS counterfactually depends on SUZY-THROWS but not on PARIS or BIRD. But counterfactual dependence does not seem necessary for causation. Suppose that in our Suzy story we had Billy throw a rock as well so that his rock would have hit the window simultaneously with Suzy's. In that case, BREAKS would have been true even if Suzy hadn't thrown. Or suppose that Suzy's was the only rock, but there was someone or something that would have broken the window if Suzy hadn't thrown: a backup window breaker. In that case, too, (1) would not have been true.

Such cases show that counterfactual dependence is not necessary for causation, but they do not undermine the core idea that a cause is a *necessary part* of a sufficient condition for an effect. Necessary, not in the sense that the effect depends on its truth, but in the sense that were it not true, the balance of the condition that remained would not be sufficient for the effect. If we add a second rock thrower or a backup window breaker to our original story we are adding additional sufficient conditions. The facts that were originally sufficient for BREAKS would still be true and would still be sufficient for BREAKS. And the fact that Suzy throws her rock would still be a necessary part of *that* condition. We know this because we know that in worlds without these additional sufficient conditions— as in our original story—the window's breaking *does* counterfactually depend on SUZY-THROWS.

This suggests a first step towards distinguishing the necessary parts of a sufficient condition for a fact *E*. Where *S* is nomologically, but not logically, sufficient for *E*:

$$S \nrightarrow \mathrm{E} \;\&\; \boxed{\mathrm{L}}(S \supset E)$$

then we will say:

$$P \text{ is relevant to } S \text{ for } E \;=_{\mathrm{df}}\; \diamondsuit(S \;\&.\; {\sim}P \;\Box\!\!\rightarrow\; {\sim}E)$$

SUZY-THROWS is relevant to BREAKS because there is a world — in this case, the actual world— where there is a sufficient condition for BREAKS and where BREAKS counterfactually depends on SUZY-THROWS. That counterfactual dependence remains a possibility— and hence SUZY-THROWS is *relevant*— even at worlds where backup window breakers or other rock throwers mean that BREAKS doesn't counterfactually depend on Suzy's throw.

P is a relevant *part* of a sufficient condition *S* for *E* if *P* is relevant to *S* for *E* and *P* is a part of *S*; that is, if:

$$S \rightarrow P$$

We will say that *C* is a cause of *E only if* it is a relevant part of some nomologically sufficient condition for *P*.

That *P* may be a relevant part of a sufficient condition for *E* even if *E* doesn't counterfactually depend on *P* explains how *C* may cause *E* even if it is not true that:

$$\sim\mathrm{C} \;\Box\!\!\rightarrow\; \sim\mathrm{E}$$

Still, this result should give us pause. Remember that BIRD and PARIS are also parts of sufficient conditions for E and now we cannot say that they are *not* relevant *just* because BREAKS does not *actually* counterfactually depend on them.

So why do we think that BIRD is *irrelevant* to the window's breaking? It's not that we think it is nomologically impossible for a bird's singing to cause a window to break. There surely are nomologically possible worlds where BIRD is a cause of BREAKS and

(2) ~BIRD $\Box\!\!\rightarrow$ ~BREAKS

is true. At those worlds, BIRD will be relevant to whatever condition suffices for the window breaking there. But those worlds are not like the actual world. At the actual world, BIRD is irrelevant to BREAKS because at this world the reason that the window breaks— that is, the t_1 conditions that nomologically guarantee that it will break— would remain true even if BIRD were false. We don't think BIRD is irrelevant just because BREAKS doesn't *actually* counterfactually depend on it but because we are confident that there are facts that suffice for BREAKS at the actual world that do not depend on BIRD at *any* nomologically possible world.

This gives us a criterion for *irrelevance. S*upposing that S is a condition which is nomologically sufficient for *E* and *P* is any fact that is nomologically independent of E[12] then we say:

P is irrelevant to *S* for *E* $=_{df}$ $\sim\Diamond$ (*S* & . ~*P* $\Box\!\!\rightarrow$ ~*E*)

Or, equivalently

P is irrelevant to S for E $=_{df}$ $\Box$ (S $\supset$. ~P $\Diamond\!\!\rightarrow$ E)

If *P* is irrelevant to *S* for *E*, then at every nomologically possible world where *S* is true, *E* might be true even if *P* were false.

This defines 'relevance' as relevance to a specific sufficient condition , but we will also speak of a fact *P* as irrelevant to *E simpliciter* if *P* is irrelevant to *every* true sufficient condition

[12] We exclude nomologically dependent facts, since facts that are nomologically sufficient or nomologically necessary for E are obviously not *irrelevant* to E.

for *E*. Thus we say that BIRD is irrelevant to BREAKS because if *any* conjunction of facts which are *actually* sufficient for BREAKS obtained at *any* nomologically possible world then the window would still break even if ~BIRD.

A fact which is irrelevant to any actual sufficient condition for *E* is not a cause of *E*. But we cannot say that once we set aside the irrelevant facts only causes remain. To see why not, consider the counterfactual:

(3) ~(SUZY-THROWS & PARIS) $\Box\!\!\rightarrow$ ~BREAKS

On the standard semantics, a counterfactual is true iff there is a world where the antecedent and consequent are true that is more similar to the actual world than any world where the antecedent is true and the consequent is false. The antecedent of (3) is true at worlds where either Suzy doesn't throw the rock or where Paris is not the capital of France. But, by any standard of similarity any world of the former sort is far more similar to the actual world than any of the latter sort. All that would be required for ~SUZY-THROWS is that Suzy decide not to throw the rock, whereas ~PARIS would require enormous changes in world geopolitics. It seems, then, that at the *closest* worlds where the antecedent of (3) is true, it is SUZY-THROWS that is false and, at those worlds, the window doesn't break.

So (3) is true and that means that

(4) SUZY-THROWS & PARIS

is not irrelevant to BREAKS even though PARIS is not plausibly a cause of BREAKS.

Still, it is not hard to see what is going on here. (4) is relevant to BREAKS only because it conjoins a relevant fact (SUZY-THROWS) with an irrelevant fact (PARIS). (4) is only *partly* relevant because only some of its parts are relevant. What we should say, then, is that a fact is a

necessary part of a sufficient condition for *E* only if it does not entail anything irrelevant to that condition for *E*.

With that limitation in place we can now say what it is for a fact *P* to be a *necessary* part of a sufficient condition for *E*. Where *S* is a nomologically (but not logically) sufficient condition[13] for *E* and *S* entails *P*:

> *P* is a necessary part of *S* for E $=_{df}$ *P* is relevant to *S* for *E* and *P* does not entail any proposition which is irrelevant to *S* for *E*.

Our analysis says that every necessary part of a sufficient condition for *E* is either a nomologically necessary condition or a cause of *E*.

The conjunction of the necessary parts of any sufficient condition will constitute a *minimally* sufficient condition: a conjunction of facts which is nomologically sufficient for the effect and such that every conjoined fact is required for the conjunction to be sufficient.

Following Lewis, we call the set of propositions that comprise a minimally sufficient condition for a fact a "determinant" of that fact.

> Any particular fact about a deterministic world is predetermined throughout the past and post determined throughout the future. At any time, past or future, it has at least one *determinant,* a minimal set of conditions jointly sufficient, given the laws of nature, for the fact in question. [14]

Alas, Lewis never got around to saying what would make such a condition "minimal." We have.

Framed in these terms, our account of causation becomes:

> *C* causes *E iff* i) *C* & *E* are nomologically independent facts; &
> ii) *C* is a member of a determinant of *E*.

[13] Recall that we use "condition" to name a conjunction of *true* propositions. So conditions name *facts*.
[14] Lewis 1979, p.474. Note though that we will argue below that Lewis was wrong to think that the past is overdetermined by the future.

RELEVANCE

We expect the objection that all this arcane metaphysics cannot be part of our homely conception of causation. We demur. We think that these standards of causal relevance are part of common sense.

