EXPLICATING LAWHOOD*

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D. M. Armstrong, Michael Tooley, and Fred Dretske have recently proposed a new realist account of laws of nature, according to which laws of nature are objective relations between universals. After criticizing this account, I develop an alternative realist account, according to which (1) the nomic structure of a world is a relation between initial world-histories and world-histories, and (2) a law of nature is a fact that holds solely in virtue of nomic structure (and not, for example, in virtue of past history).

1. Introduction. What is a law of nature? The most well-known accounts are the regularity (or Humean) accounts that were popular among the logical empiricists. According to the simple regularity account, laws are just facts expressed by contingently true, universally quantified, spatiotemporally unrestricted, material conditionals. Although there have always been critics of the regularity account, it was not until the 1970s, with the rising tide of scientific realism, that alternatives were systematically developed and discussed. In particular, D. M. Armstrong (1978, chapter 24), Michael Tooley (1977), and Fred Dretske (1977) each independently proposed an alternative account of lawhood—called *the property (or universal) theory*—according to which laws are mind-independent relations between universals—not mere regularities.[1]

Property theorists—and nomic realists in general—argue that being a regularity is neither necessary nor sufficient for being a law. Being a regularity is *not sufficient* for being a law, because regularities may be mere accidents, not laws. To use an example of Popper's (1968, p. 427–428), suppose that as a matter of fact every Moa (a now extinct bird species) died before age fifty. Suppose further that at least some Moas were capable of living longer, but didn't, due to the presence of a virus.

*Received June 1986; revised December 1986.

†I have benefited from the critical comments of David Armstrong, Bryson Brown, Philip Catton, Bill Demopoulos, Chris Gauker, Bill Harper, Patrick Maher, John Metcalfe, Rick Otte, Howard Sobel, Michael Tooley, Bas van Fraassen, and two anonymous referees for this journal. Research on this paper was supported by an internal grant from the Social Sciences and Humanities Research Council of Canada while I was at the University of Western Ontario.

[1]See also the articles of Chris Swoyer (1982), John Earman (1984), David Lewis (1983), and Bas van Fraassen (forthcoming) for further discussion of the property theory account.

Philosophy of Science, 55 (1988) pp. 598–613.

In such a case the regularity that all Moas die before age fifty is a historical accident—not a law. The history of worlds does not strictly determine what their laws are.

Being a regularity (of a certain sort) is *not necessary* for being a law, because nondeterministic (for example, probabilistic) laws need not manifest themselves in any particular regularities. For example, it may be a law that there is a 90% chance that anything with property P will also have property Q, and yet as a matter of fact 80% (or any percentage other than 90%) of Ps are Qs. Nondeterministic laws of worlds do not strictly determine the histories of the worlds.

Sophisticated regularity accounts (such as Braithwaite 1927; Goodman 1954; and Lewis 1973) attempt to overcome the above problems by claiming that a regularity is a law (if and) only if it satisfies some further epistemic, pragmatic, or systemic requirement (for example, that it be highly confirmed, widely accepted, or a theorem of each true deductive system that best combines simplicity and strength). These sophisticated regularity accounts are inadequate because they inappropriately make lawhood mind-dependent (in that they entail that the existence of laws depends on what humans have confirmed, on what they accept, or on their standards of simplicity). The existence of laws (and their character) in no way depends on the existence of minds.

Finally, both the naive and the sophisticated regularity accounts of lawhood are too weak for laws to provide objective support for counterfactuals and inductive inferences. For laws to support counterfactuals they must determine what might (or would) have happened, had the history of the world been different at some point. For laws to support inductive inferences they must determine what may (or will) happen in the future. On regularity accounts, laws do neither of these things, since laws are claimed to be just whatever regularities happen to take place.

In assessing a work on laws it is important to distinguish between two projects: (1) that of giving an explication of the intuitive notion of lawhood, and (2) that of defending a claim that there are (or are not) laws in the explicated sense. With respect to the first project, the property theorists' criticisms of the regularity account of lawhood establish a strong case against the regularity account as an explication of lawhood. Any adequate explication of lawhood must clarify the important role of laws in supporting counterfactuals and inductive inferences. The property theorists argue, and I shall assume, that only a realist account of lawhood (that is, one that ascribes necessity to nature), can meet these demands. The main goal of this paper is to present and defend a realist explication of lawhood different from the property theory.

