6. FIXED PAST, UNFIXED FUTURE

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1. Introduction

By 'Fixed past, unfixed future' I mean that alternative futures are really possible in a serious sense in which alternative pasts are not. This proposition is of course a commonplace. It is not seriously contested and needs no argument from me. My problem is not to defend it, but to make sense of it on my tenseless view of time (Real Time, 1981). This is a problem because I deny the non-relational difference between past and future on which this difference in 'fixity' (Mackie 1974, p.180) appears to depend; and the relational difference I do admit, between being earlier than some time and being later than it, hardly suffices. On Newton's deterministic theory of gravitation, for instance, a planet's position at a time is just as much fixed, i.e., determined, by its later positions as by its earlier ones: there is no asymmetry here between earlier and later to make tenseless sense of the past being fixed and the future not.

Maybe the proposition demands some indeterminism, as Mackie maintains in his tensed account of the matter (1974, p.191). But on a tenseless view of time indeterminism does not seem to help. For if, on a merely statistical theory, a planet's position at a time were only more or less probable given earlier positions, so would it be only more or less probable given later ones. Probability seems not to discriminate between earlier and later in the way we require.

In fact a kind of probability, which I call chance, or rather something closely related to it, can be given the right temporal direction. My objective here is to show how (though I shall not incidentally thereby commit myself to indeterminism, since my account would work as well with chances all 1 or 0). My excuse for pursuing this objective in this volume is that,

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though the objective is not his, my pursuit of it relies extensively on Dummett's remarkable paper "Bringing About the Past" (1964).

2. Chance

In what follows I shall draw on my account of chance in The Matter of Chance (1971), modified (in "Chance and Degrees of Belief", 1982) to make (e.g.) a fair coin toss's 50 per cent chance of landing tails compatible with its landing tails being determined by a more detailed description of it. The account is a so-called 'propensity theory' of probability, a type of theory that should be familiar enough by now (see e.g. Tuomela 1978, Pt.III) not to need detailed exposition or defence; except to say that I use the term 'propensity' not for chance itself but for a related concept to be introduced shortly.

I should however say at least that I take chance to be a species of objective probability. That is, it satisfies the standard probability calculus and measures more than the strength of people's beliefs. But I take it not to be definable as long run relative frequency, nor yet as epistemic (i.e. inductive) probability, closely related to it though both of these are: a 50 per cent chance of tails on future coin tosses virtually entails that in a sufficiently long run close to 50 per cent of them would land tails; while to know that any one toss has this chance is ipso facto to have a 50 per cent epistemic probability for the hypothesis that it will land tails. All chances in fact are also epistemic probabilities (Lewis 1980); but not vice versa, and when from now on I refer to epistemic probabilities, I shall mean ones that are not also chances.

Prima facie, chances measure the real possibilities the future has and the past lacks. The possibilities obviously vary in extent (a tossed coin has a greater possibility of landing heads than of landing on its edge), and I take it for granted that the extent has a probability measure. So there is a greater or less, but anyway non-zero, chance that a present toss of a coin will land heads or on its edge, even if as a matter of future fact the coin lands tails; but once a coin has landed tails, the chance of it landing heads or on its edge on that past occasion is now zero. No alternative to the actual past is now a real possibility.

Note that on any view of time chance must be more than epistemic

probability for this to be so. We don't know all about the past, and what we do know may make various alternative hypotheses about it more or less epistemically probable. If I don't know that a coin has landed tails, there may be some epistemic probability of its having landed heads, even though it now has no chance of having done so. The difference between the two might be put by saying that whereas chances can make us ignorant (by limiting our knowledge), epistemic probabilities never cause ignorance, they merely measure it. I may fail to know that a coin will land tails, even though it will, because that outcome now has only a 50 per cent chance. But a 50 per cent epistemic probability of a coin having landed tails doesn't prevent my knowing how it landed; it merely reflects the fact that I don't.

How can a tenseless view of time confine chances other than 1 and 0 to the future? That is my ultimate problem; but not the one I mean to tackle here. Here I tackle the slightly different and preliminary problem: why are only future alternatives feasible? That is, why is it sometimes sensible to try and realise alternative futures, but never alternative pasts? This fact demands, not more future chances than past ones, but that only future chances depend on present actions. The chances of alternative pasts are not only all zero, they would be no greater than zero whatever we now did. Whereas some future alternatives would have greater chances if we now took some action than if we didn't, and that makes sense of acting now to try and realise them.