Take an unremarkable example: One morning Mary goes out for a walk and sees her old friends Tom, Dick and Harry. She shouts "Hello!". Her action has three different upshots. Tom is startled. Dick is surprised. Harry is gratified. Tom is startled because her greeting was so loud. Dick is surprised, not by the volume (he knows Mary often shouts) but because she said "Hello" and not her usual "Ciao!". Harry is gratified that Mary said anything at all. He had thought she wasn't talking to him.

Philosophers who take events to be the primary causal relata tell us that Mary's greeting had these different effects because it is actually an amalgam of three different events. There is an event which is essentially a saying by Mary of something loud but only accidently a saying of "Hello". That is, *metaphysically* essential*:* this event doesn't exist in possible worlds where she says "Hello"— or anything else— quietly (which is why Tom wouldn't be startled there). It is a different event— one that is *essentially* a saying of "Hello" (or maybe of not saying "Ciao", the status of omissions is controversial) that causes Dick's surprise. And neither of these events is identical to the event which is essentially an event of Mary's saying something that is only accidentally a saying of any particular thing at any particular volume. That is the one that causes Harry to be happy. These three events are non-identical but not quite "distinct" from one another and all are distinct from but somehow "part" (though not a spatiotemporal part) of a larger (though not spatiotemporally larger) event which is Mary's greeting. [15]

[15] Lewis 1986b.

This, it seems to us, *is* arcane metaphysics and unnecessary, given that the facts are clear. Among the facts are that Mary said something, that what she said was "Hello!", and that she said something loudly. The fact that she said something loudly is relevant to the fact that Tom is startled. That fact is irrelevant to Dick's surprise, or Harry's delight. What is relevant to Dick's surprise is the fact that Mary did not say "Ciao!". The fact that Mary said "Hello" is relevant to what made Harry happy, but only partly relevant. The relevant part is that she said *something*. This, it seems to us, is just common sense.

OVERDETERMINATION

In our story the t_1 determinant of BREAKS is a set of facts, including SUZY-THROWS which are, in conjunction, a minimally sufficient condition for BREAKS. Let us call that conjunction 'S_{SUZY}'. S_{SUZY} is sufficient but not necessary for BREAKS. There are lots of ways that the window could have been broken. For example, there are worlds where Suzy doesn't throw and it is Billy who breaks the window. In that situation, BREAKS would have a different determinant: an S_{BILLY} that would include the fact that BILLY-THROWS at t_1.

We count determinants as different if they are nomologically independent: if there are nomologically possible worlds where one obtains and not the other. This does not preclude the possibility that two determinants might be true at the same world. There is, for example, a world where Suzy and Billy throw their rocks simultaneously and both S_{SUZY} and S_{BILLY} are true. At such a world BREAKS is *overdetermined*. At such a world the window still breaks since the conjunction:

(5) S_{SUZY} & S_{BILLY}

is nomologically sufficient for BREAKS. But notice that, while sufficient, (5) is not *minimally* sufficient for BREAKS. The fact that SUZY-THROWS is irrelevant to (5) for BREAKS because

(6) $\boxed{L}(S_{SUZY} \ \& \ S_{BILLY} \supset . \sim$SUZY-THROWS $\ \Box\!\!\rightarrow$ BREAKS)

A world where both Suzy and Billy do not throw is less like this world than any world where only Suzy doesn't.

Even so, in the case of overdetermination S_{SUZY} and S_{BILLY} remain, independently, minimally sufficient for BREAKS. Each is sufficient on its own, and there are worlds— worlds without overdetermination— where BREAKS depends on each of them. Accordingly, even in the presence of overdetermination, SUZY-THROWS and BILLY-THROWS are causes of BREAKS since each is a conjunct in a minimally sufficient condition. Both are causes even though the breaking of the window does not counterfactually depend on either fact.

A determinant is a set of facts about a time. We have said that an outcome is overdetermined if it has more than one nomologically independent determinant at the same time. But this should not be understood as implying that it is always possible to say how many determinants or how much determination is at work in any given case. Conditions which are nomologically independent in pairs may not be so in n-tuples.

A simple case: Tom and Dick simultaneously step into a one-man canoe. It sinks. In this case they are clearly the joint causes of the sinking. If either had not stepped in, no sinking. But now suppose that Tom, Dick and Harry simultaneously step into the canoe. This time the sinking is clearly overdetermined, but how many determinants are there? There are three pairs of minimally sufficient conditions for the sinking, and any pair of them are nomologically independent, but not all three.

The case is a simple illustration of what Mackie called "quantitative overdetermination". His example was of a sledgehammer flattening a chestnut:

> [T]he whole of the blow was not necessary for [the flattening of the chestnut], though it was more than sufficient: a somewhat lighter blow would have sufficed. Even if part of the hammer-head had been absent, this result would still have come about [16]

Cases like these are perplexing for theories of causation that suppose that causal relata must be events. How many events occur when three people step into a boat or when a hammer hits a chestnut? Such questions will seem urgent if events are causes. What then of our own question: How many determinants are there of the canoe sinking or the chestnut flattening? The answer is that it does not matter how we count them because determinants are not causes. Determinants are nomologically sufficient for their effects and nomologically sufficient or necessary conditions are never causes. A fact is a cause if it is a nomologically independent part of a sufficient condition. Which means that the fact that Tom steps in, and the fact that Dick steps in and the fact that Harry steps in are each a cause of the canoe's sinking. They are causes because each is a necessary part of at least one sufficient condition for the sinking of the canoe. Likewise, we can count the uncountable facts about which parts of the hammer hit the chestnut as each and every one a cause so long as each is a necessary part of *a* nomologically sufficient condition for the chestnut's flattening.

[16] Mackie 1980, p. 43 .

EARLY PREEMPTION

Overdetermination is one way in which an effect can fail to counterfactually depend on a cause. There are other ways, much discussed in the literature under the labels "early preemption", "late preemption" and "trumping". We'll begin with early preemption.

Retell our story of Suzy and Billy— the version in which Billy does not throw— but imagine now that Billy is as angry as Suzy and that if he hadn't seen Suzy throw, he would have thrown a rock and made BREAKS true. Let us stipulate that what we are supposing is that if Suzy had not thrown, Billy's rock would have broken the window at t_3— *the same time* at which Suzy's rock *actually* breaks the window, the time BREAKS is about. (That is what makes this a case of *early* preemption.)

Cases like this are sometimes described in terms that presuppose that causation is propagated by "causal chains". Thus, Lewis describes them as:

> cases in which, first, there is a completed causal chain running from the preempting cause all the way to the effect; but, second, something cuts short the potential alternative causal chain that would, in the absence of the preempting cause, have run from the preempted alternative to the effect.[17]

Described in this way it seems that the problem such cases pose for the theory of causation is to say what causal chains are and how they are "completed" or "cut short".

We see things differently. Our account does not require causal chains. Early preemption cases are ones where *C* causes *E*— and thus *C* belongs to a determinant of *E*— but where ~*C* would cause or allow[18] a different determinant of *E* to be true. The situation in this pre-emptive case is no different than in our original story, where there was no overdetermination. Billy does

[17] Lewis 2000, p 183.
[18] As we shall see below, causing and allowing are different.

not throw and hence S_{BILLY} is false. S_{SUZY} is still true and it suffices for BREAKS. The only difference is that in this situation.

$$\sim\text{SUZY-THROWS} \mathrel{\Box\!\!\rightarrow} S_{\text{BILLY}}.$$

S_{BILLY} would have been a minimally sufficient condition for BREAKS if it were true. If Suzy hadn't thrown and Billy had thrown, then S_{BILLY} *would have been* true and his throw *would have been a cause* of BREAKS. But, in fact, Suzy does throw, and Billy doesn't. So it is she, not he, who causes the broken window.

The presence of the preempted backup cause means that BREAKS does not counterfactually depend on S_{SUZY}. Even so, S_{SUZY} remains minimally sufficient for BREAKS because there is *a* nomologically possible world— one without a backup and without overdetermination— where BREAKS *does* counterfactually depend on it.