With respect to the second project—that of defending a claim that there are (or are not) laws in some realist sense (that is, involving natural ne-

cessity), the property theorists hold, as do I, that the best explanation of the observable phenomena—including the apparent success of science—will postulate such laws (just as it postulates not only sense data, but also material objects), and that that is a good reason to believe that there are such laws. Of course, even those who accept a realist explication of lawhood can reject either the claim that the best explanation will postulate such laws, or the claim that postulation by the best explanation is a reason to believe in the truth of the postulate. My goal here is simply to provide a more adequate explication of lawhood—not to defend a claim that there are such laws.[2]

Let us start, then, by considering the property theory of lawhood, and seeing why an alternative realist account might be more adequate.

2. The Property Theory of Lawhood. According to the property theory, laws of nature are objective relations between universals. *Universals* (properties and relations) are here to be distinguished from *concepts*. Both are to be understood as entities that may be instantiated (in general by many different things). They differ, however, in two important ways. First, universals are *wholly present* as non-spatiotemporal parts in whatever instantiates them. Concepts, on the other hand, are not *parts* of the individuals that instantiate them. Second, and for the present purposes more importantly, universals are relatively *sparse* compared to concepts. Universals are determinates, whereas concepts may be either determinates or determinables. Thus, for each universal (such as: "weighs exactly 2 kilograms") there is a corresponding concept, but for many concepts (namely those that are determinables, such as: "does not weigh exactly 2 kilograms", and "weighs at least 2 kilograms") there is no corresponding universal.[3] In summary, the notion of universalhood used by the property theory is not merely the notion of something that (in general) can be instantiated by many things (in other contexts 'universal' is used in this weaker sense), but rather the notion of something that is relatively sparse and that is wholly present as a non-spatiotemporal part in those things that instantiate it.

The two most comprehensive statements of the property theory are given by D. M. Armstrong (1983) and Michael Tooley (1977). Armstrong's main thesis is that the obtaining of a law of nature is a state of affairs of the form "$(N:p)(F,G)$", where $0 < p \leq 1$, F and G are universals, and N is the metaphysically contingent relation over universals of *probabi-*

[2]For a statement of some of the empiricist reasons for not believing that there are any laws of nature realistically understood, see Earman (1984). For a statement of some scientific realist reasons for believing that there are such laws, see Boyd (1985).

[3]See Armstrong (1978) and Lewis (1983) for more on the difference between universals and concepts.

listic nomic necessitation. Thus, "(N:p)(F,G)" is read as: the laws of nature necessitate with probability p that Fs are Gs. (Deterministic laws necessitate with probability 1.) Tooley's account is essentially the same, except that in addition to probabilistic nomic necessitation (N), he recognizes a multitude of other nomic relations. Simplifying somewhat, Tooley's main thesis is that the obtaining of a law of nature is a state of affairs of the form "$R(F_1,F_2 \ldots F_n)$", where: n is some natural number, F_1, F_2, . . . F_n are universals, and R is an n-ary nomic relation over universals. Examples of nomic relations include: ___ nomically necessitates ___ with probability 0.6, ___ nomically excludes ___ with probability 1.0, not being ___ nomically necessitates being ___ or ___ with probability 0.7.

Armstrong and Tooley not only have different accounts of lawhood, they also differ in their ontologies for universals. Although neither recognizes negative or disjunctive universals (that is, universals equivalent to the negation or disjunction of other universals), Tooley recognizes—but Armstrong does not—uninstantiated universals.

