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An Empiricist's Guide to Objective Modality

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1. MODALITY

Modality is a sticking point for empiricists. Some of them (e.g., Ladyman 2004) recognize that science comes with a heavy dose of modal commitment—a whole slew of beliefs not only about how things are, but how they might have been, could have been, or would have been had things been otherwise—and accept modality on the strength of their commitment to science. But others shun it on the grounds that talk of non-actual possibilities is epistemologically and metaphysically suspect.[1] If we take the semantics of modal belief at face value, moreover, it seems that we are committed to the existence of non-actual possible worlds, and it has never been clear what these are, or how we could know about them. So understanding modality is a matter of some urgency for philosophers of science. On the one hand, there is a near-universal recognition that modality is central to science. Science cares not only about the pattern of actual events but also what they reveal about the modal substructure behind the phenomena. On the other hand, there is among many a desire to reject metaphysical commitment to non-actual, possible worlds. To satisfy that desire while preserving scientific practice, one needs an account of modality that makes modality immanent in the actual world, i.e., one that does not take the semantics of modal belief at face value.

[1] Van Fraassen takes rejection of modality to be one of the defining features of empiricism: "To be an empiricist is to withhold belief in anything that goes beyond the actual, observable phenomena *and to recognize no objective modality in nature*" (1980, 202; emphasis mine).

Early attempts to remove metaphysical commitment took the form of attempts to reduce modal concepts to non-modal ones. Views of this form hold that modal concepts do not add anything to a description of the pattern of actual events. Such views run into difficulties, however getting the contents of modal belief correct. In this paper, I defend an empiricist account of modality that keeps a substantive account of modal commitment, but throws out the metaphysics. I suggest that if we pair a deflationary attitude toward representation with a substantive account of how scientific models are constructed and put to use, the result is an account that deflates the metaphysics of modal commitment without deflating the content of modal claims.

In section 2, I review the recalcitrant stumbling block for reduction. In section 3, I look at the function of models and the practical and epistemic role that modal structures play.[2] In section 4, I introduce a generic account of modal structures as partially prepared solutions to frequently encountered problems (PPS's to FEP's). In section 5, I compare my account of laws and chances with the account that comes out of David Lewis's Best Systems Analysis. In section 6, I suggest that the account avoids the pitfalls of both reification and reduction.

2. THE PERSISTENT STUMBLING BLOCK FOR REDUCTION

Modal notions enter science with concepts like cause, natural law, probability, dispositions, and capacities.[3] These notions all have a modal component. To say that L is a law is to say more than that things always happen in accord with L. It is to say that things happen in accord with L in every physically possible world (or that every physically possible world satisfies L). To say that a certain type of event (e.g., a coin flip coming up heads, or an atom decaying within a given time frame) has a good chance of occurring is not to say that it *does* happen, but to say that it happens in a large measure of physically possible worlds. Similar things can be said about causes, capacities, and dispositions. The truth conditions of claims about these structures, on standard construals, make reference to possible worlds.[4]

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[2] I use "structure" in a generic way to refer to any property or relation. For examples of discussion in this mold, see Price (2011) and Kment (2014). I would not follow Kment in calling it an external standpoint, because it will itself *use* modal concepts. I explicitly deny the possibility of stepping outside the practice, as though we could describe or conceptualize or come to understand anything without using modal notions. The idea is rather to take a side-on view of the practice in which these concepts arise that is internal to a fully articulated scientific picture of the world. Doing this kind of genealogy for everyday modal belief is more difficult, since the epistemology of everyday belief is less explicit and systematic, and since the logic of common sense is less regimented than that of scientific discourse.

[3] I have benefitted greatly from audiences in Toronto and Rutgers, from discussion and correspondence with Barry Loewer, and from comments by Katherine Brading and Martin Jones that helped the paper immeasurably.

[4] Possible Worlds Semantics, which analyzes modal beliefs as beliefs about possible, non-actual worlds, has greatly clarified the formal and logical properties of modal thinking. According to Possible Worlds Semantics,

Here and throughout, I use laws and chances as exemplars of modal structures in science because they appear explicitly in fundamental theories, and because there are particularly well-developed discussions of their ontological status. I use the term "structure" generically to refer to any property or relation defined on our models of the world. According to this usage, dispositions, causes, and capacities provide other examples of modal structures.