But on any view of time the present is later than the past and earlier than the future. So the fact I have to explain follows from the tenseless fact that it sometimes makes sense to act to try and realise alternatives to events later than the action, but never to earlier events. That is what, with Dummett's help, I mean to show, by giving a tenseless but temporal direction to what I call propensities. But first I had better say what propensities are.

3. Propensities

Propensities are statistical dispositions like the bias of a coin. A coin is biased if, were it to be fairly tossed, the chances of it landing heads and tails would differ. A coin's bias is thus defined by what would be the

case in specified circumstances, which makes it a disposition like solubility. But seemingly unlike solubility, it depends not on what would happen then but on what the chance would then be of some specified happening. But this distinction is illusory. Soluble objects don't just happen to dissolve when put in water. They are certain to: the chance of their dissolving then is 1. Dispositions like solubility are really just extreme cases of propensities where the chances involved are 1 or 0.

Propensities of course are not chances, any more than being soluble is the same as dissolving. Unfortunately many who share my view of chance now call it propensity, partly because some mistake chance to be a disposition (to yield long run frequencies) and partly because Popper (1959) called this kind of theory of chance a propensity theory. But Popper arguably meant the disposition rather than chance itself (he doesn't distinguish them); and whatever he meant, the disposition would not be chance even if chance were also a disposition. So the disposition needs another name; so, faute de mieux, I shall go on calling it propensity (Mellor 1971, Ch.4).

Whatever it's called, the bias of a coin is not the actual difference between its chances of landing heads and tails, but what that difference would be if the coin were fairly tossed. (Consider that the coin has its bias even when there is no chance of it being tossed and thus no difference between its actual - zero - chances of landing heads and tails.) What a thing having a propensity makes true is a conditional ascription of a chance, not an unconditional one. Specifically, it makes true a subjunctive conditional whose consequent ascribes a chance: 'If this thing were now put in water, the chance of it dissolving would be 1'.

Not everyone agrees that subjunctive conditionals are true or false, or that mere dispositions can make them true. I have argued elsewhere ("In Defense of Dispositions", 1974) that all properties of things are dispositional, i.e. nothing but 'truth makers' for subjunctive conditionals, neither having nor needing any 'categorical basis' in intrinsic non-dispositional properties. Here perhaps Newtonian mass, the classical measure of quantity of matter, will serve to make the point. A thing has a mass m if and only if any net force f in any direction would (provided it would not divide or destroy the thing) give its accelerating at f/m in that direction a chance at least very close to 1. The ascription of a Newtonian mass entails nothing but an indenumerable infinity of these subjunctive

conditionals: if they lack truth value, so does it; and if mass is not an intrinsic and categorical property of things, what is?

I take it then that subjunctive conditionals are made true by things having propensities. And the truth of these conditionals is just what we need to make sense of acting to try and realise one alternative rather than another.

4. Propensities and actions

Suppose that recovering quickly from an illness is an alternative (to not recovering quickly) that I want to realise, e.g. by taking some nasty medicine. Let M be the proposition that I take the medicine, and call taking it 'doing M'. Let R be the proposition, not directly 'do-able', that I recover quickly. Suppose further that whether I should do M depends only on how valuable the truth of M&R, M&-R, -M&R and -M&-R would be in the circumstances, and let these values be measured on some suitable scale as follows:

	R	-R
M	7	-3
-M	8	-2

Suppose finally that in the circumstances the probability of my recovering quickly would be .4 were I to take the medicine and .1 were I not to. Should I take it?

Two different principles of decision theory, expected utility and dominance (Jeffrey, 1965, Ch.1; Nozick, 1969), prescribe different answers to this question. Expected utility prescribes taking the medicine because the expected utility of taking it, 1 [7x.4 - 3x.6], exceeds that of not taking it, -1 [8x.1 - 2x.9]. Dominance prescribes abstinence because M's truth has less value than its falsity both when R is true and when it's false: taking the medicine will make life nastier whether I recover quickly or not.

If the probabilities involved were merely epistemic I should follow the dominance principle. For then my taking the medicine would merely be evid-

ence that I should recover quickly without making a quick recovery more likely in any stronger sense. By the same token, merely epistemic probabilities make no sense of my doing M to try and make R true. That sense requires the probabilities involved to be more than epistemic, i.e. to be chances, and so to allow expected utility to justify taking the medicine and violating dominance.