LATE PREEMPTION

In cases of *early* preemption, the preempting cause (Suzy's throw) prevents a preempted cause (Billy's throw)– from happening. Late preemption cases are different. In them a preempted cause is not prevented but a preempting cause prevents it from causing the effect. For a late preemption story imagine that both Suzy and Billy throw rocks but the setup is such that Suzy's rock reaches and breaks the window a moment before Billy's rock so that when Billy's rock arrives the breaking has already happened.

In the literature, cases of late preemption are held to be especially worrying examples of causation without counterfactual dependence. But it is impossible to share these worries unless one is committed to the idea that causation is a relation between *events*. On this way of understanding the story there are three events: Suzy's throw, Billy's throw and the breaking of the window. In actuality, the breaking of the window happens at t_3. But, goes the argument, the

time at which an event occurs is not metaphysically essential to it so the very same event of breaking could have happened at a different time, t_4, and *it* would have happened then if Suzy's rock hadn't arrived first. Therefore, the occurrence of the event which is the breaking of the window does not counterfactually depend on Suzy's throw. It would have happened— albeit a bit later— even if she hadn't thrown.

Far be it from us to dispute anyone's intuitions about event essences, but it seems to us that rather than posing a problem for causation, the case demonstrates why it is a mistake to suppose that events are the primary causal relata.

Whatever events might be, nomological and counterfactual dependence are relations between propositions, and if we are to make sense of this story we must consider what propositions are true— what the facts are— in the case. Telling the story in event language, these facts seem to be:

SUZY THROWING: The event which is Suzy's throwing of a rock occurs at t_1.

BILLY THROWING: The event which is Billy's throwing of a rock occurs at t_2.

BREAKING: The event which is the breaking of the window occurs at t_3.

What isn't true, but would have been if Suzy hadn't thrown, is:

LATER BREAKING: The event which is the breaking of the window occurs at t_4.

Apart from the purely grammatical transformations, the situation is not logically or causally different from our original case. Whatever one's theory of events, the facts that entail SUZY THROWING must be entailed by S_{SUZY}: S_{SUZY} entails that Suzy threw a rock at t_1 and that surely entails that the event which is Suzy's throwing of a rock occurs at t_1.

The facts that make it true that Suzy threw her rock at t_1— though now described with event language— are still causes of BREAKS and hence of BREAKING[19]. Since there is no overdetermination or early preemption here it is still true that:

~SUZY THROWING □→ ~BREAKING

Now notice that if Suzy's throw hadn't occurred, BREAKING would not have been true. What would be true is BREAKING LATER. So if SUZY THROWING were false, BILLY THROWING would not have caused BREAKING; it would have caused BREAKING LATER. In that situation, BILLY THROWING *would have been* a cause of an event of window breaking. But Suzy did throw and Billy's throw didn't cause *any* breaking. That the *event* that Billy *would have* caused is the very same event as the event that Suzy *actually caused* seems to us as irrelevant to the causal facts as is the fact that the *window* Billy would have broken is one and the same window as the one Suzy actually broke. [20]

CHAINS OF DEPENDENCY

Preemption is a problem for an event counterfactual analysis of causation because in such cases the effect does not counterfactually depend on the preempting cause. David Lewis' way of dealing with the problem was to say that in such cases there is always a chain of counterfactual dependence from the preempting cause to the effect but not so for the pre-empted cause. Accordingly, he defined causation as the ancestral of counterfactual dependence: cause and

[19] We ignore here the niggling complication that by exerting a minute gravitational tug on Suzy's rock, Billy's rock might delay Suzy's so that if Billy hadn't thrown the window would have broken after BREAKING but before BREAKING LATER. In that case Billy's throw and Suzy's would be joint causes of BREAKS and BREAKING.

[20] Though his version of fact causation is over-simple, we think Bennett (1988) provides an entirely correct account of the role of event talk in causal statements. In a nutshell: at least in causal contexts, event talk is a conveniently vague and context dependent way of talking about facts that are not about events. To say "the occurrence of e1 causes the occurrence of e2" is just to say that some (non-event) fact which grounds "e1 occurred" is a cause of some (non-event) fact which grounds "e2 occurred". On this view events are peripheral to the theory of causation and of marginal philosophical interest generally.

effect must be linked by chains of events where each link counterfactually depends on its predecessor even if the first does not depend on the last.[21]

Lewis gave up on this analysis when confronted by Jonathan Schaffer's "trumping" cases which seem to demonstrate that there can be causation without connecting chains of counterfactual dependence. Nevertheless, the idea that causation can only be propagated over time by chains of *some* sort of dependence remains central to the many successor theories of causation that try to define cause in terms of causal "processes", "connections" or "networks". Moreover, the idea that causes can operate *over* time only by operating *through* time seems part of common sense. The fall of the first domino causes the fall of the last only by causing the fall of every domino in between. What happens in the morning can't make a difference to the way the world is in the evening unless it makes a difference to the way the world is at mid-day.

Our analysis does not *define* causation in terms of chains of dependent facts or events across time, but it does *explain* them. They are a consequence of the way causation must work in a fully deterministic world.

As we have seen, determinism entails that there must be a nomologically necessary and sufficient condition at every time for every fact about any time. So, suppose that E_n is a fact about t_n and thus

(7) $$\boxed{L}\ (\ \mathcal{NS}(E,t_1).\equiv.\ \mathcal{NS}(E,t_2).\equiv .\mathcal{NS}(E,t_3)\ \ldots\ \equiv E_n))$$

If C_1 is a relevant part of a t_1 condition, S_1 for E_n, it must also be a relevant part of a sufficient condition for $\mathcal{NS}(\mathrm{E},t_2)$ since it must then be the case that:

(8) $$\Diamond_L (S_1\ \&.\ {\sim}C_1 \;\Box\!\!\rightarrow {\sim}\mathcal{NS}(t_2,E_n))$$

[21] Lewis 1973.

And if that is so, then C_1 must satisfy (8) for every for every intervening $\mathcal{NS}$ condition for E_n. In other words, in a deterministic world if a fact is relevant to some fact at some other time, it must be relevant to some fact about every intervening time. This is not to say that there must always be a chain of causes and effects across time, since, as we saw above, relevance alone is not sufficient for causation.[22] But it does mean that if some present fact makes a difference to what happens later it must make some difference to the world at every moment between now and then.

Note, though, that the existence of such chains of relevance is a consequence of *determinism*, it is not essential to causation itself. To see what causation looks like in a world which is not fully deterministic we need look no further than the case of Trumping.

TRUMPING

Jonathan Schaffer invented "Trumping Preemption" to refute counterfactual accounts of causation by demonstrating that neither counterfactual dependence nor chains of counterfactual dependence are necessary for causation. In this it is entirely successful. It is also an ideally simple test case for our account.

> Imagine that it is a law of magic that the first spell cast on a given day match the enchantment that midnight. Suppose that at noon Merlin casts a spell (the first that day) to turn the prince into a frog, that at 6:00 pm Morgana casts a spell (the only other that day) to turn the prince into a frog, and that at midnight the prince becomes a frog. Clearly, Merlin's spell (the first that day) is a cause of the prince's becoming a frog and Morgana's is not, because the laws say that the first spells are the consequential ones. Nevertheless, there is no counterfactual dependence of

[22] As we shall see below, the links in such chains may be forged by preventings and allowings that are not causes.

> the prince's becoming a frog on Merlin's spell, because Morgana's spell is a dependency-breaking backup.[23]

The world Schaffer describes is not fully deterministic. There is no indication that Merlin's spell makes any difference to subsequent states of the world until midnight. It is, magically, cause at a temporal distance. (To understand the story otherwise— to suppose that what Merlin casts is like an invisible stone that travels all day long till it hits the prince, deflecting Morgan's cast along the way— would turn it into a standard, boring case of early preemption.)

