An Empiricist's Guide to Objective Modality[i]

Jenann Ismael
draft
jtismael@u.arizona.edu

"[Science] is for coping, not copying."[ii]

Modality

Since the late 20th century, the concepts of necessity and possibility have occupied center stage in philosophical discourse. Modal facts concern what is possibly or necessarily the case. These contrast with categorical facts, which concern only what, is actually the case. Modal notions including concepts of conceptual, metaphysical, and nomic necessity and the counterfactual conditional are central to philosophical theorizing in every area of philosophy— from the foundations of logic to moral theory.

Modality enters science with notions like cause, natural law, probability, dispositions, and capacities. So, for example, consider laws. Laws are related to regularities in the pattern of actual fact (they have to be, if we are to use information about regularities to form beliefs about laws, and information about laws to predict actual events), but they have implications that outrun their implications for what actually happens. 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 they must happen that way, i.e., that they couldn't happen otherwise.

Or consider chance. Facts about chance are related to the categorical facts (they have to be if we are to use information about categorical facts to form beliefs about the chances, and information about the chances to guide expectation for categorical facts), but chances have implications that outrun their implications for what actually happens. To say that a certain type of event (a coin flip coming up heads, or an atom decaying within a given time frame) has a good chance of occurring is to say both more and less than that it will occur.

In both cases, there is an ineliminable modal component to the content of these claims that distinguishes them from any mere claim about how things actually are. They have implications not just for the way things are in *non-actual*, *possible* worlds. Similar things can be said about other notions that have important roles in science: causes, for example, are famously connected to counterfactuals. But the same goes for capacities and dispositions. There is no way of giving truth conditions for claims about these structures without adverting to counterfactual implications.

Modality is a sticking point for empiricists, some of them (e.g., Ladyman) recognize that commitment to science comes with a heavy does of modal commitment – a whole slew of beliefs not only about how things are, but how they might have been, could have been, would have been had they been

otherwise, and accept modality on the strength of their commitment to science. Science cares less about the pattern of actual events than what they reveal about the modal substructure behind the phenomena. But others shun it on the grounds that this talk of non-actual possibilities if it is not veiled talk about actuality, must be nonsense. 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*".[iii]

So understanding modality is a matter of some urgency for philosophers of science. There are different ways of trying to elucidate modal notions. One can try to give an analysis that doesn't use modal vocabulary. There are good reasons for thinking that no informative analysis of modal concepts in non-modal terms is possible. Barring that, one can shed some light on it by clarifying its formal and logical properties, and its inferential and analytic connections to other notions. A lot of excellent work like this has been done on modal concepts. But one can do more than that as well; one can turn her attention to a side-on view of the role modal beliefs play in our cognitive lives. She can ask how modal beliefs are formed and put to use, why creatures with our concerns and interests developed the capacity for modal thought. What does it *do* for us? What benefits accrue to the practice of modalizing?[iv]

Intermediate structures

I'll talk of the modal content of scientific *models* rather than modal *beliefs*. And I will be looking at how these kinds of modalized notions relate to the pattern of categorical fact. Consider laws. The most fundamental laws have the form of differential equations that give the rate of change for a quantity at a point. They entail the existence of regularities, but they cannot be reduced to regularities because the very notion of law recognizes the possibility of regularities that are not laws. Consider chances. These are single case probabilities represented by a real valued function over space-time. 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 strength (the weak and strong laws of large numbers and Bernoulli's Theorem). 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.[v] But – as with laws - probabilities cannot be reduced to frequencies, because even the strongest of the theorems relating probability and frequency explicitly allow the possibility of probabilities that diverge arbitrarily far (albeit with diminishing probability) from the frequencies. The logic of probability entails if something has the probability of 0.9, that does not mean it will occur. It doesn't even mean it will occur 9 out of 10 times. It means that it will probably occur 9 out of 10 times, roughly, over the indefinitely long haul.

I could have added here causal relations, dispositions, capacities, and potencies. Among these, causal relations have a particular importance, and I'll say some things specifically about them below. These

are representative of a class of structures that I call 'intermediate structures'. 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 modalized structures that play a role in epistemic and practical deliberation, or as I will say, guiding belief and decision, though I mean here the kinds of beliefs and decisions that take some deliberate reasoning.