Chance may indeed be defined as the kind of probability that enables expected utility to outrank dominance when the two principles conflict, the case for chances being basically that expected utility sometimes does outrank dominance. When it does, it gives just the sense we need to acting to try and realise one of a number of alternatives (I consider two, but the generalisation is trivial), as follows.

Suppose that M should be done if at all purely to try and make R true, i.e. that the medicine is no effort to take and neither nasty nor nice. Taking it would neither detract from nor add to the value either of R's truth or of its falsity, so that each row of values in the above table is now the same:

	R	-R
M	$\underline{v}$	$\underline{v}'$
-M	$\underline{v}$	$\underline{v}'$

where $\underline{v}$ exceeds $\underline{v}'$. Let the table of chances in the circumstances be

	R	-R
M	$\underline{p}$	$1-\underline{p}$
-M	$\underline{p}'$	$1-\underline{p}'$

where $\underline{p}$ may or may not exceed $\underline{p}'$. Then the expected utility of doing M will exceed that of not doing it if and only if

$$(\underline{v}-\underline{v}')(\underline{p}-\underline{p}') > 0.$$

So expected utility prescribes doing M if and only if the more valuable alternative R, the one it makes sense to try and realise, would have a greater chance were M done than it would have otherwise. In short, it only makes sense to act to try and realise an alternative that would in the circumstances have a greater chance were the action done than were it not done.

This principle needs propensities as well as chances. For it compares the chance an alternative would have were an action done with the chance it would have were the action not done. So whether the action is done or not, its rationale depends on a non-existent chance, namely on what the alternative's chance would have been had something happened which in fact did not happen. Which is why we need propensities: in the example, a pair of metabolic properties to make it true both that my chance of recovering quickly would be such-and-such were I to take the medicine, and less were I not to. And whereas I will have only one of these two chances of quick recovery, depending on what I do, my taking the medicine makes sense because I have both the relevant propensities in any case.

(Since the above principle is the basis of all that follows, I should at least acknowledge the more contentious assumptions made in deriving it, though the principle itself I take to be unimpeachable. First, I have tacitly aligned myself with the 'two box' solutions to Newcomb's problem (Nozick, 1969) arrived at by so-called 'causal' as opposed to 'Bayesian' decision theorists (Lewis, 1981; Eells, 1982). But secondly, I decline the various reductions these theorists have mooted of 'If M were true R's chance would be p' - reductions to resilient, objective, epistemic or subjective probabilities of R conditional on M, or to such probabilities of the conditional 'If M were true R would be'. In my view, the expected utility principle is justified only when taken as it stands and taken objectively, i.e. as prescribing objectively right action, not merely action made rational by rational or subjective utilities and degrees of belief (Mellor, 1983a). I therefore require truth, not merely assertibility, of the subjunctive conditionals the principle relies on, which in turn requires the realism about propensities defended in section 3 above.)

Propensities then are what make sense of acting to try and realise alternatives, and are therefore what we must constrain to limit that sense to alternatives later than the action. Which is where Dummett comes in, via his treatment of causation in "Bringing About the Past".

5. Causation

Causes traditionally determine their effects, and universal causation traditionally implies determinism, i.e. the entailment of all but the first

events - if any - by earlier events plus laws of nature. Yet though quantum mechanics shows determinism to be false, causation survives even there. Bombarding an atom, for example, will cause it to decay (if it does), merely by making the decay more probable. So the deterministic conception of causation is too strong. And it is no use taking causes to be necessary rather than sufficient for their effects, or to be some combination of necessary and sufficient conditions as in Mackie's 'INUS' - causes as Insufficient but Necessary parts of Unnecessary but Sufficient conditions (Mackie, 1965, p.16) - account. For these sufficient, necessary or INUS conditions are general, particular causes and effects being mere instances of them. They still imply that similar causes (or effects) would have similar effects (or causes), or would do so in the presence (or absence) of some other such conditions. But this is not always so. One bombarded atom may decay while another, identical in properties and surroundings, survives. As Anscombe (1971, p.63) says, there need be no relevant further difference between a situation in which an effect occurs and one in which it doesn't. And even if relevant differences exist, they may be beside the causal point. Smoking for example causes cancer in many smokers, though each may differ relevantly from every other smoker. Even 100 per cent laws linking cancer to metabolism would leave us asking why the metabolism that always leads to cancer is commoner among smokers, and the answer 'Because they smoke' is not to be ruled out a priori.