One might have thought that magical worlds are a poor venue to test our intuitions about causation especially when they are so thinly described. We might wonder what the other laws of magic are. What happens if the second spell is different from but consistent with the first? What happens when the first spells cast are contrary and simultaneous?

And yet none of this can be important. Schaffer's story is compelling. It is perfectly clear from the little he tells us that Merlin and not Morgana causes the Prince's enfrogging. It must be, then, that in these few lines Schaffer has told us everything we need to know to draw confident conclusions about what causes what. So what has he told us?

The facts in this story are:

> ENFROGS: The prince turns into a frog at midnight that day.
>
> MERLIN CASTS: Merlin casts Prince-to-Frog that day.
>
> MORGANA CASTS: Morgana casts Prince-to-Frog that day.
>
> MERLIN FIRST: Merlin's cast is the first that day.

And, crucially, he has told us that the laws of magic entail:

[23] Schaffer 2000, P. 165

$\Box_L$(A magician casts Prince-to-Frog & this is the first spell cast that day. ⊃ ENFROGS)

The laws of magic are so simple that we can say *exactly* what the minimally sufficient condition is for ENFROGS in Schaffer's story:

S_{MERLIN}: MERLIN CASTS & MERLIN FIRST

Since:

$\Box_L$ (S_{MERLIN} ⊃ ENFROGS)

And every conjunct of S_{MERLIN} is relevant to ENFROGS. There is a nomologically possible world (given the laws of magic) where:

S_{MERLIN} &. ~MERLIN CASTS $\Box\!\!\rightarrow$ ~ENFROGS

Namely, a world where Merlin's is the only spell cast that day and there is no other wizard who would cast if he did not. And there are worlds where:

S_{MERLIN} &. ~MERLIN FIRST $\Box\!\!\rightarrow$ ~ENFROGS

For example, worlds with a first cast of the day that would have turned the prince into something else.

The Prince's enfrogging doesn't counterfactually depend on Merlin's cast in Schaffer's story because there ENFROGS doesn't counterfactually depend on S_{MERLIN}. There, if Merlin hadn't cast his spell, Morgana's cast would have been first, and in that case a different condition, $S_{MORGANA}$, would have obtained:

$S_{MORGANA}$: MORGANA CASTS & MORGANA FIRST

$S_{MORGANA}$ is minimally sufficient for ENFROGS and would have been true if Merlin had not cast.

~MERLIN $\Box\!\!\rightarrow$ $S_{MORGANA}$

So, if Merlin had not cast, Morgana's spell would have caused ENFROGS. But he did cast. So S_{MORGANA} is false and her cast is not a cause.

NECESSARY CONDITIONS

Overdetermination, preemption, and trumping are cases where counterfactual dependence is not necessary for causation. There are also cases where counterfactual dependence is not sufficient.

On our account, cause and effect must be nomologically independent facts. If *C* is nomologically necessary for *E*, *C* is not a cause of *E* even though it will be nomologically necessary that $\sim C \boxrightarrow \sim E$.

We think this conforms to ordinary usage. The presence of oxygen was necessary for Notre Dame to burn. But no one— at least no one not in the grip of a philosophical theory— would say that the presence of oxygen caused that or any other fire. No one would ever have died had they not been born, but no one's death is *caused* by their being born.

Here we diverge from traditional law theorists who, seeing that causes must be in *some* sense necessary for their effects, have standardly assumed that nomologically necessary conditions must be treated as causes. While conceding that it sounds at least *odd* to speak of oxygen causing fires and births causing deaths they have been willing to bite the bullets.

Counterfactual theorists can avoid some of these embarrassments by insisting that causation is a relation between events and saying that a condition like "the presence of oxygen" is not an event-like thing. As for being born causing death, well, that was a bullet even Lewis was prepared to bite.[24]

[24] Cf. Lewis 1986a, pp. 184-185

Yet, even when restricted to events and with all the bullets bitten, the underlying difference between counterfactual and causal connections does not go away. It surfaces in the literature in the form of worries about the *transitivity* of causation.

TRANSITIVITY

Counterfactual dependence is not necessarily transitive: from A $\Box\!\!\rightarrow$ B and B $\Box\!\!\rightarrow C$ it does not always follow that A $\Box\!\!\rightarrow C$.[25] On the other hand, there is widespread agreement that "preserving transitivity seems to be a basic desideratum for an adequate analysis of causation".[26] If causation is the ancestral of counterfactual dependence, then chains of counterfactual dependence among events ought to carry causation with them. And yet the literature has produced a number of cases where transitivity seems to fail. This has led some to conclude, not that the counterfactual analysis of causation is wrong, but that causation is not transitive.

Here is a case from Ned Hall:

> A hiker is walking along a mountain trail when a boulder high above is dislodged and comes careering down the mountain slopes. At the last moment, the hiker sees it coming and ducks just in time so that it narrowly misses hitting him in the head. The hiker strides on unharmed and arrives at his destination at the scheduled time.
>
> The careering boulder causes the walker to duck and this, in turn, causes his continued stride. … However, the careering boulder is the sort of thing that would prevent the walker's continued stride and so it seems counterintuitive to say that it causes the stride.[27]

Here the facts seem to be:

> BOULDER: A boulder tumbles down the hill at t_1 .

[25] Lewis, 1973a
[26] Hall and Paul 2013, p.215.
[27] As reported in Menzies and Beebee, 2020.

DUCKS: The hiker ducks at t_2 .

ARRIVES: The hiker arrives at his destination at t_4.

If the hiker hadn't ducked, it seems it would be true that:

KILLED: The hiker is killed at t_3 .

There is a clear chain of counterfactual dependence from BOULDER to ARRIVES

~BOULDER $\Box\!\!\rightarrow$ ~DUCKS

~DUCKS $\Box\!\!\rightarrow$ ~ARRIVES

If counterfactual dependence, or a chain of dependencies, were always sufficient for causation, we would have to say that BOULDER was a cause of DUCKS and DUCKS of ARRIVES so that BOULDER was a cause of ARRIVES. But no one wants to say this.

Before we take up the case, we should make it clear that causation *is* transitive on our account, since it is not at all obvious why this must be so.

Suppose that *A*, *B,* and *C* are respectively facts about times t_1, t_2, and t_3 and that *A* causes *B* and *B* causes *C*. Determinism requires that there are sufficient conditions at every time for every fact about every other time. So there must be at t_2 some condition S_2 which is nomologically sufficient for *C*, and there must be at t_1 some condition S_1 which is sufficient for S_2 and hence for *C*. Given that *B* is a cause of *C*, it must be that *B* is a *necessary* part of such an S_2 sufficient condition for *C*: And we know that *A* must be a part of a condition, S_1 which is sufficient for that S_2 and hence for *C*. We know that because, trivially, *every* truth about t_1 is part of *some* sufficient condition for every truth about every fact about every time. So, whether or not *A* causes *C* is a matter of whether or not *A* is a *necessary* part of S_1 for *C*. And it must be. For suppose that *A* was not relevant to S_1 for *C* so that:

$\Box_L (S_1 \supset .\ \sim A \Diamond\!\!\rightarrow C)$

Given that S_1 is nomologically sufficient for S_2, it would follow that *A* was likewise irrelevant to S_2 for *C*.

(9) $\Box_L(S_2 \supset .\ \sim A \diamond\!\!\rightarrow C)$

But if that were so that would mean that *B* could not be a cause of *C* since *B* entails

$B \vee A$

And B v A is irrelevant to S_2 for *C* given that (9) entails[28]

$\Box_L(S2 \supset .\ \sim(B \vee A) \diamond\!\!\rightarrow C)$

By the same reasoning, if *A* were relevant to S_1 for C but entailed something, *P* that was irrelevant, then *B* would entail the irrelevant *B* v *P* and would not be a cause of *C*.

