

ROBERT PARGETTER

LAWS AND MODAL REALISM

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1. CONSTANT CONJUNCTION

It is widely agreed that constant conjunction is a necessary condition for a proposition such as 'Every A is a B ' being a law.¹ That is each A is also a B (where A and B are kinds of events, objects states of affairs, or whatever) or the property of being an A is always conjoined with the property of being a B . It is also widely agreed that this cannot be the whole story. How can we distinguish accidental generalisations from laws? Why is it that 'Every massive object attracts every other massive object' is taken as a law, while 'Every golden object is less than a million kilograms (say) in mass' is not? Both are true universally, do not make reference to particular entities or places or times, and so on and so forth, and yet they are given vastly different ontological and/or epistemic status. This is the problem of laws.

The development of a realist theory of possible worlds suggests an obvious answer to this problem.² While laws and accidental generalisations are alike in being true in the actual world, we can distinguish them by considering what is true in other worlds. The intuition is that if we consider the "right" other worlds we will have the laws true in *all* such worlds while accidental generalisations will *not* be true in *all* such worlds. But this suggestion suffers from an obvious and apparently insurmountable problem: how do we identify the "right" worlds to consider? The three most ready answers are all unsatisfactory.

If we allow all worlds, then we have laws as necessary truths, albeit necessary *a posteriori*. But, *prima facie*, laws could have been other than they are, we can make sense of counterlegal conditionals, and surely the Hume world where all "laws" are merely constant conjunctions and on a par with accidental generalisations is at least a logical possibility.

If we do not take all the logically possible worlds, but restrict ourselves to the physically possible ones, we find we are in a vicious circle. For to distin-

guish these worlds we need to specify that they are the worlds in which causes remain the same or where the laws are the same.

If we try to take the worlds which are most similar to ours, we again seem to be involved in circularity. For it now seems agreed that similarity is not just similarity in particular matters of fact, but most essentially involves similarity in matters of causation and constancy of laws. And if we leave similarity at an intuitive level, a host of now well known counterexamples emerge.

This paper argues that the failure of these three attempts to specify without circularity the “right” worlds does not exhaust realist possible world accounts of laws.

2. ACCESSIBILITY

Formal possible world semantics defines possibility in terms of a set of worlds, and a binary relation on those worlds called accessibility. The semantics reveals possibility as a relative notion. A proposition is not possible absolutely, rather it is possible relative to some world. It is possible in world w_0 if and only if it is true in some world accessible from w_0 . Similarly with necessity, a proposition is necessary relative to world w_0 if and only if it is true in all worlds accessible from world w_0 .

While care is taken with these formal accounts of possibility and necessity to see them as relative notions, when they are viewed metaphysically they seem to lose their relativity and take on an absoluteness. It is said, simply, that a proposition is possible if and only if it is true in some (possible) world, and that it is necessarily true if and only if it is true in all (possible) worlds. When we ask which formal model is really being taken as the model of reality in such accounts, it is commonly said that it is the model where all worlds are accessible to all other worlds. But it is consistent with our metaphysical practice to say rather that consideration of accessibility is just dropped, and that possibility and necessity are not metaphysically taken to be relative notions. So we can distinguish two modal realist theories of possibility.

- (i) A proposition is possible if it is true in some world.
- (ii) A proposition is possible in world w_0 if it is true in some world accessible from world w_0 .

Correspondingly with necessity.

- (i) A proposition is necessary if it is true in all worlds.
- (ii) A proposition is necessary in world w_0 if it is true in all worlds accessible from world w_0 .

The assumption has been that the two theories are not distinct. (i) is a simplification of (ii) because all worlds are really accessible to each other. Let us reject this view, and see them as two distinct accounts of possibility and necessity. The first gives an account involving only worlds, and the second gives an account involving worlds and a universal, a binary relation, on those worlds which we do not assume trivially holds between any two worlds.

Having distinguished these two theories of possibility and necessity, we can ask which best corresponds to logical possibility and logical necessity. It seems that we should adopt the first theory, hence preserving the usual metaphysical intuition that a proposition is logically possible if and only if it is true in some (possible) world and that a proposition is logically necessary if and only if it is true in all (possible) worlds. This commits us to a logic for such possibilities and necessities of S5, but this is of small consequence as it has long been the favoured logic for logical modalities by most modal realists.