Causes need neither be nor instantiate any combination of sufficient and necessary conditions. What then are they? Several authors have recently based causation or causal explanation on probability (e.g. Reichenbach, 1956; Suppes, 1974; Salmon, 1975; Cartwright, 1979, Skyrms, 1980), and so far I agree with them. But not in detail, nor with the kinds of probability, and the probability values, they invoke for causation or causal explanation (Mellor, 1975, 1976, 1983). Here, however, I propose not to expound and criticise but to compete, with materials mined from Dummett.

Which of causation's connotations should we use to extend the concept to indeterministic contexts? The obvious candidates are explanation and prediction: causes must explain their effects, and give grounds for predicting them. Might probabilistic causation not therefore be defined as a species of probabilistic explanation or of grounds for prediction? I think not, though I don't deny these connotations: causes must indeed

explain and give grounds for predicting their effects. But probabilistic explanation is too vague and problematic a notion to base causation on; and probable prediction, which only needs indicative conditionals, is too thin a one (see Hempel, 1965, S.3; Jeffrey, 1969; Salmon, 1970; Mellor, 1976).

I start instead from Dummett's dictum (1964, p.333) that it always makes sense to bring about a cause in order to bring about one of its effects. This I believe is all the concept of causation needs - to be what makes sense of acting to try and realise one alternative rather than another. And what that sense is we saw in section 4: for it always to make sense to bring a cause about for the sake of its effects, a cause must raise its effects' chances above what they would in the circumstances otherwise be.

This thesis needs propensities, but not determinism: as Dummett remarks (1964, p.345), to satisfy his dictum, causes need be neither necessary nor sufficient for their effects. There are of course necessary causes, in whose absence the effect's chance would be zero, and sufficient ones, in whose presence it would be 1. But these are merely special cases of the effect's chance with the cause exceeding its chance without it, which does not require either chance to be 1 or 0.

The 'circumstances' in which the chance would be less without the cause must of course include the absence of alternative causes. For sometimes if one cause did not occur, another would that would give the effect no less a chance. Consider a man who would have been hanged had he not been shot, with as great a chance of dying either way, whom nonetheless the shooting surely kills. So it does: but only because his chance of dying then would otherwise be less were no alternative cause of death to occur - a cause of which the very same thesis would have to be true.

The existence of alternative causes indeed prevents me eliminating reference to causes altogether (since the subjunctive conditionals involved are tacitly restricted to 'other causes being equal') but that was anyway not my object. And they do demand care of anyone intending to exploit Dummett's maxim: when bringing a cause about for the sake of an effect, make sure you don't thereby also prevent a more efficacious alternative cause.

I can admit alternative causes, but not overdetermination by separately sufficient ones. If our man is simultaneously hanged and shot and either

fact alone would make his chance of dying 1, then on my account neither causes his death: what kills him is the disjunction of the two facts. But this is an implausibly extreme case. Normally neither fact alone would raise his chance of death to 1, and the other will have raised it further, so each is still a cause of death. In short, I can cope with all but the most extreme overdetermination; and that, once distinguished, I am willing to deny.

6. Explanation and prediction

Causation's other connotations should follow from Dummett's dictum; in particular, causes so construed should explain their effects and give grounds for predicting them. And so they do.

First, actions obviously explain the effects for whose sake they are performed. On the other hand, though the concept of causation depends on that of agency, the propensities that embody it need no agents; nor need they be restricted to what agents could exploit, since the relevant subjunctive conditionals don't entail their antecedents' feasibility. We need not be able to make the earth tilt as it rotates around the sun for tilting it to make sense as a way to bring about the seasons, and thereby to explain them. Nothing said here inhibits causal explanation by and of inanimate phenomena.

Secondly, causes explain effects precisely because and insofar as they raise their chances, which Dummett's dictum makes them do. I have elsewhere suggested (Mellor, 1976) that we call for explanation only of what, though we know it is so, might have been otherwise for all else of some suitable sort we know. What makes deterministic explanation (where we can get it) ideal in this respect is that it shows how in the circumstances what happens has to happen. What better explanation of an event could there by than that there was no chance of it not happening? And failing determinism, to the extent that a cause reduces the chances of its effects not happening, it helps to explain why they do.

Thirdly, whatever the reason, we do in fact require statistical explanations to raise the chances of what they explain, a fact that Dummett's dictum itself explains if these explanations are causal. Consider the example of section 4 (or the analogous case of smoking and cancer).