If the foregoing seems complicated, it is because the relation between causation and counterfactual dependence is complex. Thus, it is consistent with the transitivity just demonstrated that *A* might cause *B* and *C* even if there is *no* nomologically possible world where A,B and C are true and $\sim A \ \Box\!\!\rightarrow \sim B$ and $\sim B \ \Box\!\!\rightarrow \sim C$ were both true. Think of an *A* which can only cause *C* by way of causing a *B* and a *B'* which overdetermine *C*. Or an *A* which can only cause *C* by causing a *B* which is a pre-empting cause of *C*. On our account, such an *A* would be a cause of *C* nevertheless.

So, if causation is transitive, what is going on in the hiker story? It is clear, in the story, that BOULDER is not a necessary part of any sufficient condition for ARRIVES. There are no worlds remotely close to this one where the hiker's arrival depends on BOULDER. Indeed, in at least some of the closest worlds, ~ARRIVES is true *because* BOULDER and ~DUCK. Something other than the boulder *might* have prevented the hiker from arriving but the worlds

[28] The inferential principle at work here is $\Box_L$ (P $\diamond\!\!\rightarrow$ Q) $\vDash$ $\Box_L$ ((P & R) $\diamond\!\!\rightarrow$ Q). Antecedent strengthening, though not valid for counterfactuals generally, is valid for nomologically necessary counterfactuals.

where those other things happen would not be made more like the actual world by taking the boulder out of the picture.

In our terms, this means that BOULDER is not relevant to ARRIVES, since:

$$\Box_{L}\ (\boldsymbol{S}_{\text{ARRIVES}} \supset .\ \sim\text{BOULDER} \ \Box\!\!\rightarrow \text{ARRIVES})$$

where $\boldsymbol{S}_{\text{ARRIVES}}$ names any conjunction of facts nomologically sufficient for the hiker's arrival.

So, BOULDER is not a cause of ARRIVES. On the other hand, it is clear from the story that it is seeing the boulder that causes the hiker to duck. BOULDER causes DUCKS. The issue of transitivity thus turns on the question of whether DUCKS causes ARRIVES.

On our account it does not. It is true that ARRIVES counterfactually depends on DUCKS. If the hiker hadn't ducked, he would not have arrived. But DUCKS is only *partly* relevant to $\boldsymbol{S}_{\text{ARRIVES}}$. It is relevant only because of BOULDER and BOULDER is irrelevant. This becomes clear when we notice that DUCKS entails:

(10) BOULDER v DUCKS

which is irrelevant to ARRIVES since the hiker does not have to duck at a world where there is no boulder:

$$\Box_{L}\ \boldsymbol{S}_{\text{ARRIVES}} \ \&\ \sim(\text{BOULDER v DUCKS}) \ \Box\!\!\rightarrow \text{ARRIVES}$$

In the circumstances of the story, what is necessary for the hiker to arrive is that he duck *if* there is a boulder. That is:

(11) BOULDER ⊃ DUCKS

This fact is a necessary part of what gets the hiker to his destination because:

$$\Diamond\!\!\!\!-\ (\boldsymbol{S}_{\text{ARRIVES}} \ \&.\ \sim(\text{BOULDER} \supset \text{DUCKS}) \ \Box\!\!\rightarrow \sim\text{ARRIVES})$$

So (11) is a cause of ARRIVES but (11) does not entail either BOULDER or DUCKS and neither is a cause of ARRIVES.

Why then does arriving counterfactually depend on ducking? The commonsense answer is that the hiker *has* to duck because BOULDER is true and if he doesn't duck, he will be killed. And not being killed is a *nomologically necessary* condition for the hiker to arrive.

(12) $\boxed{L}$ (KILLED ⊃ ~ARRIVES)

Given that BOULDER is true, (11) counterfactually depends on DUCKS. So, as a matter of fact:

~DUCKS $\Box\!\!\rightarrow$ KILLED

And given (12) it follows[29] that:

~DUCKS $\Box\!\!\rightarrow$ ~ARRIVES

The hiker's arrival counterfactually depends on his ducking only because ~KILLED depends on it. But ~KILLED— though surely part of any minimally sufficient condition for ARRIVES— does not count as a cause of ARRIVES because it is nomologically necessary for it.

PREVENTING AND ALLOWING

If DUCKS and ~KILLED are not causes of ARRIVES how should we describe their roles? We say that DUCKS *prevents* KILLED and ~KILLED *allows ARRIVES*. Preventing and allowing encompass precisely those cases where counterfactual dependence is not causation.

C prevents E $=_{df}$ i) *C* & ~*E* ; and
ii) ~*C* $\Box\!\!\rightarrow$ *E*; and
iii) *C* is not a cause of ~*E*.

C allows/enables E $=_{df}$ *i) C* & *E*; and
ii) ~*C* $\Box\!\!\rightarrow$ ~*E*; and
iii) *C* is not a cause of *E*

[29] The inferential principle at work here is *P* $\Box\!\!\rightarrow$ *Q*, $\boxed{L}$ (*Q* ⊃ *R*) ⊨ *P* $\Box\!\!\rightarrow$ *R*

Getting killed would have prevented the hiker from arriving but ~KILLED is not a cause of ARRIVES because it is nomologically necessary for ARRIVES. Not being killed *allows* the hiker to arrive at his destination.

DUCKS prevents KILLED because the hiker would have been killed if he hadn't ducked. But DUCKS doesn't cause ~KILLED for the same reason that DUCKS doesn't cause ARRIVES. DUCKS is relevant to ~KILLED only because of BOULDER. Ducking *prevents* the hiker from being killed; it *allows* him to live and hence it *allows* him to arrive.

We think this *exactly* captures the way people use "allowing" and "preventing" in daily speech.[30] And it captures the way philosophers of causation use it too. Thus, Hall and Paul call the hiker story a case of "double prevention": that is, a case where "*C* prevents something from happening which, had it happened, would have prevented *E*"[31]. And sure enough, when we look at the story we can see that not only does DUCKS prevent KILLED, KILLED would have prevented ARRIVES.

We can see why double prevention cases are an embarrassment for counterfactual theories of causation. Since causation and counterfactual dependence so often go together it is easy to treat them as one and the same. But prevention gives rise to counterfactual dependence without causation and because mere counterfactual dependence, unlike causation, is *not* transitive the difference shows up in chains of counterfactual dependence where some of the links are preventings and not causings.

We see this going on in other "double prevention" stories in the literature that are offered as counterexamples to causal transitivity. Here is a case from Hartry Field:[32]

[30] Though we sometimes also use "makes possible" or "enables" as synonyms for "allows".
[31] Paul & Hall 2013,p.28
[32] As recounted in Yablo 2004.

> Billy puts a bomb under Suzy's chair. Later, Suzy notices the bomb and flees the room; later still, Suzy has a medical checkup (it was already arranged) and receives from her doctor a glowing report.

Suzy wouldn't have got the good report if she hadn't fled the room; she wouldn't have fled the room if she hadn't noticed the bomb; she would not have seen the bomb if Billy hadn't planted it. But no one wants to say that Billy's planting the bomb caused the glowing report.

Nor should they. Billy's planting the bomb was a cause of Suzy's fleeing the room, but Suzy's fleeing did not cause her good report. Her fleeing *prevented* her getting killed and her not being killed *allowed* her to go on to get a good medical checkup.

DOING AND ALLOWING

The distinction between causing and allowing is central to many debates in ethics where some contend that it is as wrong to allow harm to come to others as it is to cause them harm. Whether or not this is morally correct is not our current concern. However, this claim is often argued for on the grounds that there is no intelligible difference between causing an outcome and allowing it. That is not so.

Three simple cases:

> CASE 1: A train is roaring down the mainline track. A child stands on a siding waiting to watch the train pass safely by. Which it would do, except that Tom throws a switch which diverts the train down the siding. The child is killed.
>
> CASE 2: A train is roaring down the mainline track. A child has wandered onto the track ahead and would certainly be killed but Dick throws a switch which diverts the train down a siding. The child does not die.