Tooley's account has, I think, two main advantages over Armstrong's. First, because Armstrong recognizes only *instantiated* universals, he has problems dealing with laws involving uninstantiated universals (for example, a law that objects not subject to any external force move at a constant velocity). For if uninstantiated universals (for example, "not subject to any external force") do not exist in a given world, they are not there to be a relatum for the laws of nature. But surely there are, or at least could be, such laws. Armstrong deals with this problem by claiming that the purported laws involving uninstantiated universals are not really laws, but rather counterfactuals about what the laws would be, if the universal were instantiated. To support such counterfactuals he postulates a hierarchy of higher order laws governing what the lower order laws would be, if the universal were instantiated. Tooley, on the other hand, has no need to postulate these mysterious higher order laws, since uninstantiated universals are part of his ontology, and thus nomic relations involving uninstantiated universals are unproblematic. Armstrong is understandably reluctant to include uninstantiated universals in his ontology, but if the choice is between recognizing uninstantiated universals and recognizing a hierarchy of laws governing what the lower level laws would be if certain uninstantiated universals were instantiated, the former choice seems preferable.

A second and more important advantage of Tooley's account over Armstrong's concerns the complexity of laws of nature. Many nomic relations will involve a very large number of—and certainly more than two—universals. For example: "All Fs must be H_1s or H_2s . . . or H_ns" and "All Fs that are not G_1s, or G_2s, . . . or G_ns must be Hs". Because Tooley

recognizes a multitude of nomic relations, he has no problem recognizing these complex nomic relations. Armstrong, on the other hand, has problems, because he only recognizes the nomic relation of nomic necessitation. To handle complex nomic relations, he distinguishes between iron laws and oaken laws. An *iron law* that all Fs must (perhaps with some specified probability) be Gs holds just in case all Fs—*no matter what other universals they may instantiate*—must be Gs. *Oaken laws* of that form, on the other hand, hold just in case all F's *which do not instantiate any "interfering" universals* must be Gs. (If, as a matter of fact, there are no interfering universals, then such oaken laws are also iron laws.) His relation of nomic necessitation, he suggests, should be understood as an oaken relation, that is, $(N{:}p)(F,G)$ holds just in case Fs *which do not instantiate any interfering universals* must be Gs with probability p. Complex laws are to be understood as a combination of one or more oaken laws. For example, a law of the form "All Fs which are not Gs must be Hs" is understood as the oaken law "All Fs must be Hs", with G as the only interfering universal.

The problem with this proposal is that the notion of an interfering condition is too open-ended. Without a specification of what the possible interfering conditions are, the claim that $(N{:}p)(F,G)$—understood as an oaken law—says nothing (even where $p = 1.0$) about the actual propensity of Fs to be Gs. It all depends on how sparse the interfering conditions are. If there are no interfering universals, then the propensity of Fs to be Gs is p. If, however, almost every universal is an interfering universal, then Fs may have very little propensity to be Gs. Statements of oaken "laws" are not law statements, but rather partial and incomplete sketches of law statements. They are incomplete because they do not specify what the interfering conditions are. For this reason, one cannot take the nomic relations to be oaken relations. Consequently Armstrong's account of lawhood is unable to adequately deal with complex nomic relations.

Tooley has no need to appeal to the problematic notion of non-iron laws in order to deal adequately with complex nomic relations. Where Armstrong would say that it is a non-iron law that all Fs must be Gs (with the only interfering factors being $H_1,\ldots,H_n$), Tooley would say that it is an iron law that all Fs which are not H_1, not H_2, . . . and not H_n must be Gs. Because Tooley's nomic relations may be many-place and may involve the logical relations of negation, disjunction, etc., there is room for the explicit specification of interfering conditions.

Tooley's account of lawhood seems to be the most promising property theory. The main problem with it—indeed with any property theory—is that it requires realism about universals (of the sparse and wholly present kind). Most of us would like to avoid postulating universals, if at all possible. Of course, some (for example, Armstrong 1978) are convinced

that we need to postulate universals in order to solve other philosophical problems (for example, problems concerning the One over the Many, meanings, and intentional attitudes), and so will see no harm in postulating universals to give an account of lawhood. Many of us, however, are not convinced that we need to postulate universals to solve these other problems, and so see the loss of ontological economy required by the property theory as a serious disadvantage. This, of course, is not a knockdown objection to the property theory, since an adequate account of lawhood may very well require realism about universals. Still, it suggests that we should investigate realist accounts of lawhood that do not require realism about universals.