It is tempting to suppose that these structures on the second-order overlay are just re-descriptions of lower level patterns, 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 someone as a wife, mother, and physician, that is not an intrinsic description. It carries a lot of extrinsic information about the world, her place in it, and her habits. And that information comes with a slew of expectations and guides interaction with her.[vi] This is this is not just true of the way that we represent in language. It has been known for a long time that the brain engages in predictive coding at various different levels. It builds complex models of worldly regularities that guide expectation about what will happen and offline predictions about what would happen if we acted in various ways.[vii] Even perception may best be seen as a process in which our brains don't just passively relay information but rather use an incoming signal as input to a stored schema that is used to predict a signal before it comes in. The difference between the predicted signal and the one that occurs is then used to revise the schema.[viii] The building of models that encode regularities that guide induction both about what will happen and what would happen in hypothetical conditions is common ground with representation in physics.

But as tempting as it is to see intermediate structures as simply summaries of information about lower level patterns, it turns out that no reduction is possible. Intermediate structures fail the logical test for identity with lower level patterns. There is a logical gap between claims about law and regularity, or chance and frequency. 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. Or 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. And the same goes for dispositions, capacities and causes. (Neo)-Humeans in the tradition of Lewis have tried to finesse this by combining stipulations about all of these into a single package and try for a more holistic reduction.[ix] But the difficulty remains. The problem is a generalization of the one 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. There are models of our law+chance packages 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 the Best Systematization of C.[x] 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).[xi]

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 patterns 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, claims about the laws and chances, on the other, falls short of identity. You might scratch your head here and say 'but what does that mean, since the difference in truth conditions can only be made out in modal terms. It's an empty difference if all meaningful claims about modality bottom out in implications for actuality'. Or you might say that the claim that there are models of our law+chance packages 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, just *is* the claim that Humeanism is false, so the argument presupposes what it means to prove.[xii] Or you might acknowledge that the Humean view closes a logical gap that our everyday notions of law and chance leave open, but biting the bullet.[xiii]

The really telling objection against the Humean view is this. The Humean view has to close the logical gap between the modalized structures on the second order overlay and 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 mere description of patterns in the manifold of actual fact could play the *role* that these modalized notions play in guiding belief and action.[xiv] 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.[xv]

Function

Let's start with a wide-angle view of why we construct models of the world at all. And here I don't just mean the relatively esoteric products of professional science, I mean, the internal world-models that the brain makes 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, not the beating of our hearts, but 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 based out projected outcomes. This process is our most powerful cognitive tool, one that gives us our primary advantage over other kinds of naturally evolved cognitive system. 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.

So, functionally, constructing models is a human strategy for behavior management. Science is an extension of this basic strategy involving the collectivization and systematization of information, construction of models of varying scope, different models for different contexts. We construct maps of space, models of atoms, cells and ecosystems. And these models all play a role in 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 prepared for inference.

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 use 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's a quite specialized function. There are others that encode information about more distributed structures: i.e., beliefs about trends and currencies, the latest fashions, the value of the dollar, and the state of the union. And there are others that 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 doesn't 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.[xvi] 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 don't 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 the 5011 (supposing someone is around tossing at that time), it would be stupid to take even odds on heads or tails.[xvii] 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.

The epistemic uses of models have to do with carrying information, computing, 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 to the intervener in nature. The intervener doesn't simply need to know how things are; he needs to know what would happen if he acted on the world in various ways.[xviii] To think of models in purely epistemic terms is to forget about their practical functions. To the embedded agent, the world is chock-full of opportunities and affordances, and the terms in which he represents the world will be designed to disclose them. Causal relations are the generic form of these opportunities and affordance. 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. Formally, these relations are captured in DAGs (directed acyclic graphs) that highlight strategic routes to bringing about ends.[xix]

Recognizing the practical dimension of use is what we need 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 '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 because making out the modal content of an alethic modal claim involves quantification over specifically counterfactual possibilities. Saying that A follows B is not merely a regularity (even an exceptionless regularity), but a *law,* means not just that B failing to follow A doesn't happen but that it *couldn't.* 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 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 doesn't add anything new to our beliefs about what *does* happen. But it does add something of practical importance, something that makes a difference to choice. You might try to bring about an exception to a regularity, but you wouldn't want to try to bring about an exception to a law. It would be a waste of time, a *strategic* mistake. To know that the relation between A and B is causal one doesn't add anything to our stock of categorical beliefs; it signals that one could use the link strategically manipulating A to bring B about. Philosophers have focused on the counterfactual as the most basic alethic modality, but counterfactuals are just hypotheticals with false antecedents. And in cognitive terms, the hypothetical is the more basic category. The role of beliefs about hypothetical circumstances that *may or may not be actual* in practical reasoning is easy to discern.[xx] When I am deciding how to act, I consider under 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 Should I accept the Queen's Gambit or defend my knight? Should I take the beaten path or the road less

traveled? That depends on what *would* happen *if* I did.[xxi] And there's 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 failed. In both cases, the looseness of fit between the categorical facts and the structures 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 under conditions in which we have some 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.[xxii] And the open-ended application means they have to cover possible, not merely actual instances. They have to cover any system we might come across, and we have no way 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 deliberation. To play this role, these quantities have to have implications that guide belief about hypothetical, potential futures.[xxiii]