> CASE 3: A train is roaring down the mainline track. A child has wandered onto the track ahead. Harry could throw a switch which would divert the train down a siding. He doesn't throw it. The child dies.

In case 1, on anyone's account, including ours, Tom causes the child's death.

In case 2, the child would have died if Dick had not thrown the switch. Should we say then that Dick caused the child not to die? No. For the same reason that DUCKS doesn't cause the hiker not to die. The switch's being thrown is only relevant to the child's survival because of the train, just as ducking was relevant to the hiker's arrival only because of the boulder. By throwing the switch Dick prevents the child's death. By causing the train to go down the siding he allows the child to live.

But now what of case 3? If Harry had thrown the switch the child would have lived. But did Harry cause the child's death by not throwing the switch? In case 3 there are obviously conditions which are nomologically sufficient for the child's death. The child does die after all. And in case 3 there are conditions in place which would have nomologically sufficed for the child's survival if Harry had thrown the switch. But the conjunction of the latter facts with the fact that Harry *doesn't* throw do not add up to a *minimally* sufficient condition for the fact that the child dies. To see this note that for Harry's throwing the switch to have saved the child, the switch would have to have been in working order. It is only because the switch is in working order, that Harry's throwing it would have caused the train to go down the siding. But, given that in Case 3 no one throws the switch, the fact that it was in working order is irrelevant to the *actual* conditions which suffice for the child's death. The child would have died even if the switch were broken, or even if there were no switch, or for that matter, even if there were no Harry. The child's death counterfactually depends on the fact that Harry does not throw the switch. But the fact that he does not throw the switch is not part of a *minimally* sufficient

condition for the child's death and so is not a cause of the death. Harry allowed the child to die, but he did not kill the child.

BITE AND SWITCH

Not every putative counterexample to transitivity turns on conflating allowing and causing. Michael McDermott gives us this story:

> My dog bites off my right forefinger. Next day I have occasion to detonate a bomb. I do it the only way I can, by pressing the button with my left forefinger; if the dog-bite had not occurred, I would have pressed the button with my right forefinger. The bomb duly explodes. It seems clear that my pressing the button with my left forefinger was caused by the dog-bite, and that it caused the explosion; yet the dog-bite was not a cause of the explosion.[33]

Laurie Paul tells a similar tale about a skiing accident.

> While skiing, Suzy falls and breaks her right wrist. The next day, she writes a philosophy paper. Her right wrist is broken, so she writes her paper using her left hand…. She writes the paper, sends it off to a journal, and it is subsequently published. Is Suzy's accident a cause of the publication?[34]

Schaffer gives an incendiary example.

> Tom puts potassium salt in the fireplace …, Dick then tosses a match in the fireplace, which results in a purple fire blazing in the fireplace …, which then spreads and immolates Harry … but Tom's putting potassium salt in the fireplace does not cause Harry's immolation[35]

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[33] McDermott 1995, p.531.
[34] Paul 2000, p.235.
[35] Schaffer 2016.

In the literature such cases are said to confront us with a dilemma: either we must accept them as showing that causation is not transitive, or we must live with an implausibly fine-grained parsing of events. To preserve transitivity, we will have to say that in McDermott's story there are two left-handed button pushings— one essentially a button pushing but only accidentally left handed, the other essentially left-handed, but only accidentally a button pushing— and that it is the former that causes the explosion while only the latter is caused by the dog. In Paul's case, we will need to say that there are two writing events and that the paper writing that the accident causes is not the one that gets the paper published. In Schaffer's, we will have to distinguish "..the fire becoming purple at region *r*, from … the fire blazing at *r''*.[36]

We avoid the dilemma by understanding that causes are facts, not events. In McDermott's case the facts are:

BITES: The dog bites off the bomber's right forefinger at t_1.

LEFT-PUSH: The button is pushed with his left forefinger at t_2

EXPLODE: The bomb explodes at t_3.

It is also a crucial part of McDermott's story that we are to understand that had the dog not bitten him and:

RIGHT-PUSH: The button is pushed with his right forefinger at t_2

then the explosion would still have happened. This is vital to the story because if it were not so— if this were a specially gimmicked bomb that, unknown to the bomber, would *only* go off if pushed with a left forefinger— then everyone would agree that BITES *was* a cause of EXPLODE and the case wouldn't be an argument for intransitivity.

[36] Schaffer 2016.

We should agree then that at time t_2 there is a conjunction of facts, S_{BOMB}, which would have nomologically guaranteed an explosion if either RIGHT-PUSH or LEFT-PUSH had happened at t_2. So, we agree:

(13) $\Box_L$ (S_{BOMB} & (RIGHT-PUSH & ~LEFT-PUSH) $\Box\!\!\rightarrow$ EXPLODE

Notice that we can agree that (13) is true while still acknowledging that in McDermott's story it is false that:

~LEFT-PUSH $\Box\!\!\rightarrow$ RIGHT-PUSH

If the bomber hadn't pushed with his left forefinger he certainly would not have pushed with his right because the dog had bitten it off. That is why EXPLODE counterfactually depends on LEFT-PUSH:

~LEFT-PUSH $\Box\!\!\rightarrow$ ~EXPLODE

But counterfactual dependence is not causation. LEFT-PUSH isn't a cause because it entails a fact which is irrelevant to S_{BOMB} for EXPLODES *viz*.

(14) LEFT-PUSH v ~RIGHT-PUSH

(14) is irrelevant because, as (13) tells us, the bomb would explode whether (14) was true or false. Because LEFT-PUSH entails something irrelevant, it is only *partly* relevant to EXPLODE. Its relevant part is:

PUSH: The button is pushed at t_2

It is PUSH that causes the explosion and, as McDermott tells the story, PUSH would have happened whether or not the dog had bit; that is, BITE is irrelevant to PUSH. BITE *prevented* the Bomber from RIGHT-PUSH but LEFT-PUSH *allowed* him to detonate the bomb.

Paul's story embeds the same kind of irrelevance. Given the accident, it is true that Suzy would not have written the paper and so it would not have been published had she not written it

with her left hand. Even so, the fact that she wrote the paper with her left hand is not a fact which causes its publication. It does *entail* a fact which *is* a cause: *viz*. that she wrote the paper. That fact would have obtained even if there had been no accident. The accident prevented Suzy from writing the paper with her right hand but writing it with her left allowed her to get it published.

Schaffer's case embeds the same lacuna even less well concealed. Common sense tells us that the fact that the fire was purple was irrelevant to Harry's immolation, and common sense is right.

This leaves us with one other genre of supposed intransitivity cases which, though they are usually treated as of a piece with the foregoing, are fundamentally different.

> A train is approaching a switch. If the switch is to the left, the train will go down the left-hand track. If it is to the right, it will go down a right-hand track. But the tracks meet up farther down the line so the train will arrive at its destination in either case. Does the switch's being to the left cause the train's arrival?[37]

In this case the facts are:

> SWITCH-LEFT: The switch is set to the left at t_1.
>
> LEFT-TRACK: The train is on the left-hand track at t_2.
>
> ARRIVES: The train arrives at t_3.

At t_1 there is a conjunction of facts, S_{LEFT}, nomologically sufficient for ARRIVES. SWITCH-LEFT is a necessary part of S_{LEFT} for ARRIVES because there are nomologically possible worlds where S_{LEFT} is true and ARRIVES counterfactually depends on SWITCH-LEFT and on every nomologically-independent fact entailed by SWITCH-LEFT:

$$\Diamond_{\text{L}}(S_{\text{LEFT}} \,\&\, \sim\text{SWITCH-LEFT} \;\Box\!\!\rightarrow\; \sim\text{ARRIVES})$$

[37] Cf. Paul and Hall, 2000, p 232ff. Schaffer (2004) calls such cases "nudges".

These are worlds where the right-hand track doesn't exist or is washed out.