One possibility is a *concept theory* of lawhood according to which laws are relations among *concepts*.[4] More specifically, according to the concept theory, a law of nature is the obtaining of a state of affairs having the form "$R(F_1,F_2,\ldots,F_n)$", where: n is a natural number, $F_1, \ldots, F_n$ concepts, and R an n-place concept over concepts. This account is exactly like Tooley's, except that it involves concepts instead of universals.[5]

Recall that, like universals, concepts are entities capable of being instantiated, but, unlike universals, concepts are neither sparse nor wholly present in the things that instantiate them. Concepts are Fregean senses, or rules for classifying things (for example, functions from worldbound individuals to truth values). They are not *in* worlds (as universals are claimed to be), but rather something that we use to classify things in worlds. Of course, the exact nature and status of concepts is controversial; the point here is simply that they are quite different sorts of entities than universals.

The main advantage of the concept theory is that it does not require the postulation of universals as basic ontological entities. Indeed, it can give a reductionistic account of universals. Following a suggestion of Putnam (1970), universals can be identified with sets of nomologically equivalent concepts. Although the concept of having a certain temperature and that of having a certain mean kinetic energy are distinct, in our world the property of having the specified temperature is (according to the lore, at least) strictly identical with the property of having the specified mean kinetic energy (since the two equivalence classes of concepts are strictly identical).[6] This account of universals has the advantage that

[4]Here and below I use 'relation' to refer to n-place concepts, except when discussing the property theory, where I use it to refer to n-place universals.

[5]Lewis (1983, pp. 365–366), briefly discusses and rejects this possibility, but he restricts the relata to "natural concepts", where these are roughly those concepts that are relevant to causal powers. (Lewis actually uses the term 'property', but by this he means 'concept'—not 'universal'.)

[6]Natural concepts can be identified with concepts that are satisfied just in case all their

it properly recognizes the role of laws in determining what universals there are in the world (in that the laws determine which concepts are nomologically equivalent). Viewing laws as relations among universals (the property theory account) does not properly recognize the role of laws, since on that account universals are assumed to exist independently of the laws that relate them.

Although the concept theory of lawhood does not require a strong realism about universals, it does require some sort of realism about concepts. That, however, is less worrisome than realism about universals, since some sort of realism about concepts is needed in any case to give an adequate account of the meanings of utterances and intentional attitudes (see, for example, Lewis 1983, and Stalnaker 1984). I shall return to this point below.

The concept theory seems to give an adequate account of lawhood, but it does not yield a very perspicuous account of the important notion of the nomic structure of a world. The nomic structure of a world determines, for any given state of the world, which future states of the world are nomically possible. Individual laws are facts guaranteed by the nomic structure of the world. Law statements are partial descriptions of the nomic structure. Because the notion of the nomic structure of the world is an important one (science aims to describe the nomic structure of the world), in the rest of this paper I shall develop and defend an account of nomic structure, and relate lawhood to nomic structure.

3. An Alternative Realist Account. Let a *world-history* be a state of affairs that involves everything that happens at all points in time of some world. World-histories need not have a beginning or an end. An *initial world-history* is a state of affairs that involves everything that happens up to some point in time in some world, and which involves nothing pertaining to later times. World-histories and initial world-histories involve only what happens; in particular, they involve nothing concerning nomic features of the world.

To forestall some objections, two comments need to be made about the notions used to characterize the notion of a world-history. First, for simplicity I write as if temporal order were completely absolute, and not—as relativity theory tells us—in some degree relative to a coordinate frame. All discussion is to be understood as relative to an arbitrary coordinate frame. Second, I here ignore the important problems of explicating temporal aboutness (that is, the notion that a state of affairs is "about", or

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nomological equivalents are satisfied. Note that on this account natural concepts (and universals) are sparse, but not wholly present in whatever instantiates them.