Dynamical laws typically take the form of differential equations that give the rate of change for a quantity at a point. They entail the existence of regularities, but cannot be simply identified with regularities because the notion of law recognizes the possibility of regularities that are not laws. So, for example, we can easily write down a solution to the Newtonian equations of motion in which all of the birds in flight over Australia change direction as the clock strikes noon every day in Sydney. If this actually occurred, it might raise our suspicions that there were some laws that hadn't been identified, but it is possible that this is a merely accidental regularity, and the possibility that it is an accidental regularity is provided for by the Newtonian laws. It does not help to place restrictions on which *kinds* of regularities get counted as laws. Whatever condition one places on which regularities get counted as laws, it will always be possible to find solutions for a set of laws in which there are accidental regularities of the relevant kind.[5]

A very similar point can be made about chances. Chances are single-case probabilities represented by a real valued function over space-time.[6] The chance of a particular a that is b (e.g., a particular flip of a coin that lands heads) is derived from the indefinite probability of a/b (the indefinite probability that a flip of the same, or physically indistinguishable coin lands heads). And indefinite probabilities are connected to frequencies via a number of theorems of different strengths (the weak and strong laws of large numbers). So the link between chances and categorical facts goes by way of a link to indefinite probabilities, and indefinite probabilities are connected to frequencies in a way that suggests that they are not entirely distinct existences. The relationship between chances and frequencies is very like the relationship between laws and regularities. As with laws, views that try to reduce

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to say that something might have happened is to say that it happens in some possible world. To say that something could not happen is to say that it happens in no possible world. To say that something would happen under conditions C is to say that it happens in the nearest possible world in which C obtain.

[5] This is a complex issue that has been rather heavily discussed in the literature. For an overview of the problems faced by reductive accounts of law, see Carroll (2016). For an overview of the problems faced by reductive accounts of chance, see Hajek (2011).

[6] In referring to chances as single-case probabilities, I am following the tradition of Lewis (1980). See also Bigelow, Collins, and Pargetter (1993) and Hall (1994). The philosophical discussion of chance, however, is fraught by ambiguous usage. Chances are sometimes identified with the indefinite probabilities described above.

probabilities to frequencies face a number of well-known problems, that stem from the fact that even the strongest of the theorems relating probability and frequency explicitly allow the possibility of probabilities that diverge from the frequencies. The logic of probability entails if something has the probability of 0.9, that does not mean it will occur. It does not even mean it will occur nine out of ten times. It means only that it will probably occur nine out of ten times, roughly, over the indefinitely long haul (or, perhaps, that it will probably occur nine out of ten times, in any large enough, not too carefully selected, set).[7]

Other modalized notions that resist reduction include causal relations, dispositions, capacities, and potencies. Among these, causal relations have a particular importance, and I will say some things specifically about them below. These are representative of the modal structures that appear in our scientific theories.[8] They are typically locally defined, but bear necessary connections to distributed structures or "patterns" in the manifold of categorical fact. We might say that they "encode information" about such patterns, and that information is drawn out in the kinds of empirical inferences in which they figure. A convenient way to picture things is that there is the ground level of categorical fact and then a second-order overlay of modal structures that play a role in epistemic and practical deliberation, or (as I will say), in guiding belief and decision.[9]

It is tempting to suppose that the structures on the second-order overlay are just re-descriptions of lower-level patterns, i.e., compact summaries of information about the pattern of actual fact. It is easy to see why we might find defined quantities that contain this kind of veiled information about distributed patterns useful. In general, we build a lot of useful, but extrinsic, information about how things generally hang together into our local representations of things, and this information can be unpacked to guide prediction and interaction with those things. When I describe a person as a wife, mother, and physician, for example, that is not an intrinsic description of her. It carries a lot of extrinsic information about the world, her place in it, and her habits. That information comes with a slew of expectations that are useful

[7] See Hajek (2011).

[8] I will focus on them. For discussion of causes, dispositions, and capacities, see Pearl (2000); Paul and Hall (2013); Kistler and Gnassounou (2007); Cartwright (1989).

[9] The image to have in mind is one of those old atlases in which some country or region is represented in colored ink on ordinary paper, followed by pages of transparencies that can be laid overtop of the original, adding information about anything from distribution of wealth to topology. In the analogy here, the categorical content is represented on the first pages as a four-dimensional mosaic of events. The modal content is drawn on the transparent overlays that assign chances to points, highlight causal pathways, give the dispositional profiles of the systems located in various regions, and so on. The structures on the overlay are second-order in that they contain information about patterns and relationships among the events that comprise the manifold.

in guiding interaction with her.[10] This is not just true of the way that we represent things in language. It has been known for a long time that the brain builds complex models of worldly regularities that guide expectation about what will happen, as well as offline predictions about what would happen if we acted in various ways.[11] Even perception is being increasingly understood as a process in which our brains do not just passively relay information but rather use an incoming signal as input to a stored schema that is used to predict the next signal before it comes in. The difference between the predicted signal and the one that occurs is then used to revise the schema (Clark 2013). The building of models that encode regularities that guide expectation (both about what *will* happen and what *would* happen under specified hypothetical conditions) is a common ground with representation in physics.