What do we say about these structures, then, if they don't just describe what happens? We say that they are inductions on patterns in the manifold of fact that supply us with best-guesses-under-the-circumstances for what will happen, and hypotheses about would happen if we acted in various ways. The regularities that ground 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 isn't 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 for cognition more generally. Scientific models – on the local and global scale – are embodiments our very best inductive practices. And I'm 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.[xxiv]

Models as PPS's to FEP's

Scientific induction is a holistic enterprise that proceeds in two steps. The first step involves the construction of a model in which information about local matters of particular fact is used to produce models with locally modalized structures that act as guides in belief and decision. The second step simply draws out modal implications that are built into the content of models at the second stage with the introduction of chances and laws and other derived modalized quantities.

Edwin Hutchins in an account of the cognitive ecology of a naval vessel uses a phrase to describe navigational instruments like the compass and alidade. He calls them partially prepared solutions to frequently encountered problems (PPS's to FEP's, for short).[xxv]   That phrase captures quite precisely the functional status that the modal quantities that are part of the induction output of a scientific theory have. We use models to predict, compute, and intervene. The structures on the modalized overlay are designed to facilitate those tasks. They encode partial solutions to the kinds of problems that situated agents face. Viewing models as PPS'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 mould. Laws, dispositions and capacities are differentiated from these and one another both by their categorical content and modal implications and are to be viewed similarly as encoding inductive inferences that can be drawn on by the situated agent under different conditions to guide belief and action.

Lewis' program and PPS's to FEP's

I take my title from David Lewis' "A subjectivist's Guide to Objective Chance"[xxvi] which sought to ground notions of objective chance in subjective probabilities. In that article he set about trying to show someone who was a subjectivist about probability – i.e., someone that thought that probabilities expressed subjective degrees of belief - might 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."

Lewis's strategy was to first identify a use that creatures like us would have for beliefs about chance, embodied in PP. He then treated PP as an implicit definition of chance, and looked for something to assign as extension to beliefs about chances, i.e., something for those beliefs to Represent.

I want to pause to relate the view here to his, 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 modality, which was to show

that we don't need to reify modality in the absolute fabric of nature in order for it to be objective. We take over two insights: first, defining chance functionally, in terms of its role guiding credence. Second, 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 decision rather than guiding belief.[xxvii] Second, we see these structures as the objective faces of structures that describe the embedded agents epistemic and practical relations to events. [xxviii]

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 would modify Lewis's account in two ways: (i) as described 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 which gives it 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 make predictions and guide expectation for historically embedded creatures that are partly involved in creating the manifold of fact. Experimental practice, which has little place in the Lewisian recipe is now center stage and crucial (for reasons given more explicitly elsewhere) to the alethic content of laws and chances, and (ii) we hold that the BSA is a recipe for forming laws and chances, but not a content-preserving reduction, because we hold that laws and chances have modal implications that outrun beliefs about what actually happens. We make a distinction between the *content* of the beliefs about laws and chances and *the facts that ground* those beliefs. We want to say that PPS's to FEP's are inductions grounded in objective facts about patterns in the Humean mosaic, but they have modal implications that outrun those patterns, and that 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/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 all there is to the world is a vast mosaic of local matters of particular fact, just one little thing and then another. We depart from Lewis in denying that all belief has that function.[xxix] 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.

Modality for the empiricist

This, I believe, is a form of empiricist realism about modality that steers a path between reduction and reification, but I want to acknowledge that there are different sources of the pressure to reify. One part of the pressure to reify comes from an argument that goes: if intermediate structures don't 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 don't represent anything at all.[xxx] I have argued against this that PPS's to FEP's don't fit clearly into either of these categories, and 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 intermediate 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 instrumentalism? 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 are empty nodes in a formal calculus without any representational significance. It is much closer to the instrumentalism of Dewey, according to which *all* belief is both contentful and geared towards action.[xxxi]

But the other pressure to reify comes from a quite different source, one that appeals to 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. I leave an alternative account of what makes our world hospitable to inductive practices to another occasion.[xxxii] For now, it is enough if we have sketched an empiricist account of modal belief.