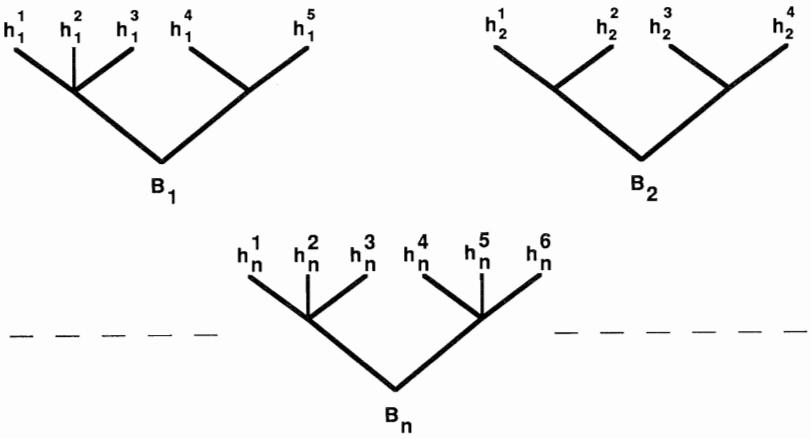

Diagram 1

"pertains to" some point in time), and of explicating the difference between nomic (for example, dispositional) features and non-nomic (for example, occurrent) features. In particular, I remain neutral on the question of whether or not these notions are language-relative (for example, dependent on the specification of a "non-temporal", or of a "non-nomic" vocabulary).

Consider first a world in which the laws are merely possibilistic (including deterministic laws), but not probabilistic, in that they determine what is possible, but ascribe no probabilities. The nomic structure of such a world is, I suggest, *a relation between initial world-histories and world-histories*. For a given initial world-history this relation (for a given world) is satisfied by exactly those world-histories that are nomically possible relative to the given initial world-history. In general this relation is different for different worlds (since in general different worlds have different nomic structures), but in every case the nomic structure of a given world is a relation between initial world-histories and world-histories. The relation need not be defined for all initial world-histories, since intuitively some are incompatible with the given laws of natures.[7]

The nomic structure of a world can be graphically illustrated, as in Diagram 1, as a set of tree diagrams, with each branch representing a

[7]Note that on this account the nomic structure of a world may—but need not—be a Markov process, that is, such that which future states of affairs are nomically possible at a given time depends only on the current state of the world, and not necessarily on the whole history of the world up to that point. This is as it should be, since although most believe that the laws of our world are Markov processes, it is surely not conceptually (or metaphysically) necessary that this be so.

world-history (with time increasing as one moves upward). Each tree diagram represents a different way that the world might have begun (if there was a beginning) and the different world-histories that were then nomically possible. A state of affairs is nomically possible relative to a given initial world-history just in case the state of affairs is realized by some world-history that is accessible (by "extension") from the given initial world-history.

For a world in which the laws are probabilistic, the nomic structure is, I suggest, a conditional probability function for world-histories relative to initial world-histories. The function may be undefined for some initial world-histories, but where defined for a given initial world-history it gives the objective probability of world-histories given the initial world-history. Probabilistic nomic structures can be represented diagrammatically as in Diagram 1 by further adding a probability function at each node (giving the objective probabilities of world-histories relative to the initial world-history that ends at that node).[8]

Note that on this account the fundamental relation, or function, is that of the nomic structure. A proposition expresses *a law* of nature just in case the nomic structure of the world guarantees its truth, that is, just in case it is a conceptual (analytic) truth that if the world has the given nomic structure, then the proposition is true (that is, just in case the proposition is true at all times in all worlds that have the given nomic structure). (A proposition expresses a law *in the strong sense* just in case it expresses a law and it is not a conceptual truth.) A relation among concepts (or universals) is *a nomic relation* just in case the nomic structure of the world guarantees that it holds for all individuals. Thus, for example, if the nomic structure guarantees that the half-life of radium is t, then it is a law that the half-life of radium is t. If the nomic structure guarantees no particular half-life, but does guarantee that the objective probability distribution for the half-life of radium is d, then it is a law that the objective probability distribution for the half-life of radium is d.