But as tempting as it is to see the chances, laws, and other modal structures built into our scientific models of the world as simply summaries of information about lower-level patterns, it turns out that no reduction is possible. These modal structures characteristically fail the logical test for identity with lower-level patterns for the reasons we saw already reflected above. Make any stipulation you like about what the laws are, and that stipulation will permit models in which there are exceptionless regularities that are not laws. There is a similar gap between claims about chance and claims about frequency. Make any stipulation you like about what the chances are, and that stipulation will permit models in which the chances diverge arbitrarily far from the frequencies. Something similar goes for dispositions, capacities, and causes. What this means is that claims about laws are not logically identical to claims about regularities, and claims about chances are not logically identical to claims about frequencies.

(Neo-)Humeans in the tradition of Lewis have tried to finesse this by combining stipulations about all of these into a single package and trying for a more holistic reduction.[12] But the difficulty remains. The problem is a generalization of the one

[10] To so much as call something a material object, or talk about its location in space, is to say something with very broad consequences about the possibility of various types of experience. It presupposes the whole embedding framework in terms of which material objects are defined. The constraints imposed by the embedding framework are the source of our most basic expectations about the world.

[11] The image of the brain as an engine of prediction can be found in various forms in contemporary neuroscience; see Bubic, von Cramon, and Schubotz (2010); Friston (2010); Helmholtz (1860); Kveraga, Ghuman, and Bar (2007). It remains an open question whether all brain processing can be subsumed by the predictive coding framework, but there is little doubt that the brain builds models that guide expectation, and that these models play a role in perception, imagination, and action.

[12] Lewis (1980) calls his view "Humean," and the terminology has become standard, though the view that goes under this label was almost certainly not Hume's own. Like Lewis, Hume denied that there are necessary connections between distinct existences, but he did not hold that beliefs about laws and chances reduce to beliefs about patterns in the manifold of categorical fact (Morris 2009; Strawson 1989; Beebee 2004). I have argued for a form of Humeanism closer (I believe) to Hume's own that cleaves to the denial of necessary connections,

that foils the more simple-minded reductions above; the logic of beliefs about laws-and-chances recognizes a modal gap between the facts about laws-and-chances and the categorical facts. Make any stipulation you like about what the laws + chances are, there are models of that law + chance package in which the categorical facts are very different than they actually are, and there are worlds in which the categorical facts are as they are, but the laws and chances are different. Let C be the categorical facts at a world W, and T be the Best Systematization of C. There are worlds at which C but not T (C is a model of other theories), and worlds at which T but not C (there are models of T in which not C). The persistent stumbling block for Humeanism is that there is a difference in truth conditions between structures on the second-order overlay and patterns in the manifold of categorical fact. These structures have a built-in inductive content in the form of implications for what would happen in hypothetical conditions that outruns any information about the pattern of actual fact. Information about the pattern of actual fact can provide evidence for claims about law or chance, but the relationship between the pattern of actual fact, on the one hand, and claims about the laws and chances, on the other, falls short of identity.

This can seem inconclusive for several reasons. A defender of reduction might say, that, since the difference in truth conditions can only be made out in modal terms, it is an empty difference. Or he might say that the claim that there are models of our law + chance packages in which the categorical facts are very different from what they actually are, and the claim that there are possible worlds in which the categorical facts are as they are, but the laws and chances are different, are both equivalent to the assertion that Humeanism is false. So the argument presupposes what it means to prove.[13] Or he might acknowledge that the Humean view closes a logical gap that our everyday notions of law and chance leave open, but bite the bullet. Barry Loewer—the most influential defender of (neo)-Humean reduction—adopts the last option. He acknowledges that the view is slightly revisionist about the everyday meaning of chance, but says (effectively): so much the worse for our everyday notion of chance (2004). This is a viable position only as long as the revised notion can serve all of the crucial functions of the everyday notion.

The problem with Loewer's response is that the revised notion *cannot* serve all of the crucial functions of the everyday notion. That brings us to the really telling objection against the Humean view which is that the Humean view has to close the logical gap between the modalized structures on the second-order overlay and

but drops the demand for reduction (Ismael 2015). I will follow the standard terminology here, using "Humean" to refer to the Lewisian tradition, without meaning to impute these views to Hume.