Accordingly, we say that SWITCH-LEFT is a cause of ARRIVES, notwithstanding the fact that, at the actual world, it is false that

$$\sim\text{SWITCH-LEFT} \;\Box\!\!\rightarrow\; \sim\text{ARRIVES}$$

This is false because we understand that:

$$\sim\text{SWITCH-LEFT} \;\Box\!\!\rightarrow\; \text{SWITCH-RIGHT}$$

And there is another condition, S_{RIGHT}, which, if it obtained, would be sufficient for ARRIVES. SWITCH-RIGHT would be a necessary part of S_{RIGHT} and so SWITCH-RIGHT would be a cause of ARRIVES if ~SWITCH-LEFT since, given the setup:

$$\sim\text{SWITCH-LEFT} \;\Box\!\!\rightarrow\; S_{\text{RIGHT}}$$

But SWITCH-LEFT *is* true and a cause of ARRIVES. It is a preempting cause; the cause it preempts is SWITCH-RIGHT.

That such cases are not generally regarded as simple pre-emption is likely due to the befuddling powers of "event" talk. Is the switch being to the left really an event? And what about its not-being-to-the-left? Are either really things that *occur?* Again, so much the worse for thinking of events as the causal *relata*.

UNCAUSED FACTS

We said that ducking allows— but does not cause— the hiker not to be killed. So, if DUCKS doesn't cause ~KILLED, what does? Our answer is: nothing causes it. Not every fact has a cause.

Nomological determinism means that there must be at every moment a nomologically sufficient condition for everything that happens at every other moment. But causes must be nomologically independent of their effects, so a nomologically sufficient condition is not itself a

cause. For a fact *C* to cause another fact *E*, *C* must be part of a nomologically sufficient condition *S* for *E*. But it must be *only* a part; that is, it must be entailed by, but not entail, *S*.

Nomological independence also means that a cause cannot be nomologically necessary for its effect. Even if *C* is a necessary part of an *S* sufficient for *E*, it will not be a cause if it is a part of *every* nomologically possible sufficient condition for *E*. Neither can a cause be a part of a nomologically necessary condition for *E* since every part of a necessary condition for *E* is itself necessary for *E*.

To see how all this plays out in an artificially simple case, think back to Schaffer's Trumping world. The laws of magic say that it is sufficient for the prince to turn into a frog that the first spell of the day be Prince-to-Frog. In Schaffer's story the determinant of ENFROGS was:

> S_{MERLIN}: Merlin casts Prince-to-Frog and his is the first spell of the day.

This is sufficient for ENFROGS but not necessary. It would also be sufficient if:

> S_{MORGANA}: Morgana casts Prince-to-Frog and hers is the first spell of the day.

There are thus many nomologically independent conditions each of which would be nomologically sufficient and none of which are nomologically necessary for ENFROGS— at least as many as the number of nomologically possible magicians.

But now what about ~ENFROGS? The same law of magic says that ~ENFROGS will come about only if *no one* casts Prince-to-Frog as the first spell of the day. That is, if and only if Merlin doesn't cast it first *and* Morgana doesn't and so on. ~ENFROGS will be true only if *every* magician so refrains. That means that the only nomologically sufficient condition for ~ENFROGS is also nomologically necessary for it. And since every part of a nomologically necessary condition is also necessary this means that ~ENFROGS cannot be caused though ENFROGS can be prevented.

As it is with enfrogging, so it is with life and death. If the hiker hadn't ducked that careering boulder he would have been killed at t_3. But in the realm of nomological possibilities there are lots of other things that could have killed him at that time. Some other un-duckable boulder might have fallen, or he might have been buried in a landslide, struck by lightning, shot by a careless hunter, suffered a heart attack or aneurism… There are, alas, countless ways to die. Each and every one of these would be— assuming the relevant ancillary detail— nomologically sufficient for KILLED. So $\mathcal{NS}(t_1,\text{KILLED})$ must comprise a long disjunction, each disjunct of which describes a condition nomologically sufficient for the hiker to be killed at t_3. The corollary is that $\mathcal{NS}(t_1,\sim\text{KILLED})$ must comprise an equally long *conjunction*, each conjunct of which describes facts that must *not* obtain if the hiker is to live. It must be that he is not struck by a boulder *and* not struck by lightning *and* not suffer a heart attack and so on. At any nomologically possible world, the hunter survives t_3 if and only if *none* of these things happen. The only condition nomologically sufficient for ~KILLED is also nomologically necessary. And there must be such a vast, conjunctive, necessary and sufficient condition for not-being-killed for every moment in the life of the hiker (and of everyone else). This condition is minimally sufficient for ~KILLED: it is nomologically sufficient and if any of its entailments were false— if there was a lightning strike or a heart attack…— KILLED would be true. But because it is also a *necessary* condition each of its entailments is also a necessary condition for ~KILLED and hence not a cause.

Many things can cause death. We can do things to *prevent* death and if we are lucky, circumstances will *allow* us to live. But nothing *causes* anyone not to die.

Note too, that nothing in the forgoing shows that a fact which is not caused cannot itself be a cause. The fact that the hiker does not die at t_3 is not caused but it might nevertheless cause consternation on the part of the would-be assassin who pushed that boulder.

In the case of KILLED and ENFROGS we have facts *E* such that *E* can be caused but ~*E* cannot. Is it always so? That is, is it always the case that if *E* can be caused then ~*E* cannot? No. It depends on the structure of the natural laws at work.

Suppose that *A*, *B*, C and E are nomologically independent propositions but are connected by laws which entail:

(15) $\Box_L (C \,\&\, B) \vee A \equiv E)$

A cannot cause *E* since it is nomologically sufficient for *E*. The conjunction, *C* & *B* cannot cause *E* because it is nomologically sufficient for *E*. But each of *C* and *B* can be causes of *E* because each is a proper part of a nomologically sufficient but not necessary condition for *E*. Things are different for ~*E* since (15) entails that the only proposition nomologically sufficient for ~*E* is:

(16) ~(*C*&B) & ~A

But (16) is also nomologically necessary for ~*E* as is every proposition it entails so none are causes. This is a case, like KILLED or ENFROGS, where *E* can be prevented but ~*E* cannot be caused.

But now suppose the laws connect these propositions in a different way:

(17) $\Box_L((A \,\&\, B) \vee (C \,\&\, \sim B) \equiv E)$

Now both *E* and ~*E* can be caused since, for example,

A & *B*

is sufficient but not necessary for *E* and

~*C* & ~*B*

is sufficient but not necessary for ~*E*. Thus, *B* could be a cause of *E* if *A* were true and ~*B* can cause ~*E* if ~*C*. There are abundant real-life examples. The light may be on because the switch is closed. The light may be off because the switch is not closed. Depending on the circumstances both the light's being on or off can be caused. The salient difference here between (15) and (17) is that in the latter the sufficient conditions for *E* are not nomologically independent of one another.

Whether or not a fact can be caused depends wholly on how it is nomologically connected to other facts. Thus, different laws or disagreements about what the laws are can lead to differences and disagreements— not just about what causes what— but about what *can* be caused.

For example: when Suzy's rock leaves her hand, it does not immediately halt in its forward motion and fall to the ground. It keeps moving forward towards its target. Why doesn't it stop? Aristotle's explanation was that the rock is constantly pushed along by vortices in the air it displaces. Medieval physics held that Suzy's throw implants in the rock a quantity of "impetus" which, until it dissipates, keeps pushing it along. Both theories assumed that nature required motion to cease unless constantly caused. Newton's theory supplanted both, not by identifying a different cause, but by saying that for the rock to keep going forward it was sufficient that it encounter no opposing force. Sufficient *and* necessary and, because necessary, not a cause. What Newton showed us is that the continued motion of the rock does not *need* a cause.