I wish to suggest that we consider the second theory of possibility and necessity as a theory of nomic possibility and nomic necessity.

3. NOMIC POSSIBILITY AND NOMIC NECESSITY

Suppose generalisations are laws in the actual world if and only if they are true in the actual world and in all worlds accessible from the actual world. More generally, a generalisation is a law in world w_0 if and only if the generalisation is true in world w_0 and in all worlds accessible from world w_0 . That is we have added to the requirement of constant conjunction a further requirement: constant conjunction in all accessible worlds. Such an account takes our intuition that laws have a "necessity" which accidental generalisations lack as being explained by the necessity being real.

What characteristics does the accessibility relation have? We clearly want a world to be accessible from itself. If a distinction is to be maintained between nomic possibility and logical possibility there will be some worlds not accessible from worlds which have the laws of the actual world. So accessibility will partition the logical space around any world into the worlds which are accessible from that world and hence nomically possible relative

to the world, from the other inaccessible worlds of the logically possible but nomically impossible.

Take the proposition 'Every A is a B ' which is true in world w_0 . It is a law in w_0 if and only if it is true in all worlds accessible from w_0 . This does not mean that all accessible worlds have the same laws, only that all propositions which are laws in w_0 will be at least *true* in all worlds accessible from w_0 . Some of these worlds will have the same laws. Some will be like the "Hume world" and have no laws at all – all the true generalisations are in a sense accidental, but all are nonetheless true. Some of these worlds could have different laws to those in w_0 , providing that such laws are at least consistent with the propositions which are laws in w_0 and hence true in these worlds. So in general accessibility will not be symmetric. What there will not be are worlds accessible from w_0 which have incompatible laws to those of w_0 . For consider a world w_1 accessible from w_0 : if p is a law in w_0 , p is true in w_0 and w_1 , and so if q is a law in w_1 , p and q must be consistent as they must both be true in w_1 .

Accidental generalisations in w_0 will be laws in some worlds accessible from w_0 , just as some generalisations which are laws in w_0 will be accidental generalisations in some worlds accessible from w_0 . But if a proposition is an accidental generalisation in w_0 , it will be false in some world accessible from w_0 .

Accessibility will not in general be transitive. Consider the following three worlds w_0 , w_1 and w_2 . w_1 is accessible from w_0 , so all the propositions which are laws in w_0 are true in w_1 . w_2 is accessible from w_1 , and there is some proposition which is a law in w_0 , a true accidental generalisation in w_1 and which is false in w_2 . Clearly w_2 is not accessible from w_0 . Without transitivity, we can nonetheless move to worlds with different laws in "steps". The easiest way is via a Hume world, that is a world with no laws but only accidental generalisations. For any world w_0 there will be many accessible Hume worlds in which there are no laws and where the laws of w_0 are merely true accidental generalisations. In these cases, accessibility is trivially symmetric as the Hume world has no laws. Also, seeing by definition Hume worlds have no laws, all worlds are accessible from any Hume world. Thus we can get from w_0 to any world with different laws from those of w_0 in two steps. From w_0 to a Hume world accessible from w_0 , and then from this Hume world to any world including worlds with laws different from those of w_0 .

Two final points about nomic possibility and nomic necessity. First, as so far characterised the logic of nomic possibility and nomic necessity is a system obtained from the system T . Besides accessibility being reflexive, we have accessibility being “two-step” transitive, and all worlds having access to a world from which all worlds are accessible. So to the axioms of T we add

$$\begin{aligned} & \Box \Box p \supset \Box p \\ & (\Box p_1 \wedge \dots \wedge \Box p_n) \supset \Box (\Box p_1 \wedge \dots \wedge \Box p_n) \\ & \text{for every } n \geq 2 \end{aligned}$$

This system is complete and sound.³ Secondly nomic possibility and nomic necessity thus characterised are not equivalent to the usual accounts of physical possibility and physical necessity. For accessibility is not limited just to worlds which have the same laws.