[13] The Humean can say this only at the cost of rejecting the identification of models of a physical theory with the physically possible worlds in which that theory holds.

categorical facts, but there is a difficulty with any attempt to do so that emerges when we adopt the side-on view and look at the function of these notions. No beliefs about mere description of patterns in the manifold of actual fact could play the role that beliefs involving these modalized notions play in guiding belief and action.[14] Creatures who need to make decisions about how to act have a need for beliefs whose inferential implications outrun beliefs about what merely happens, for they need to know what would happen if they acted in any number of ways, only one of which will be actualized. Beliefs about the results of hypothetical interventions in nature are indispensible in practical reasoning.[15]

3. FUNCTION

Let us start with a wide-angle view of why we construct models of the world at all. And here I do not just mean the relatively esoteric products of professional science; I mean the internal world-models that the brain constructs in order to help us navigate a complex and changing terrain. We are the only creatures who seem to have evolved to use models as the setting for an explicit form of practical reasoning (or at least do so with anything like the power and sophistication that we do; there is evidence that mice and other creatures do a rudimentary form of map keeping, but we have full-blown models of the world on which we represent ourselves and our ends). Our behavior (or, rather, our deliberate behavior, i.e., the willfully initiated movements of our limbs) is governed by a decision process that involves explicitly representing potential actions, imaginatively tracing out their effects, and making a choice about what to do based on projected outcomes. This process is our most powerful cognitive tool, one that gives us our primary advantage over other kinds of naturally evolved cognitive systems. Models provide the setting for this deliberative process. The added layer of representational mediation between stimulus and response gives us a kind of flexibility and foresight that holds perhaps our greatest advantage over natural competitors.

Functionally, constructing models is a human strategy for behavior management. Science is an extension of this basic strategy which involves the collectivization and systematization of information, the creation of models of varying scope, specially

[14] By "modalized notions," I mean notions that have a modal component to their content. I am arguing that modalized notions have different cognitive roles from their proposed non-modal counterparts, so even though the Humean wants to say that their descriptive content is exhausted by what they say about actuality, their modal implications are needed to capture their cognitive role. (If we assume that facts are as finely individuated as beliefs, we could run the argument for irreducibility with either facts or beliefs.) The sense in which these structures are second order is that they are functions of the first-order pattern of fact.

[15] The same is true, though less obviously so, for creatures who need to form expectations under ignorance, because such creatures need guides to belief that cover all epistemically possible situations, and for all such creatures the epistemically possible situations will include non-actual ones.

tailored for all different kinds of purposes. We make maps of outer space and build models of atoms, cells, and ecosystems. These models all play a role in our interaction with the natural environment. In this capacity, model construction is not merely a matter of copying. It involves restructuring, reorganizing, and reconfiguring information: integrating and reformatting it in ways that prepare it for use in inference or navigation. Models are tools. Their job is to facilitate interaction between an embodied agent and an open environment. Some of the structures defined in a model have the job of representing: tracking or mirroring localized elements in the landscape. In those cases, the account of how the models are used will support the kinds of localized correspondence that most people think of as paradigmatic of representation. We expect this kind of localized extensional correspondence, for example, between first-order elements in a model of space-time and localized events (e.g., a lightning strike or the decay of a radioactive atom). But that is a quite specialized function. There are also structures defined on our models that encode information about distributed features of the world like trends and currencies, the latest fashions, the value of the dollar, or the state of the union. And there are structures whose main function is to facilitate computation. We store information about dates and locations in formats that make it easy to compute duration and distance. And, in general, information will be encoded in different formats to facilitate different kinds of function. The lesson here is that models provide embedding frameworks for phenomena that package information for useful application in situ. This re-packaging can introduce a holistic restructuring that does not in general preserve piecemeal correspondence, and (more importantly for our purposes) introduces elements that do something other than simply reflect first-order features of the landscape.

Chances are easy to understand in these terms.[16] Chance is a species of statistical probability tailored to guide credence for creatures that have no direct source of information from the future. Statistical probabilities are objective, modalized quantities grounded in relative frequencies that guide expectation in open-ended classes of systems. They do not correspond to actual frequencies because actual frequencies can be skewed in a way that would make them unsuitable for that role. If a coin falls heads half the time, but all of those head-tosses occur before the birth of Socrates and after, say, 3011 CE, it would be stupid for you and I to take even odds on heads or tails. Chances reflect facts about stable relative frequencies over the short term in a way that is quite precisely designed to allow them to play their role-guiding expectation.