Given those chances, we surely think that taking the medicine would explain the quick recovery it raised the chance of, albeit to less that 1/2; but not the failure to recover quickly whose chance, though still over 1/2, was reduced by taking the medicine. What explains a cure (or a cancer) if it happens would not be taken ipso facto also to explain its failure to happen (pace Jeffrey, 1969; Salmon, 1970).

Finally, causes that have to raise the chances of their effects evidently give grounds for predicting them, since chances entail corresponding epistemic probabilities. Not necessarily good grounds - the chance may still be less than 1/2 - but better than there would be otherwise have been. Hempel's famous thesis (1965, S.2.4), that explanations give grounds for predicting what they explain, thus survives in a comparative form: the more a cause raises the chances of its effects, the better (ceteris paribus) it explains them; and by the same token, the better grounds it gives for their prediction.

7. 'Because' as a connective

'R because M' reports a causal connection, between my taking medicine and my recovering quickly; and though other sentences of the form 'Y because X' have other uses (e.g. '3 is odd because it's prime'), this is the use I will discuss. In this use, 'Y because X' entails that Y's chance would be greater in the circumstances were X true than were it false. It also entails Y and X. Causes and effects must be real: if I don't recover quickly, my quick recovery can have no cause, and if I take no medicine, my taking it can have no effects. 'Y because X' is thus a partial truth function of Y and X, false if either Y or X is false; a fact one might express by calling causation a relation between facts, i.e. the true propositions Y and X. The relation is not of course symmetrical, since 'Y because X' does not entail 'X because Y'. The truth of X and Y neither verifies nor falsifies 'Y because X', which is therefore not a complete truth function.

I have assumed that 'because' in this use connects propositions or sentences (which it certainly appears to do) as well as reporting a relation between events. My account moreover requires it to, since it relies on effects having chances, chances are a species of probability, and

probability is probability of truth, an attribute of sentences and propositions but not of events. (Consider for instance that R can have a chance of being true even if it is false, when my quick recovery, construed as an event, does not exist to have a chance.) But a notorious argument purports to show that 'because' is not a connective, an argument I must therefore refute.

The argument goes as follows (Davidson, 1967, p.153): (i) Any proposition 'Y because X' entails any proposition got from it by substituting for Y (or X) any logical equivalent, such as '$\hat{x}(x=x\&Y) = \hat{x}(x=x)$' ($\hat{x}(x=x\&Y)$ is the set of everything, $\hat{x}(x=x)$, if and only if Y is true). So 'Y because X' entails '$\hat{x}(x=x\&Y) = \hat{x}(x=x)$ because X'. (ii) 'Y because X' is referentially transparent, i.e. its truth is unaffected by any true redescription of any entity referred to in it. But if Z is any proposition that shares Y's value, '$\hat{x}(x=x\&Z)$' truly redescribes $\hat{x}(x=x\&Y)$, i.e. $\hat{x}(x=x)$ if Y is true and the null set if it isn't. (iii) So 'Y because X' entails '$\hat{x}(x=x\&Z) = \hat{x}(x=x)$ because X' and hence, applying (i) again, 'Z because X'. And since the argument applies equally to substitutions for X, 'because' becomes a complete truth function; which it isn't.

On my account this argument fails at step (ii). (i) may be all right: all Y's logical equivalents have the same chance as it does; so whatever raises its chance in the circumstances will also raise all theirs. But not necessarily those of merely material equivalents like Z, nor hence of Z's logical equivalents. One may well raise the chance of '$\hat{x}(x=x\&Y) = \hat{x}(x=x)$' without raising that of '$\hat{x}(x=x\&Z) = \hat{x}(x=x)$'. The argument shows therefore not that 'because' isn't a connective, merely that it is opaque to some redescriptions of the set of everything.

But if 'because' is a connective, should not '(Y because X) because W' and 'Z because (Y because X)' make sense for suitable W,X,Y and Z? Yes, and so they do: my having the metabolic propensities that make my taking medicine cure me quickly might itself have a genetic cause (W), and might itself cause me to contract some other illness (Z). Iterated causation is uncommon, not because it makes no sense, but because the causation that relates events is (as Hume observed) not generally embodied in other causally related events; but rather - as we shall see - in things with propensities.