4. CIRCULARITY AND REALISM

Possible world theories have long been accused of circularity. How can they provide a non-circular account of possibility if the fundamental concept of such theories is that of a “possible” world? It may well be objected that the proffered account of laws may similarly be challenged, but doubtly so. For the account now has two fundamentals, possible worlds and accessibility. And the use of accessibility seems also to be open to the same charge: how can you use such a relation to say when a generalisation is a law when such a relation only holds between worlds where such generalisations are true?

In the case of possible worlds, *realism* provides an answer to the charge of circularity. This answer has two parts. First the possible worlds exist. What happens within them is what is possible. The actual world is only special in the token reflexive sense: it is the world in which we exist. Secondly our grasp on the notion of possible world is not dependent upon the concept of possibility itself. We know what the actual world is like, and therefore we know what other possible worlds are like for they differ not in merely being possible rather than actual. Rather they differ in what items are in them, on what properties the items in them have, or in what relations hold between the items in them. Of course it is important to note that we cannot eliminate the fundamental concept of possible worlds, for if we could it would not be the fundamental concept of our theory and the theory does not attempt to

provide an analysis without the use of any concepts. Also it is important to note that the theory does not provide a recipe for finding out what is possible rather than what is impossible.

If this realist defence against circularity is successful in the case of possible worlds, it is equally available as a defence against the circularity charge in the case of accessibility. First accessibility is a relation which holds between some pairs of worlds. Secondly our grasp on the notion of accessibility is not dependent upon the concept of physical law. The relation does not only hold between worlds which have the same laws; all that is required is that the appropriate generalisations are true in the accessible worlds. Worlds vary in what universal generalisations are true in them, and this reveals or determines (depending on your view about relations) whether the accessibility relation holds. We have a grasp on the relation holding between countries, and between time slices, in this world. The theory of laws postulates this relation holding between worlds. Of course it is important to note that we cannot do away with the notion or explicate accessibility in terms of more fundamental concepts, for it is fundamental in the theory and the theory is of course bound to some fundamental notions. Also it is important to note that the theory does not provide a recipe for finding out what laws there are.

Of course there is more that needs to be said about accessibility. What has been provided at this stage is a framework. On this framework accessibility is a relation with certain formal properties. The filling out of a theory of accessibility is work for another occasion, but it should be noted that there could be alternative theories. Some modal realists would favour postulating a fundamental metaphysical universal (relation), and flesh it out beyond its formal properties using further features of accessibility as it applies between countries and time slices in this world, or perhaps by the use of analogies and models such as by comparison with the way in which time slices in the one world are "temporally accessible" to each other while those in distinct worlds are not. But other modal realists could offer an epistemic account of accessibility in terms of certainty or robustness; for example if it was thought that a true universal generalization was a law if it was held with certainty, then the accessible worlds could be the worlds where those true generalizations held with certainty in this world are true. The trivial case of fleshing out accessibility would be a Humean type account where the only world accessible to this world is itself, which reduces a law to a universal generalisation true over all space and time.

The methodology here is the same as with the similarity relation in modal realist theories of counterfactuals. The first stage is the framework stage where similarity is a fundamental relation with certain formal properties, which holds between some possible worlds. This gives enough to explain various formal properties of counterfactuals but leaves open how the relationships should be fleshed out. This is the stage established by Lewis and Stalnacker in their original presentations even though the second stage, the development of a comprehensive theory of similarity, remained and perhaps still remains incomplete and controversial. Different fleshings out of similarity are available,⁴ and new ones could be put forward in the future. But the success of the framework stage is independent of how such a theory is developed. The task of providing a full theory of accessibility, that of arguing which particular relation satisfying the formal requirements should be identified with accessibility, is put aside much as it was left to provide a fully adequate theory of similarity when modal realist accounts of counterfactuals appeared. (It shall be suggested in the next section that there may only be one job, not two.)

5. COUNTERFACTUALS

The usual possible world theories of counterfactuals involve a relation of similarity between world.⁵ Briefly, a counterfactual is true in world w_0 if and only if its consequent is true in the world (or worlds) most similar to world w_0 in which its antecedent is true. Similarity is thus a relation which holds between pairs of worlds. Similarity has degrees: world w_0 can be more similar to w_1 than to w_2 . The full details of the theories vary, but they shall not concern us here.