[16] Because of Lewis's influence, the problem that chance played in his metaphysics, and the pristine clarity of his own work on the subject, there is a very well-developed discussion of chance in the philosophical literature. These programmatic remarks about chance are supported in more precise detail in Ismael (2011b, 201). For some of the background on chance, see Bigelow, Collins, and Pargetter (1993) and Hall (1994).

The epistemic uses of models have to do with carrying information, computing, and predicting. But these are not the only uses. Models also guide our interactions with the systems they represent. In this manner, the ways in which we represent things will contain information that is useful for the purposes of intervention. The intervener does not simply need to know how things *are*; he needs to know how things *would* be if he acted on the world in various ways.[17] To think of models in purely epistemic terms is to forget about their practical role. To the embedded agent who doesn't just observe, but also intervenes in, his environment, the world is chock-full of opportunities and affordances. The terms in which he represents the world will be designed to disclose them. Causal relations are the generic form of these opportunities and affordances. Formally, causal relations are inductive generalizations of emergent relations among networks of variables that tell us what would happen to other variables in a network if we intervene on one. These relations are captured in DAGs (Directed Acyclic Graphs) that highlight strategic routes to bringing about ends.[18]

Recognizing the practical dimension of use is what we need in order to understand alethic modalities. Epistemic modality involves the notion of *how things might actually be, given what we already know*. Alethic modality involves the notion of *how things would be, under conditions that may or may not be actual*. It is the alethic modalities that have seemed to carry metaphysical commitments that have been uncomfortable to empiricists. This is because making out the modal content of an alethic modal claim involves quantification over specifically counterfactual (i.e., non-actual) possibilities. To say that A follows B as a matter of law, is to say that A *must* follow B, i.e., that A *could* not *fail* to follow B. To say that the association between A and B is not merely a correlation, but a cause, also adds some counterfactual force. It supports the inference that if one were (hypothetically) to bring about A, B would follow. In both cases, the extra modal force can only be made out in counterfactual terms. The modal force captures something crucial to the content of those notions. What does the modal force add? It does not add anything new to our beliefs about what *does* happen. But it does add something of practical importance that makes a difference to choice. You might try to bring about an exception to a regularity, but you would not want to try to bring about an exception to a law.

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[17] The case of cause parallels that of chance. Just as in the case of chance, causes can be implicitly defined by their role in practical reasoning. And causes relate to correlations in a manner that is quite similar to the relationship between probabilities and frequencies. See Ismael (2012; 2016, chap. 5). For background, see Pearl (2000); Spirtes, Glymour, and Scheines (2000); Woodward (2003).

[18] One might think of causal beliefs as encoding implicit, conditional practical imperatives whose practical consequences are drawn out in deliberative application. The practical consequences are a little more complex than "do x." They say "do x if you want y to be the case," or "do x if you want y to be the case, and one of $\{z_1 \ldots z_n\}$ and none of $\{z^*_1 \ldots z^*_n\}$ obtain as well," . . . or something of this sort.

It would be a waste of time, i.e., a strategic mistake. To know that the relation between A and B is a causal one does not add anything to our stock of categorical beliefs; it signals that one could use the link strategically by manipulating A to bring B about.

Philosophers have focused on the counterfactual as the most basic alethic modality, but counterfactuals are just hypothetical statements with false antecedents. And in cognitive terms, the hypothetical statement is the more basic category. The role that beliefs about hypothetical circumstances play in practical reasoning is easy to discern.[19] When I am deciding how to act, I consider a range of actions. The way that I decide is by tracing out the downstream consequences of actions considered in the hypothetical. What would happen if I accept the Queen's Gambit or defend my knight? Should I take the beaten path or the road less traveled? The answers depend on what would happen if I did.[20] And there is no way of eliminating the modal content. Only some of the hypothetical futures I consider under the guise of potential actions will be actualized. The others are, and will remain, strictly counterfactual. One way of putting this is that epistemic modalities are to theoretical reason what alethic modalities are to practical reason. Looking back now, we can see more clearly why the attempts at reduction of laws to regularities, and chances to frequencies, failed. In both cases, the looseness of fit between the categorical facts and the structures that reside on the second-order overlay is essential to the function of those structures. Chances have the function of guiding expectation in open-ended classes of systems when we have general information about the distribution of values for some quantity in the class from which the system is drawn, but no specific information about the value the quantity takes in the case in question.[21] And the open-ended application means that chances have to range over possible, not merely actual, instances. They have to cover any system we might come across, and we have no way, in advance, of delimiting the ones we will come across from those we could. Claims about laws have specifically counterfactual implications because they have the function of guiding the kinds of purely hypothetical imaginings that are part of

[19] This insight is captured succinctly in Alison Gopnik's lovely dictum, "Counterfactuals about the past . . . seem to be the price we pay for counterfactuals about the future" (2009, 23). I would change this slightly to say that past counterfactuals are the price we pay for future *conditionals*. Counterfactuals and future conditionals are both species of hypothetical. Science deals generically with hypotheticals, and although hypotheticals give us the logical resources to define counterfactuals, it is the future conditionals that have the most basic cognitive function.