The thesis that causes raise the chances of their effects restricts the

logic of 'because' in other ways as well. Thus, 'Y because X' and 'Z because X' should generally entail neither 'Y&Z because X' nor 'YvZ because X' (since raising the chances of Y and Z, while it must raise the chance of Y&Z or that of YvZ [$\underline{p}(Y\&Z)+\underline{p}(YvZ) = \underline{p}(Y)+\underline{p}(Z)$], need not raise both). And nor they do. Suppose for instance taking medicine raises the chance of a recovery being quick, and also of it being painful, but lowers the chance of it being both. If however it is both, should we not credit the medicine with causing the speed and the pain, but not with causing their conjunction? And should we not say the same of a disjunction whose chance the medicine reduced while raising the chances of its disjuncts?

On the other hand, if T is necessarily true, 'Y because X' could entail 'Y&T because X' and 'Yv-T because X', since Y has the same chance as Y&T and Yv-T. But 'T because X' has to be false, since T's chance of being true is 1 in any case.

All these implications of our thesis seem to me acceptable; so pending the discovery of others that aren't, I shall take 'because' to be a connective that makes causation relate facts, i.e. true propositions. But how then does causation relate events?

8. Causes as events

Causation is supposed to relate events (in Davidson's sense: Davidson, 1980, essays 6-10; Thalberg, 1980) as well as facts. How are these two kinds of causal relation related? Perhaps when 'Y because X' is true and Y and X refer respectively to events $\underline{e}$ and $\underline{e}^\circ$, $\underline{e}^\circ$ causes $\underline{e}$? But for $\underline{e}$ and $\underline{e}^\circ$ to satisfy a relation $\underline{R}$, '$\underline{e}R\underline{e}^\circ$' must be true, it must entail the existence of $\underline{e}$ and $\underline{e}^\circ$, and '... $\underline{R}$...' must be transparent to true redescriptions of these events. Now 'Y because X' indeed entails Y and X and thus the existence of $\underline{e}$ and $\underline{e}^\circ$. But (as Timothy Smiley has pointed out to me) it is opaque to some redescriptions of $\underline{e}$ and $\underline{e}^\circ$ as well as of $\underline{x}(\underline{x}=\underline{x})$. Consider for instance the causing of an identity: e.g., that my taking the medicine is the last thing I do, because it's been poisoned. 'My taking the medicine' is thus a true redescription of the last thing I do; so if 'Y because X' were transparent, 'My taking the medicine is my taking the medicine because it's been poisoned' would also be true. But it isn't, since 'My taking the medicine is my taking the medicine' is a necessary

truth, whose chance would be 1 whether the medicine were poisoned or not. Causation here relates facts, but not events.

'Y because X' does not entail a causal relation between particular events referred to in Y and X. But then Y and X don't usually refer to particular events. When for example I take the medicine in order to recover quickly, I don't care which events my taking the medicine and my quick recovery are. All I want is that there being an ingestion of medicine by me should raise the chance of some event being another of my quick recoveries. Any events that satisfy those descriptions will likewise satisfy me. In short, R and M in 'R because M' are existential propositions about events, not singular ones: 'I recover quickly because I take the medicine' = 'There is a quick recovery by me because there is a taking by me of the medicine'.

In this case we can define a causal relation between the particular events that make these existential propositions true. Suppose that I recover quickly because I take the medicine, and that e° is (inter alia) my taking the medicine and e my quick recovery. We might say either that e° causes or that it affects e. Which we should say depends on whether or not we think being a taking of the medicine and being a quick recovery are essential properties of those events, i.e. properties without which they would not have happened. If we think the properties essential we should say that e° causes e, i.e. causes it to happen; if inessential, that e° affects e, i.e. causes it to have a property it could do without. But this distinction, between causing and affecting, interests prospective agents no more than do the events themselves. If I want a quick recovery I don't care whether a slow one would be a different event or the same one shorn of the (to it) inessential property I wanted it to have. What matters to me is neither the identity of e and e° nor their identity conditions but the truth of 'R because M'.

Causation between facts is what matters to agents, not causation between events; and causation relates events only because it relates facts, not vice versa. And it relates far more facts than it relates events. For besides the causes (and effects) of identities, there are the causes and effects of the absence of events. My metabolic propensities for example don't just make it true that were I to take the medicine the chance of my recovering quickly would be increased. They also make it true that my not taking the medicine would increase the chance of there being no such quick

recovery. If I take no medicine and don't recover quickly, '-R because -M' will be true, just because such events do not happen.