We will explore the idea that similarity can be replaced with accessibility, and that accessibility has degrees.⁶ Accessible worlds from world w_0 will each have some degree of accessibility with respect to w_0 , while there will still be inaccessible worlds. There is a parsimony argument in favour of such a reduction to a single universal if it can be achieved. Also we have an immediate explanation of the well noted close link between laws and counterfactuals.

There is a reason to suppose that such a reduction might be successful. Consideration of laws and causal matters have been shown to be of prime importance in determining similarity.⁷ On the suggested reduction, this is a necessary requirement as the worlds accessible from the actual world in which

the antecedent of the counterfactual is true, will all be worlds where the propositions which are laws in the actual world are at least true (they may or may not be laws).

However this may be thought to create a problem, as it is a point of dispute between various theories of counterfactuals. While theories (in general) agree that matters pertaining to laws are of prime importance, there is a disagreement as to whether the antecedent worlds that need be considered are the worlds with *exactly* the same laws.

According to Pollock they are.⁸ We take the world(s) where the laws are the same and where the antecedent is true together with whatever other changes may have been produced in order to bring about the truth of the antecedent without violating the laws, even if such changes go back to the beginning of time. We can have sympathy with Pollock's intuitions on two counts. First, if similarity is to have intuitive explanatory power, surely the worlds most similar to our own will be worlds with exactly the same laws. Secondly, we can have counterfactuals where the consequent concerns or depends on what things would have had to be like in order to bring about the antecedent, assuming the laws are the same as those in the actual world.

Despite these considerations, it seems that Pollock's theory has a major problem. It just fails to give many counterfactuals the truth-values our common intuitions dictate and makes calculation of the truth-value of many counterfactuals impossibly difficult.⁹ Hence on the Lewis/Jackson accounts¹⁰ the antecedent worlds that are considered are those where the antecedent is commonly made true by a "minor miracle". So the laws in these worlds are not exactly the same as those of the actual world, as they typically have a single space-time point anomaly built into the laws to allow the miraculous realisation of the antecedent. In these worlds however, because of the minor miracle, propositions which are laws in the actual world will often not even be true in the most similar antecedent worlds, and thus certainly will not be laws in these worlds.

There is however a way of accommodating all the intuitions which have lead to these alternative theories, a way which rests on our suggested reduction of similarity to accessibility. For counterfactuals where the Lewis/Jackson theory gives a different and a preferred result to the Pollock theory, that is for counterfactuals where a minor miracle is called for, the counterfactual ' $p \Box \rightarrow q$ ' seems in no way distinct from the nested counterfactual

If it had been the case that the actual world was a world where *it was possible that* a single space-time point anomaly could bring p about with no other effects, then it would have been the case that $(p \Box \rightarrow q)$.

On the suggested theory this nested counterfactual has the right truth value and similarity can be reduced to accessibility. Suppose in order to bring about p in the required miraculous way (for the Lewis/Jackson theories) proposition r which is a law in the actual world, w_0 , will have to be amended to allow a single space-time point anomaly. For the first antecedent of our nested conditionals we will consider the accessible world w_1 (for simplicity we will assume there is just one such world) where r is true but not a law as there are worlds accessible from w_1 where r is false. For the second antecedent p we go to world w_2 accessible from w_1 (for simplicity we will again assume there is just one such world) where r is false as p has been miraculously realised. In fact w_1 and w_2 have r' as a law where r' is like r except that a single space-time point anomaly is possible and during which p has been realised in w_2 . If q is true in w_2 , the nested conditional is true in w_0 .

There appears to be another reason for opting for this way of accounting for conditionals which require minor miracles. It is because there are examples where both the Pollock reading and Lewis/Jackson reading both have intuitive appeal, and the above can allow for both readings. Consider

If the rocket component had been faulty at time t_1 , then the rocket would have exploded at take-off at time t_2 , $t_2 > t_1$.

If the rocket component had been faulty at time t_1 , then the fault would have been detected during inspection at time t_0 , $t_0 < t_1$, and the rocket would not have taken off at time t_2 , $t_2 > t_1$.