A number of formal conditions seem appropriate for the function, or relation, over initial world-histories and world-histories that represents the

[8]A uniform account of both probabilistic and non-probabilistic nomic structures can be given by viewing the nomic structure of a world as a *set* of probability functions for which all the members: (1) are defined for exactly the same initial world-histories, and (2) where defined, agree as to whether the probability assigned to any given world-history is zero or not (if one assigns a given world-history a zero (non-zero) probability, they all must do so). The nomic structure of a world is represented by whatever the members of the set have in common. Nomic structures with determinate objective probabilities will have only one probability function in the set. Non-probabilistic nomic structures will consist of some *maximal* set having the above two features. Nomic structures with *indeterminate*, objective probabilities (for example, probability ranges) will consist of some non-maximal, non-singleton set having the above two features.

nomic structure of the world. First, for probabilistic nomic structures the objective probability assigned to a given world-history relative to a given initial world-history is to be zero (one) if and only if the world-history is nomically impossible (necessary) relative to the initial world-history.[9]

Second, as already mentioned, the function, or relation, may be undefined for some initial world-histories, since for any nomic structure there may be some initial world-histories that are incompatible with it. (For example, initial world-histories in which objects travel faster than the speed of light are incompatible with the nomic structure we believe our world to have.)

Third, if the function, or relation, is defined for a given initial world-history and world-history, then it must be defined for that initial world-history and all other world-histories. This reflects the fact that the lack of definition comes from the incompatibility of the initial world-histories—not the world-histories—with the nomic structure. World-histories that are incompatible with the laws of nature simply get an objective probability of zero (are judged objectively impossible) for all initial world-histories for which the function (relation) is defined.

Fourth, if one initial world-history is a temporal extension of a second (that is, the first covers later points in time), then: (1) if the function, or relation, is *undefined* for the shorter one, then it must be undefined for the longer one (if a given initial world-history is incompatible with the laws of nature, then so must any extension); and (2) if the function or relation is defined for both, then for all world-histories: (a) if relative to the shorter initial world-history the probability of a given world-history is *zero* (the given world-history is not nomically possible), then this is also true relative to the longer initial world-history (the passage of time cannot make a nomically impossible world-history become possible); (b) if relative to the shorter the initial world-history the probability of a given world-history is *one* (the given world-history is the only nomically possible one), then this is also true relative to the longer initial world-history (the passage of time cannot make a nomically necessary world-history cease to be necessary); and (c) if relative to the shorter initial world-

[9]If (as seems plausible) there are infinitely many causally possible world-histories, this requires that the probability function assign some world-histories an infinitesimal probability (that is, a number that is smaller than any finite number). For, if for a given initial world-history there are infinitely many nomically possible world-histories, and they all receive non-zero, non-infinitesimal probability, the (infinite) sum of the probabilities will be greater than one, which is incoherent. For such a case the world-histories must be assigned a probability of zero (even though they are nomically possible) or a non-zero, infinitesimal probability. When the probabilities represent objective chances (as they do in the present case) it is preferable to assign non-zero infinitesimal probabilities, so as to ensure that the objective chance of zero (one) entails that the state of affairs is nomically impossible (necessary). See Appendix 4 of Skyrms (1980) for further discussion and references concerning infinitesimal probabilities.

history the probability of a given world-history is *strictly between zero and one,* then relative to the longer initial world-history the probability of the given world-history must either be at least as great or be zero (the passage of time does not decrease probabilities of world-histories except by reduction to zero).

Fifth, if a world-history is not a temporal extension of a given initial world-history, then if the function, or relation, is defined for that initial world-history, it must assign an objective probability of zero to that world-history (make the world-history nomically impossible) relative to the initial world-history. This reflects the fact that any world-history that disagrees in any way with a given initial world-history is not nomically possible relative to that initial world-history. Once fixed, the past cannot be changed.

To a very large extent, this account of lawhood is not especially new. Storrs McCall (1969, 1976) has suggested in passing the rudiments of this account[10], and something of this sort is implicit in much recent work on determinism and on possible worlds semantics for temporal logic.[11] Indeed, a common possible worlds characterization of laws is the following: a proposition expresses a law just in case it is true in all physically accessible worlds. If 'physical accessibility' is understood in the sense of 'having the same nomic structure' (and it often is), and the characterization is understood as requiring that the proposition be true at all times, then this characterization agrees with the proposed account. Two differences, however, should be noted.