Causation's real embodiments therefore are not events but the possessors of propensities: namely, things (celestial and terrestrial), fields (electromagnetic, gravitational etc.) and the like. What we call causal relations between events only arise when suitable subjunctive conditionals, made true by propensities, happen to have their existential antecedents and consequents instantiated by events. To restrict causation to events (as I did in Real Time) is to miss its pervasiveness, for it can be just as present where nothing is happening at all.

9. Causation and the direction of time

Having grounded causation firmly in propensities, I can at last say why effects never precede their causes, which is why it makes no sense to act now to try and realise alternatives to the actual past. The reason is that (a) effects always succeed their causes and (b) nothing precedes what it succeeds. (a) I will show here, and (b) in section 10, abbreviating arguments in Real Time (chs. 9 and 10), rephrased to make explicit the distinctions, not drawn there, between chance and propensity and between events and facts.

I shall argue that effects necessarily succeed their causes: i.e. when 'Y because X' reports a causal connection it entails 'Y after X'. 'After' should therefore be a connective like 'because', and so it is - for example, it sometimes iterates: 'I have lunch after going to London from Cambridge' means that I have lunch after (I reach London after I leave Cambridge). Then 'Y after X', like 'Y because X', entails Y and X: if I don't have lunch I don't have lunch after or before anything. Succession, like causation, is a relation between facts, including tenseless facts. (Tenseless Y and X are indeed true always if at all, but that doesn't prevent 'Y after X' also being always true.) Again, the relation is not symmetrical: 'Y after X' doesn't entail 'X after Y', and is no more a complete truth function of Y and X than 'Y because X' is. Finally, though 'Y after X' may be as opaque as 'Y because X' to some redescriptions of events referred to in singular Y and X, existential Y and X likewise enable it to define a corresponding relation between events (or times). If I have

lunch (at some time t) after I reach London (at some time t'), then my lunching is after my arrival and t is after t'.

To show that 'because' entails 'after', I must next remark that causation as defined by Dummett's dictum is the mechanism of perception and memory as well as of action. That is, perceptions and rememberings are among the effects of what is thereby perceived or remembered. To see this for perception, consider that perceiving a fact must at least include coming to believe it (or coming to believe it more strongly). But unless the chance of this experience is greater than it would have been had the proposition been false, it will not be a perception. This is partly because the experience would otherwise not be evidence for the fact, which a perception clearly must be. For that, however, the fact would only have to raise the experience's epistemic probability. What makes it raise the chance is that it always makes sense to bring a perceivable fact about in order to bring about a perception of it.

And as for perception, so for memory. Memories of things perceived are effects of those perceptions: they are evidence for them, and it makes sense to perceive something in order to remember it. So the perception must give the memory a higher chance than it would otherwise have had. (The propensities that make this true are of course embodied in our brains, just as the propensities that enable us to perceive things are embodied in our senses.)

Now consider a perception of temporal order, e.g. that on a particular circuit the second hand of a clock passes the figure '2' after it passes the figure '1'. Call perceiving (rightly or wrongly) the truth of a proposition 'seeing' it, and let K and L respectively be the propositions that the hand passes '1' and that it passes '2' on this particular circuit. Then I see 'L after K' by seeing K and seeing L and by some memory of my seeing K accompanying my seeing L. But this means that my seeing K must somehow affect my seeing L. The two perceptions have a causal order, and this fixes the temporal order K and L are thereby seen to have. If my seeing K affects my seeing L, L will be seen - rightly or wrongly - to be after K, and vice versa. And this I then claim must be the temporal order of the perceptions themselves: to see in this way that L is after K, I must see L after I see K. The causal order of these perceptions fixes their temporal order; as it does whenever temporal order is thus perceived.

This limited coincidence of causal and temporal order I then extend to any actual or hypothetical pair of causally ordered facts: since the effect would have to come after the cause if they constituted such a pair of perceptions, it has to come after the cause anyway. The argument in short makes causation determine temporal order by being the mechanism by which we perceive it. That, I believe, is why the direction of time is the direction of causation, i.e. why 'Y because X' entails 'Y after X'. (Which doesn't of course mean that temporally extended causes and effects can't overlap in time, merely that the effect cannot start until after the cause does.)

But this doesn't yet rule out so-called 'backward causation' - e.g. the time machine Tardis going back in time to make facts about its departure in 1984 affect facts about its arrival in 1884. Such phenomena just become causal - and therefore timelike - loops, in which facts directly or indirectly affect their own causes. The question remains therefore: why are causal loops impossible? Why do facts' (and therefore events') causes and effects form disjoint classes? For the nub of the answer that follows, I am again indebted to Dummett's "Bringing About the Past".