Plausibly both counterfactuals are true, yet the most similar antecedent worlds cannot have both consequents true. But on the suggested reconstrual the first conditional is to be seen as synonymous with

If the world had been such that it was possible that the rocket component should suddenly become faulty at time t_1 , then it would have been the case that if the rocket component had been faulty at time t_1 , then the rocket would have exploded at take-off at time t_2 , $t_2 > t_1$.

And with this reconstrual of the first conditional, both conditionals are true. Even if such examples fail to be decisive in arguing for two readings of counterfactuals, there are counterfactuals which do *not* require the miraculous violation of laws. Situations involving (genuine) freewill or indeterminism provide obvious cases. For example

If the uranium atom had decayed at time t , then radiation would have been detected at time $t + \delta$.

So while Lewis/Jackson counterfactuals might be the most common (in our world), there is a place for Pollock counterfactuals as well.

The other important departure between the suggested theory and extant modal realist theories of counterfactuals is in the case of counterlegal conditionals. These counterfactuals have antecedents true only in worlds with laws incompatible with the laws of the actual world. What is the truth-value of such conditionals in the actual world? Consider an example:

If the gravitational attraction between two bodies had been inverse to the power three instead of to the power two, then bodies very close together would have accelerated towards each other faster than they actually do.

It is commonly taken that this is true. The usual account of similarity allows this result. But why should we say a world varying in one law and keeping other laws constant is more similar to the actual world than a world which has variations in a number of laws — perhaps compensating variations? Why not rather take a line parallel with the modal realist's response to counterlogicals, and make all such counterfactuals trivially true rather than try to force a division of some being true and some being false.

Of course we can still ponder about what happens in worlds where different laws hold. Such worlds exist. But counterfactuals which link or liken our world to such worlds are of no real significance. All are trivially true.

While suggesting this hard line approach to counterlegals, there are two ways we can further accommodate our intuitions.

Consider the conditional

If it had been the case that the laws were L_1, \dots, L_n , and the matters of particular fact were C_1, \dots, C_m ; then it would have been the case that

Our intuitions on the truth of this conditional seem on a par with our intuitions on the truth of the non-conditional

In a world with law L_1, \dots, L_n , and matters of particular fact C_1, \dots, C_m ;

That is such a conditional can be taken as elliptical for describing some possible world the non-accessibility of which is irrelevant.

Alternatively we could see such a conditional as a nested counterfactual. For the conditional seems in no way distinct from

If this world had been a world where there are only accidental generalisations; then, if it had been the case that the generalisations were L_1, \dots, L_n , and the matters of particular fact were C_1, \dots, C_m , then it would have been the case that

Now this nested conditional can be treated in the standard way, for we consider the most accessible Hume world (most similar to the actual world) and then from this world consider the most accessible Hume world with L_1, \dots, L_n as true generalisations and C_1, \dots, C_m as matters of particular fact (the similarity being based simply on the consideration of particular facts).

6. DERIVED LAWS

We commonly make a distinction between fundamental laws, which include the entailments of fundamental laws, and derived laws. The account of laws proffered in this paper is an account of fundamental laws. Derived laws are universal generalisations which are entailed by the fundamental laws conjoined with accidental facts. So the law of universal gravitational attraction is a fundamental law, while a law which expresses the force of gravitational attraction on mass m distance r from the centre of the Earth is a derived law. It is entailed by the law of universal gravitational attraction together with certain facts about the Earth.

Derived laws will not be true in all accessible worlds, for the accidental facts on which their consistency with the fundamental laws depends will vary from accessible world to accessible world. In fact as any matter of particular fact is changed, there will be a corresponding change in the derived laws. However there is an obvious explanation as to the lawlike nature of derived laws, for a proposition p which is a derived law in world w_0 entailed by the

fundamental laws of w_0 and the particular facts C_1, \dots, C_n will be true in w_0 and in all worlds accessible to w_0 in which the particular facts C_1, \dots, C_n are true. So we will preserve a relationship between laws and counterfactual conditionals even with derived laws.