[20] On the logic of these imaginative explorations and what distinguishes them from purely epistemic reasoning, see Joyce (2002); Anscombe (1963); Ismael (2011a).

[21] There are well-defined probabilities only when there are stable relative frequencies across arbitrary subselections from the class. If the class does not have the right structure, or we have specific information about the instance in question, then chances are not relevant in the same way.

deliberation. To play this role, these quantities have to have implications that guide belief about hypothetical, potential futures.[22]

What do we say about these structures, then, if they do not describe what happens? We say that they are inductions on patterns in the manifold of facts that supply us with best-guesses-under-the-circumstances for what will happen, and also about what would happen if we acted in various ways. The regularities that underwrite the modalized structures that embody these best guesses are part of the pattern of actual events. The modal force is an inductive projection of those patterns into the unknown and the purely hypothetical. Naturalistic philosophers looking for a complete, non-redundant catalogue of the basic objects, quantities, and relations of which the world is composed can look to the categorical part of physics. But science is not just about reflecting what is the case. It is also charged with providing representations that can function as a convenient user interface for creatures with our combination of limitations and needs. Overcoming the limitations that our native equipment imposes on how far we can see, and how effectively we can intervene, sets the task for science (and, indeed, for cognition more generally). Scientific models—on the local and global scale—are embodiments of our very best inductive practices. I am suggesting that the modal content of our models—the overlay of laws, dispositions, capacities, and potencies—are to be understood in terms of their role guiding prediction and decision.[23]

4. MODELS AS PPS'S TO FEP'S

Scientific induction is a holistic enterprise that proceeds in two steps. The first step involves the use of information about local matters of particular fact to produce models that contain locally defined modal structures which act as guides in belief and decision.[24] The second step draws out modal implications that are built into the content of models at the first stage. Edwin Hutchins, in an account of the cognitive ecology of a naval vessel, uses a phrase to describe navigational instruments

[22] This is not their only role. We also care about what would have happened in the past if we had acted differently, even though there is no possibility now of changing that fact, for assigning responsibility, and learning practical lessons, for example.

[23] And if asked what the specifically modal content represents/stands-for/corresponds to, I say either (using "represents" in a deflationary way) that it represents modal facts, or (using "represents" in a non-deflationary way) that it does not represent anything. The ambiguity between inflationary and deflationary conceptions makes the vocabulary of representation famously fraught. I have tried to be explicit in the text where I mean it in an inflationary sense to avoid confusion. See Price (2011) and Thomasson (2015) for discussion of the deflationary alternative. In either case, I deny that either reduction or reification is needed for realism about these structures.

[24] "Locally defined," here, means only assigned to space-time points or regions. It does not mean "describes properties intrinsic to those regions."

like the compass and alidade that is quite helpful here. He calls them "partially prepared solutions to frequently encountered problems."[25] That phrase captures quite precisely the functional status of the modal quantities introduced into our models in the first stage of theorizing. We use models to predict, compute, and intervene. The structures that form the modalized overlay are designed to facilitate those tasks. They encode partial solutions to the kinds of problems that situated agents frequently face. Viewing models as PPS's to FEP's sets the agenda for interpretation of a wide class of structures that are important in science. I have indicated summarily how work already done on chances and causes fits neatly into this mold. Laws, dispositions, and capacities are differentiated from these structures, and also from one another, by their categorical content and modal implications. They might also be viewed as encoding inductive inferences that can be drawn on by the situated agent under a variety of conditions to guide belief and action.