First, unlike most possible-world accounts (for example those of Niiniluoto 1978 and Pargetter 1984), the proposed account does *not* treat as primitive the relation *between* worlds of having the *same* nomic structure (being physically accessible). The proposed account explicates the notion of nomic structure of a world as something *internal* to that world (a function, or relation, over world-histories and initial world-histories), and takes the notion of having the same nomic structure as derivative. The problem with the accounts that take physical accessibility (having the same nomic structure) as primitive is that they do not clarify the central

[10]Although I have benefited much from the cited articles of Storrs McCall, I developed almost all of the present account before having read them. I realize now, however, that my thoughts on these matters have been strongly influenced by a course on modal logic that I took from him some eight years ago.

[11]An important work on temporal logic using a branching world-history approach is Thomason (1970). For a wonderful survey of recent work on temporal (and deontic) logic, see Thomason (1982). Both Thomason and Gupta (1981) and van Fraassen (1981) use a branching world-history approach to provide the semantics for conditionals. Montague (1962) and van Inwagen (1983) give an account of determinism strongly suggestive of the account of laws here presented. Popper (1968, Appendix *x) gives an account of natural necessity in a similar spirit. Finally, the history-to-chance conditionals of Lewis (1980) correspond to laws on my account (although Lewis himself has a different account of lawhood).

notion of nomic structure. Like the proposed account, they say that a law is a proposition that is true in all worlds having the same nomic structure, but, unlike the proposed account, they tell us nothing about the nature of nomic structure. An analogy may help here. Consider houses (the analogues of worlds) and their structural features (the analogues of laws of nature). Some features of houses (for example, the number of floors) are structural, and some (for example, their color) are not. What makes something a structural feature? The analogue of the usual accounts would claim that a feature is a structural feature of a given house just in case it is shared by all houses having the same structure. This is true but relatively uninformative. It tells us nothing about the nature of the notion of structure. The analogue of the proposed account would go on and give such an account (for example, that the structure of a house consists of the number, size, and arrangement of rooms, etc.).[12]

Second, often the accessibility relation between initial world-histories and world-histories (or between worlds) is treated merely as a technical semantic device. On the proposed account, however, the relation is to be understood realistically, and not merely instrumentally. Nomic structure is claimed to be a real feature of the world.

Let us now consider some possible objections. It might be objected that the proposed account is uninformative in that it explicates lawhood in terms of a mysterious relation between initial world-histories and world-histories. It is certainly true that, unlike regularity accounts of lawhood, the proposed account does not provide a *reductive* explication in the sense of explicating lawhood in terms of purely observational concepts. But this is as it should be! Realist explications of lawhood would not be realist if they reduced the notion of lawhood to something observational. The goal of a realist account must rather be to show how a realist notion of lawhood relates to other concepts. The proposed account is informative because it describes the network of concepts related to the concept of lawhood.

Of course, it might be objected that we do not have—and cannot have—any evidence that there are laws in the above (or any) realist sense. This, of course, strikes at the heart of the realist/anti-realist debate. Anti-realists insist (and realists deny) that observationally equivalent theories are evidentially equivalent. Realists insist (and anti-realists deny) that postulation by the best explanation (where the criteria of goodness for explanations are not restricted to empirical adequacy) provides good reason to believe in the truth of the postulate. Because I have defended a realist semantics for lawhood and nomic structure, anti-realists will deny that

[12]Likewise, to say that a state of affairs is morally obligatory just in case it is true in all morally accessible worlds, may be true, but it is relatively uninformative until we are given an account of the nature of moral accessibility.

we have any grounds for believing that there are laws in this realist sense.

Obviously, I can't settle this deeply controversial issue here. In any case, although I would defend the realist epistemology, and argue that on this epistemology we are justified in believing that there are laws in my realist sense, I have not attempted to do that here. All I have done is to defend a realist *semantics* for the notion of lawhood. This merely sets the stage for the debate between realists and anti-realists as to whether there are laws in the explicated sense.

Finally, it might be objected that, although my account does not require realism about universals, it does require a dubious realism about world-histories. If laws are facts guaranteed by the nomic structure of the world, and the nomic structure of a world is a relation (or probability function) between initial world-histories and world-histories, then in some sense world-histories and relations (two-place, second-order concepts) between world-histories must be recognized as real.