An interesting application of the distinction between fundamental laws and derived laws is the notorious controversy concerning the difference in the status of the laws of physics and the laws of biology. It has been even suggested that biology does not have any generalisations which are truly laws. This is because that the laws of biology seem to depend on certain contingent facts, such as the fact that living organisms are carbon based. Had they been silicon based, things would have been different.¹¹

But it seems wrong to challenge the lawlike status of the generalisations of biology, though it may often be appropriate to deny that some of the more common laws of biology are fundamental. Some, such as the laws of evolutionary theory, may be fundamental. But often the laws we know and use seem to depend on accidental facts about the actual world. Thus they are better seen as derived laws which hold in all accessible worlds where these accidental facts are true. But in other accessible worlds, often accessible to a much lesser degree, where these accidental facts do not hold, there will be different (derived) laws of biology. The fundamental laws of physics will still hold in such worlds, as will the fundamental laws of biology many of which we do not know.

7. REDUCTION

The fact that we can get from any possible world to any other possible world in at most two steps does allow us to express a relationship between nomic possibility and necessity, and logical possibility and necessity.

$$\diamond p \equiv \boxed{N} \boxed{N} p$$

$$\square p \equiv \boxed{N} \boxed{N} p$$

Thus while it is not possible to give a reduction of the nomic concepts in terms of logical ones, it is possible to give a reduction the other way around. Hence the theory is not committed to a multiplicity of primitive modal concepts, only to the acceptance of a single new one.

It is tempting to offer some argument that this new primitive concept, that

of nomic possibility, is closer to the pre-analysis or pre-philosophic concept of possibility than is abstract logical possibility. This pre-philosophic concept of possibility does not have it any more possible for a man to jump over the moon or for a rocket to go faster than the speed of light, than it has it possible to construct a five sided square. Consistency may be a necessary condition for possibility, but is not a sufficient one. If nomic possibility were to be taken as providing an analysis of this possibility concept, then consistency or logical possibility can in turn be provided with a reductive analysis in terms of nomic possibility. Logical possibility becomes what is possibly possible, a result which itself does not lack intuitive pre-analysis appeal.¹²

NOTES

¹ This paper concentrates on such deterministic laws, but the account offered can be extended in an obvious way to indeterministic or statistical laws of the form 'Every A has a chance of p of being a B '.

² This theory has been developed by S. Kripke: 1963, 'Semantical considerations on modal logic', *Acta Philosophica Fennica*, and by David Lewis: 1973, *Counterfactuals* (Blackwell, Oxford).

³ See G. E. Hughes and M. J. Cresswell: 1968, *An Introduction to Modal Logic* (Methuen), pp. 259–260, and also G. E. Hughes and M. J. Cresswell: 1975, 'Omnitemporal logic and converging time', *Theoria* 41, pp. 11–34. George Hughes has shown this system is both complete and sound, and I am indebted to his assistance in this matter.

⁴ See Frank Jackson: 1977, 'A causal theory of counterfactuals', *Australasian Journal of Philosophy* 55, pp. 3–21 and David Lewis: 1979, 'Counterfactual dependence and times arrow', *Noûs* 13, pp. 455–476.

⁵ See Robert C. Stalnaker: 1968, 'A theory of conditionals', in N. Rescher (ed.), *Studies in Logical Theory* (Blackwell, Oxford), pp. 98–112, and David Lewis: *Counterfactuals*.

⁶ John Bigelow suggested treating similarity as accessibility in degrees. See 'Quantum Probability in Logical Space', *Philosophy of Science* 46 (1979) pp. 223–243.

⁷ See Frank Jackson: *op. cit.*; and David Lewis: 'Counterfactual dependence and times arrow'.

⁸ John Pollock: 1976, *Subjunctive Reasoning* (Reidel).

⁹ See Frank Jackson's (1980) review of Pollock in *Australasian Journal of Philosophy* 58, pp. 413–415; and Jonathan Bennett: 1974, 'Counterfactuals and possible worlds', *Canadian Journal of Philosophy* 4, pp. 391–393.

¹⁰ Frank Jackson: *op. cit.*; and David Lewis: *op. cit.*

¹¹ See for example, Smart, J. J. C.: 1968, *Between Science and Philosophy* (Random House), p. 93ff.

¹² I am indebted to useful comments on an earlier version of this paper by David Lewis, John Pollock and Frank Jackson.

*Department of Philosophy,
La Trobe University,
Bundoora, Victoria,
Australia.*