5. Lewis's Program

The title of this paper is intended to evoke David Lewis's (1980) "A Subjectivist's Guide to Objective Chance," which sought to ground notions of objective chance in subjective probabilities. In that article, Lewis set about trying to show how someone who was a subjectivist about probability—i.e., someone who thought that probabilities expressed subjective degrees of belief—might also recognize objective chance. In his words:

> We subjectivists conceive of probability as the measure of reasonable partial belief. But we need not make war against other conceptions of probability, declaring that where subjective credence leaves off, there nonsense begins. Along with subjective credence we should believe also in objective chance. The practice and the analysis of science require both concepts. Neither can replace the other.[26]

Lewis's strategy was to first identify a use that creatures like us would have for beliefs about chance, which he embodied in his Principal Principle. He then treated the Principal Principle as an implicit definition of chance, and looked for something to assign as extension to beliefs about chances. He looked, that is to say, for something for those beliefs to represent. I want to pause to relate the view that I have been offering to Lewis', because although I depart from Lewis in the details, I am effectively doing for alethic modality what his paper set out to do for epistemic

[25] The phrase occurs in Hutchins (1995, 134). He remarks that the phrase also has currency in computer science.
[26] Lewis (1980, 267).

modality. I am suggesting thatwe do not need to reify modality in the absolute fabric of nature in order for it to be objective. We can borrow two insights from Lewis: defining chance functionally in terms of its role guiding credence, and seeing chance as the objective face of credence. We generalize those insights as follows. First, we define all of the modal structures generated by science (chances, causes, dispositions, laws) functionally as PPS's to FEP's, understanding the alethic modalities in terms of their role in guiding decision rather than belief.[27] Second, we see these structures as the objective faces of structures that describe the embedded agents' epistemic and practical relations to events.[28]

Lewis offers his Best Systems Analysis (BSA) as a content-preserving reduction of beliefs about laws and chances to beliefs about patterns in the Humean mosaic. We hold that laws and chances and other intermediate structures embody the inductive outputs of a theoretical process that is more or less loosely modeled by the BSA. But we modify Lewis's account in two ways. First, as Lewis describes it, the BSA is an abstract logical recipe for forming beliefs about laws and chances from a full description of the manifold of categorical fact. We modify it to look more like real science, embedding it in the epistemic context that gives science its purpose. Beliefs about laws and chances are now seen as embodying inductive hypotheses that tell us how to project perceived patterns in a partially known mosaic in order to guide both expectations and interventions. Experimental practice, which has little place in the Lewisian recipe, is now center stage. This is a subtle matter that I haven't argued here, but the reason that experimental practice becomes important is that the experimental side of science is crucial to establishing its alethic content. Second, we hold that the BSA is a recipe for forming beliefs about laws and chances, but not a content-preserving reduction, because we hold that laws and chances have modal implications that outrun beliefs

[27] The take-home lesson is that reifying these quantities in the fabric of the world is not the right view. The main argument against reification is that the interpreter who reifies modality in the absolute fabric of Being has to square the *semantic* content with the *practical* function. If he makes beliefs about counterfactual possibilities beliefs about other worlds, he has to explain why beliefs about such things would guide action in our world. If he makes them beliefs about linguistic entities of some kind, he gives them something actual to refer to, but then he has to explain why beliefs about linguistic entities would guide action. And if the answer is that they do so because they represent possibilities, he has gotten nowhere.

[28] There seems to be a confused idea that if chances and laws are not reified, they are subjective in an objectionable way, i.e., not "out there" in the world as proper objects of scientific study. That is just a mistake. They are inductions grounded in what is "out there" crafted to provide solutions to problems introduced by the agent's perspective. Lewis's "A Subjectivist's Guide to Objective Chance" got the senses in which these structures are objective right. Chances are not descriptive of anyone's degrees of belief. They are rather structures meant to guide degrees of belief. They are objective in two senses: (i) in the sense that they are based on an inductive procedure that takes its departure from objective facts about the pattern of events, and (ii) in the sense that they permit a distinction between what the chances are and what I think the chances are.

about what actually happens. We make a distinction between the content of beliefs about laws and chances and the facts that provide the epistemic grounds, or support, those beliefs. We want to say that PPS's to FEP's are inductions *grounded epistemically in* objective facts about patterns in the Humean mosaic, but they have modal implications that *outrun* those patterns. Those modal implications, moreover, play crucial roles in the epistemic and practical life of the embedded agent. Lewis assumes that all beliefs have the function of representing/standing for/or reflecting some aspect of what there is, and so he looks for elements or patterns in the Humean mosaic for beliefs about chance and laws to represent. We agree with Lewis that the world is just a vast mosaic of local matters of particular fact. We depart from Lewis in denying that all belief has the function of representing/standing for/or reflecting some aspect of what there is.[29] Believing and cognizing are natural activities that are part of a behavior management strategy that involves anticipating what will happen next and acting to forestall, avoid, bring about, or promote outcomes. We hold that laws, chances, causes, and other modal outputs of science play a role in this process.