My account does require some sort of realism about world-histories and relations between them, but the required realism is relatively weak and unproblematic. First, world-histories are to be understood as propositions about what happens in worlds—not as concrete particulars. So no hard core realism about concrete possibilia (in the style, say, of David Lewis) is involved.[13] Furthermore, some sort of realism about propositions is required in any case to give an adequate account of the meaning of linguistic utterances (the meaning of a sentence is a proposition), and to give an adequate account of intentional attitudes (belief is a relation between individuals and propositions).[14] Second, no claim is made that propositions and relations exist independently of human interests and practices. Conceptual frameworks (which determine which propositions and relations there are) are admittedly not given by nature, but rather by human practice. The proposed account requires only that, however propositions may be generated, it is the world—not we—that determines whether a given proposition is true. We may generate the propositions, but the world determines their truth value.[15] More specifically, the proposed account claims that our notion of nomic structure is (or is suitably explicated as) a relation between initial world-histories and world-histories. We may generate the nomic structure relations and the world-his-

[13]The nomic structure relation for a given world is thus a relation of nomic possibility between propositions (a world-history is causally possible relative to a given initial world-history). Unlike relations of conceptual possibility between propositions, relations of nomic possibility are world-relative (that is, three-place relations between worlds and two propositions).

[14]See, for example, Stalnaker (1984) for a defense of some sort of realism about propositions.

[15]Stalnaker (1984, pp. 152–153) advocates a weak realism of this sort for propositions and possible worlds.

tories, but the world determines the truth of any attribution of nomic structure.

4. Conclusion. My goal has been to offer an adequate explication of our notion of lawhood. The property theorists have argued convincingly that the regularity account is inadequate because it fails to ascribe necessity to nature.[16] As intuitively understood, laws play an important role in supporting counterfactuals and inductive inferences, and no account that does not ascribe necessity to nature can adequately account for this feature of lawhood. The property theory of lawhood—especially Tooley's version—represents an important step forward, but has the disadvantage of requiring a strong realism about universals. I have presented and defended an alternative realist account, according to which the nomic structure of a world—that is, the totality of its laws of nature—is a relation, or probability function, over initial world-histories and world-histories. A law of nature is simply a fact that is guaranteed by the nomic structure of the world.

Because, like the property theory, this account of lawhood ascribes necessity to nature, it adequately reflects the role of laws in supporting counterfactuals and justifying induction. Nature has a certain disposition to behave in various ways (as determined by the nomic structure), and that determines what would (or might) have been true, and what will (or may) be true in the future.[17] Unlike the property theory account, however, the proposed account does not require any strong realism about universals; it only requires a weak sort of realism about propositions and concepts. Furthermore, when combined with the plausible claim that universals are classes of nomologically equivalent concepts, the proposed account, unlike the property theory, promises to provide a satisfactory reductive account of universals that clarifies the role of laws in deter-

[16]Sophisticated regularity accounts can, of course, distinguish between accidental and "lawlike" generalizations, and *treat* the latter as involving some sort of necessity. (For example, "lawlike" generalizations might be those generalizations that are widely accepted or highly confirmed.) But to ascribe necessity *to nature* the necessity must stem from causal powers of the world and be independent of human practices. A defining characteristic of regularity accounts is the rejection of such ascriptions.

[17]A highly attractive feature of my proposed account is that it provides the basis for a powerful theory of context-independent, *objective* counterfactuals. The semantics for such conditionals (which are crucial for science and for decision theory) have been developed by Storrs McCall (1984). Roughly, the semantics assess a would (might) counterfactual as true at a time in a given world just in case the consequent is true in all (at least one) of the then nomically possible world-histories in which the antecedent is true. If, given the history of the world up to the specified time, the antecedent is false on all nomically possible world-histories, one assesses the conditional by "backing up" to the nearest point in time that allows the antecedent to be true, and assessing the truth of the counterfactual relative to that initial world-history. No objective truth conditions are given for counterlegals (that is, counterfactuals that violate the laws of nature).

mining why certain properties are identical. Finally, unlike the property theory, the proposed account explicates the important notion of the nomic structure of a world.

If the new account is adequate as an explication of lawhood, then the next question becomes: Are there any such laws? Science, I would argue, postulates such laws, and so we should believe that there are such laws. But that's a topic for another paper.

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