10. The impossibility of causal loops

Suppose 'Y because X' is true, with X and Y asserting the existence respectively of events of kinds A and B with inessential properties F and G. (This prevents the events' existence depending on their being F and G, which simplifies the argument but isn't essential.) Now hypothesise many A-events, some F and some not, each with a B-event, some G and some not. ('With' means each is so linked to a B-event by a continuous path through things or fields with propensities that that A-event being F would cause that B-event to be G if it were G.) Suppose finally that all B-events with F A-events have the same chance p of being G, and all B-events with not-F A-events have the same chance p' of being G, where $p > p'$. (p and p' are what these chances, which in general will vary with circumstances, would be in the environment of X and Y.)

The so-called 'laws of large numbers' (e.g. Feller, 1957, ch.10) now entail that, given enough such events (how many depends on how much p exceeds p'), there would be a very high chance of F A-events being accompanied by a higher proportion of G B-events than accompany not-F A-events.

And as the events are only hypothetical, there can always be enough for the chance of this closer correlation (of G with F than with not-F events) to be as near to 1 as we please.

Now suppose enough other causal links between constituents of X and Y to make X undeniably after Y. Could 'Y because X' still be true? If it were, enough hypothetical pairs of A-events and earlier B-events would have to give a chance very near to 1 of G B-events correlating more closely with F A-events than with not-F A-events. What my extension (Real Time, Ch.10) of Dummett's famous (1964) argument does in effect is so to hypothesise such pairs of events that this chance would in fact be zero, thus showing 'Y because X' to be false.

Briefly, the hypothesis is this. First, suppose equal numbers of G and not-G B-events. Next suppose that whether each B-event is G or not is perceived by an agent who can make its corresponding A-event F or not F. (These perceptions - being effects of what is perceived - can always be supposed inserted into the forward causal chains that make B-events earlier than their corresponding A-events, whether the B-events are affected by the A-events as well or not.)

Now ask half the agents who see G B-events to make their A-events F, the other half to make them not F; and tell those seeing not-G B-events to do the same. If they do, G B-events will have no chance of correlating more closely with F A-events than with not-F A-events, and 'Y because X' will be false.

The high chance of the correlation, which 'Y because X' needs, can be secured in only two ways. (i) Some agents seeing G B-events are thereby caused to make their A-events F. But that makes the correlation signify forward causation: X because Y, not Y because X.

(ii) An agent's making his A-event F (or not F) sometimes shows that he misperceived his B-event not to be G when in fact it was (or to be G when in fact it wasn't). That is, a perception of a cause, say the A-event being F, corrects a misperception of its effect, namely that the B-event is not G. But as I argue in Real Time (p.182), perceptions of causes can generally only support predictions of their effects; they can't correct perceptions of them. (Imagine seeing a brick hit a window and concluding therefore that it really must be broken though you can see clearly that it isn't.) An initial seeing of a proposition may be corrected by seeing a supposed cause

of its negation only if (a) the initial perception is extremely unreliable and (b) the supposed cause really is a cause. But if (b) were true, reliable perceptions of many such causes and effects would have a high chance of revealing a correlation between them; and in this case we know they wouldn't. So perceptions of A-events being F may not be used to reject the perceptions of B-events (not being G) that refute the alleged basis for the rejection.

So if causation relates a pair of facts one way, it will not also relate them the other way. 'Because' is an asymmetric relation, which is why 'after' is. Causation is what gives time its effective direction. No fact that affects and so is earlier than a given fact can be among its effects and therefore also later than it. In particular, no fact earlier than an action can be among that action's effects. So no present action can affect the past, since to be past is to be earlier than the present.

But this is so only because causes have to raise the chances of their effects above what in the circumstances they would otherwise be. Were that not so, backward causation would not need a high chance of correlating with its effects; and the above argument, which shows that it may have no chance of correlating with them, would fail to rule it out. But then, without the difference of chances that gets the argument going, backward causation would not make sense of acting to try and realise alternative pasts. That does require the difference of chances which rules it out, whether one calls it 'causation' or not. So in any case it makes no sense to do something now to try and realise an alternative past. In that sense, the past is fixed and the future isn't. Why, in the other sense, the future is chancier than the past is (as I said) another story.

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