6. MODALITY FOR THE EMPIRICIST

The result is a form of empiricist realism about modality that steers a path between reduction and reification. The pressure to reify comes partly from an argument that goes like this: if intermediate structures do not represent patterns in the manifold of actual fact, then what do they represent? And we are given two options: either they represent something non-categorical or they do not represent anything at all.[30] PPS's to FEP's do not fit clearly into either of these categories. Part of the point of the discussion here was to break down this simple dichotomy. There is, in my view, no more compact story in principle that relates beliefs about modal structures to categorical facts than one that says how these beliefs are formed and the role they play in our cognitive and epistemic lives.

Is this simply instrumentalism? Yes and no. It does hold that modal structures are instrumental in the sense that they represent the world in a form that is poised to play a role in practical and epistemic inference. But it is not the kind of instrumentalism sometimes associated with Duhem according to which instrumental structures

[29] For further discussion, see Ismael (2014, 2015).

[30] Here is a characteristic statement of the options (reading "categorical" for "non-modal") due to Shalkowski (1994, 670): "If modality is grounded in reality, it is either a primitive or a non-primitive feature of that reality. If it is primitive, then there is nothing non-modal in virtue of which reality possesses modal characteristics—there are no non-modal facts that wholly constitute modal facts. If it is not primitive, then there is something non-modal in virtue of which modality is present in reality—there are non-modal facts that wholly constitute modal facts."

are empty nodes in a formal calculus that do not have any representational significance of their own. It is much closer to the instrumentalism of Dewey, according to which all belief is both contentful and geared toward action (Godfrey-Smith 2010). It does not matter much for my purposes what philosophical vocabulary is used to describe this, except that we should refuse to say that this account entails that there are no such things as laws or chances. We should say that the account that we have given tells us what laws and chances *are*. And we should add that once we understand what laws and chances are, we will see that forming beliefs or making claims about laws and chances does not commit us to the existence of possible worlds, or any other kind of ontologically substantive posit. Everything that there is to know about laws, chances, and other scientific modalities is given in the account of how beliefs about chances are formed, their inferential implications, and the role they play in our practical and epistemic lives. The philosophical vocabulary that I prefer to describe the account is deflationism. Deflationism holds that there is a substantive story about the formation of beliefs about laws and chances, and the role they play in our epistemic and practical reasoning. But the laws and chances themselves are just, so to speak, shadows of law and chance beliefs.[31]

It should be acknowledged, however, that there are other sources of the pressure to reify. One such pressure comes from the basic non-Humean intuition that laws act as the iron enforcers of regularity in nature. I have said nothing to address this intuition here. It has to be addressed by providing an alternative account of what makes our world hospitable to inductive practices. That is a rather different topic. Here I have been mostly focused on providing a non-reductive empiricist account of modal belief.

7. TO SUM UP

I have argued that claims about laws, chances, and other modalized structures encode inductions on observed regularities in a form that is tailored to solve the kinds of practical and epistemic problems that beings like us—beings with limited sources of information about the world that gather and store information and use it to guide behavior—face. The account of how we form beliefs about such structures is given by a description of scientific practice, modeled loosely on Lewis's Best Systems Analysis.

[31] The metaphilosophical framework has been developed by a number of people. See, in particular, Price (2011) and Thomasson (2015). In this framework, correspondence, representation, and truth are all deflated. Although the availability of deflationism deflects pressure to reify that comes from the felt need to provide truthmakers for modal beliefs, there is a pressure to reify that appeals to the basic non-Humean intuition that the regularity in nature is inexplicable without modal connections among events. I take that pressure seriously, but it is a battle to be fought on other grounds.

I denied that such beliefs are reducible to beliefs about categorical facts. The reason was that they have modal implications that are crucial to their function and that outrun any claim about what actually happens. I also denied that the extra content does anything more than to project observed regularities into hypothetical situations of the kind that we entertain imaginatively in the course of decision. I characterized the function of these structures on our models generically by saying that they act as PPS's to FEP's. Individually, their function is given by a detailed description of the particular role they play in epistemic and practical reasoning. Chances, for example, provide best guesses for creatures confronting an unknown future. Causes highlight strategic routes for bringing about ends. Laws encode general inductive hypotheses that constrain both action and belief. Dispositions and capacities encode other kinds of useful inductions that guide the interaction of the embedded agent with the systems to which they are ascribed. I have not tried to talk anyone out of a metaphysically inflated notion of modality; I have just tried to suggest that there is a sensible story for empiricists to tell about the modal commitments of science that does not saddle them with an objectionable metaphysics. This opens up space for an empiricist account of the central modalized concepts of science that looks at the inductive content they encode, and the role that content plays in our practical and epistemic lives, without trying to reduce or eliminate it.

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