This distinction between facts that can and cannot be caused is part of our commonsense understanding of the world. It surfaces there as the distinction between what we call "events" and what we do not. If the hiker had not ducked and KILLED had been true, everyone would say that an event had been caused: the death of the hiker. But given that he did duck and ~KILLED is true, no one is tempted to say that a different event— the-not-dieing-of-the-hiker— was caused

by his ducking. What we say is that a death event was prevented from occurring. If all the magicians refrained from casting spells an enfrogging event would have been prevented. But we do not say that in that case they would have collectively caused the prince to remain human or that their inaction caused a not-turning-into-frog event. The doctrine of "causal determinism"–the thesis that "every event has a cause"–is plausible only because we don't describe upshots that have no causes as "events".

CAUSE AND TIME

Some facts cannot have causes at any time because every sufficient condition for them is nomologically necessary and so each of their entailments is likewise necessary. But is it possible that a fact might have causes at some times but not others?

In our original story, SUZY-THROWS was a part of a t_1 minimally sufficient condition — ***S***suzy— for BREAKS. Can we find the same relation in the opposite temporal direction? Are there any t_3 causes of Suzy's t_1 throw? Given determinism, there must be some conjunction of facts about t_3 which are nomologically sufficient for SUZY-THROWS. Of course, ***NS***(SUZY-THROWS,t_3) must be sufficient but, because it is also nomologically necessary, its parts will not be causes. Are there any t_3 facts which are *just* sufficient for SUZY-THROWS?

There will certainly be lots of facts about t_3 that are *evidence* that Suzy threw the rock at t1. There is the fact that the window breaks, of course. But there will also be the fact that some of her DNA is on the rock, facts about the memories of those who witnessed the throw, the displaced air, perhaps surveillance camera footage. All these count as evidence because they would not obtain if Suzy hadn't thrown. That is so because all these t_3 facts are causal upshots of SUZY-THROWS and, given that there was no pre-emption or overdetermination in the case, each of them counterfactually depends on that t_1 fact.

If we conjoined all the facts that Suzy's throw caused and added in all the t_3 facts which merely counterfactually depend on it, we would certainly have enough evidence to get Suzy convicted in a court of law. And yet the result would still be far from *nomologically* sufficient for SUZY-THROWS. It is, after all, nomologically possible that the DNA was deposited at another time, or that Suzy has a twin. And it is nomologically possible that memories of witnesses are faulty and that the surveillance records were doctored... To eliminate these possibilities— to describe a condition that would make it nomologically *impossible* that Suzy did not throw the rock— we would have to include t_3 facts sufficient to guarantee that Suzy has no twin, that the DNA was deposited at t1, that the memories were accurate, that the camera's records were unaltered…

But now notice that even when we have added enough t_3 facts to make up a condition nomologically sufficient for SUZY-THROWS, the result will not be a *minimally* sufficient condition since none of these t_3 facts are *relevant* to the t1 fact.

It is not true that:

$$\sim\text{BREAKS} \mathrel{\Box\!\!\rightarrow} \sim\text{SUZY-THROWS}$$

If the window hadn't broken it *might* have been because Suzy didn't throw but it also *might* have been because she aimed too high, or low, or didn't throw hard enough… Then too there are many things that might have *prevented* the window's breaking even if Suzy had thrown. Billy might have caught her rock. Or a sudden gust of wind might have deflected it on its course. The same is true of every other piece of t_3 evidence— that is, of every t_3 fact that Suzy's throw caused. The DNA Suzy left on the rock would not be there if she hadn't thrown, but she *might* have thrown it without leaving a trace. If her throw weren't recorded on the surveillance camera,

that *might* have been because she didn't throw, or it might just have been that the camera was broken. The absence of evidence is not evidence of absence.

It isn't true that:

$$\sim\text{BREAKS} \ \Box\!\!\rightarrow \sim\text{SUZY-THROWS}$$

It is only true that:

$$\sim\text{BREAKS} \ \Diamond\!\!\rightarrow \sim\text{SUZY-THROWS}$$

This is because the window's breaking at t_3 counterfactually depends on many other t1 facts besides SUZY-THROWS, some of them causes, some of them enabling conditions[38], some of them nomologically necessary conditions. If any of these had failed to obtain, then the window might be unbroken even though SUZY-THROWS was true. Moreover, the same will be true *vis a vis every* cause and every effect. If *C* is, all by itself, nomologically sufficient for *E* then *C* is not nomologically independent of *E* and hence not a cause. If *C* is sufficient for *E* but only in conjunction with some other nomologically independent fact *F*, then, if ~*E* it *might* be the case that ~*C*. But it would not have to be; it might be the case that ~*F*.

There is one t_3 fact on which SUZY-THROWS does counterfactually depend, *viz*. $\mathcal{NS}$(SUZY-THROWS,t_3)— that vast disjunction describing the t_3 state of all and only those nomologically possible worlds where SUZY-THROWS is true. That must be so since.

$$\Box_{L}(\sim\mathcal{NS}(\text{SUZY-THROWS},t_3) \ \Box\!\!\rightarrow \sim \text{SUZY-THROWS})$$

[38]. "enabling condition" = the falsehood of facts that would prevent.

$\mathcal{NS}$(SUZY-THROWS,t_3) is a determinant— a minimally sufficient condition for — the past fact SUZY-THROWS, but because it is also a *necessary* condition anything it entails will be likewise necessary and hence not a cause. [39]

SUZY-THROWS has no causes at t_3. And since there is nothing special about Suzy's case, the result generalizes. Given the structure of the natural laws that govern our world, no present fact has future causes. There is no temporally backward causation.

Note the qualification: "given our laws". This is not an *a priori* argument against backward causation. We are not ruling out the possibility of time travel "by definition", only explaining how, in a world in which determinism operates in two temporal directions, it is possible for causation to operate only in one.

What causes what depends on what the laws of nature are and the direction of causation is dictated by the logical structure of those laws. Any law that describes some state of the world *E* as a function of two or more independent facts, {C_1 , C_2 …}— so that *E* is nomologically necessary but not sufficient for C_1 & C_2 …— necessarily describes an asymmetric counterfactual relation between *E* and {C_1 , C_2 …}. For in that case it must be that there are at least some nomologically possible worlds where $\sim C_1 \Box\!\!\rightarrow \sim E$ but there need not be any world where $\sim E \Box\!\!\rightarrow \sim C_1$.

Not every law of nature takes this asymmetric form, but the *dynamic* laws– the laws that describe causal interactions— all do. That is, they describe the variation in some quantity (*e*.g. velocity) as a function of two or more independent quantities (*e*.g. mass, force, initial velocity). The functions are logically irreversible in the sense that one cannot infer their arguments from

[39] This contradicts Lewis's 1979 claim that the future *overdetermines* the past, suggesting that he had in mind some different understanding of "minimally sufficient" than ours. Whatever that might have been, there are independent reasons for thinking that Lewis was wrong about this. Cf. Tomkow & Vihvelin 2017, Vihvelin 2017.

their values. This logical asymmetry directly entails counterfactual asymmetries. Thus, if the mass or the initial velocity or the force applied to some object over an interval t_1- t_3 had been different, then its velocity at t_3 would have to have been different than it was. The laws of motion require it. But if the velocity of the object had been different at t_3 than it actually was, it would not have to have had a different initial velocity, or a different mass, or been subject to different forces along the way. Changing any one of these facts about the past has determinate upshots in the future but changing the future fact has only indeterminate implications for the past.[40]

Our definition of causation is consistent with the *logical possibility* of temporally backward causation. And it might turn out to be nomologically possible after all: Gödel is said to have shown that General Relativity makes it physically possible that a rock thrown now might— by traveling through contorted twists in space-time— break a window in the past. That would count as causation on our account. Whether or not this is a real possibility is an empirical matter.

Our argument may prompt another question: Even if the direction of causation— what is cause and what is effect— is dependent on the form of the laws of nature, why is it that at our world causation always operates in one temporal direction? Why do the laws make it so that causes always precede their effects and not *vice versa*?

This worry seems to us misguided. It asks how to explain why the direction of causation happens to coincide with the direction of time. We think there is no coincidence. We think the direction of time just is the direction of causation.

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[40] For more discussion of this point cf. Tomkow 2018.

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