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 BSA. I denied that such reducible to categorical facts because they have modal implications that are crucial to their function and that outrun any claim about what actually happens, but I denied that the extra content doesn't do anything more than project observed regularities into hypothetical situations of the kind that we all entertain imaginatively in the course of decision. I argued that the function of these structures is characterized generically as partially prepared solutions to frequently encountered problems (PPS's to FEP's) and individually by the 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 haven't tried to talk anyone out of a metaphysically inflated notions of modality, I've just tried to argue that there is a sensible story for an empiricist to tell about the modal commitments of science that doesn't saddle them with a commitment to the existence of possible worlds or primitive necessities in nature, or the like. For the philosophy of science, it opens up the space for examination of the central modalized concepts of science that looks at the inductive content they encode and the role they play in our practical and epistemic lives, without trying to reduce or eliminate that content.

i I have benefitted greatly from audiences in Toronto and Rutgers and especially from discussion and correspondence with Barry Loewer.

ii The original remark comes from Rorty: "The mind is for coping, not copying".

iii *Scientific Image*, Cambridge University Press (1980), p. 202.

iv For an example of discussion in this mould, see Kment, B., *Modal Concepts and Causal Inquiry,http://www.princeton.edu/~bkment/Home%20Page%20-%20book%20manuscript%20-%20introduction.pdf*) I wouldn't 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. We use modal notions in any act of explication as surely as we use language in any act of description. Without attempting to reduce or e

v Whenever we have a necessary connection between a and b, even if that link is merely a probabilistic one, we have a violation of the Humean ban on necessary connections between distinct existences. In contexts like the present, this ban functions as a test for identity, and a violation signals some redundancy in the ontology.

vi 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, and the constraints imposed by the embedding framework are the source of the most basic expectations about the world.

vii The image of the brain as an engine of prediction can be found in various forms in contemporary neuroscience. Bubic A, von Cramon DY and Schubotz RI (2010) Prediction, cognition and the brain. *Front. Hum. Neurosci.* 4:25: 1-15, Friston K. (2010) The free-energy principle: a unified brain theory? *Nature Reviews: Neuroscience* 11(2):127-38, Helmholtz, H. (1860/1962). *Handbucder physiologischen optik* (Southall, J. P. C. (Ed.), English trans.), Vol. 3. New York: Dover. Kveraga, K., Ghuman, A.S., and Bar. M. (2007) Top-down predictions in the cognitive brain. *Brain and Cognition*, 65, 145-168

viii Andy Clark "Whatever Next? Predictive Brains, Situated Agents, and the Future of Cognitive Science", *Behavioral and Brain Sciences* (in press).

ix Lewis 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 denies that 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. See Morris, William Edward, "David Hume", *The Stanford Encyclopedia of Philosophy* (Spring 2013 Edition), Edward N. Zalta (ed.), URL = http://plato.stanford.edu/archives/spr2013/entries/hume/, Strawson, Galen, 1989. *The Secret Connexion: Causation, Realism and David Hume*, Oxford: Oxford University Press, Helen Beebee: *Hume on Causation*, London, Routledge, 2004. I have argued for a form of Humeanism closer (I believe) to Hume's own cleaves to the denial of necessary connections, but drops the demand for reduction ("How to be Humean"). I will follow the standard terminology here using "Humean" to refer to the Lewisian tradition, without meaning to impute these views to Hume.

x For purposes here, I'm allowing the globalist perspective that makes the object of representation the world as a whole, and modal beliefs about non-actual possible worlds. But I have argued in "Against Globalism" that if we want to understand modal belief, we should be looking at modal beliefs that apply to smaller than world-sized units.

xi See Maudlin, *The Metaphysics in Physics*, OUP. P.

xii 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. This would require a new notion of physical possibility

xiii Loewer adopts the last option ("David Lewis's Humean Theory of Objective Chance" Philosophy of Science, Vol. 71, No. 5, Proceedings of the 2002 Biennial Meeting of The Philosophy of Science Association, Edited by Sandra D. Mitchell (December 2004), pp. 1115-1125). He to acknowledges that the view is slightly revisionist about the everyday meaning of chance, but he can say 'so much the worse for our everyday notion of chance', if the revised notion can serve all of the crucial functions of the everyday notion.

xiv 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. (I assume that facts are as finely individuated as beliefs, so we could run the argument for irreducibility with either facts or beliefs.

xv The same is true, though less obviously so, for creatures who need to form expectations under ignorance, for 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.

xvi Because of Lewis' 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 (single-case, objective probability) in the philosophical literature. These programmatic remarks about chance are supported in more precise detail in my "A Modest Proposal About Chance", *Journal of Philosophy*, 108 (8), p. 416-442, 201. For some of the background on chance, see Bigelow, J., J. Collins and R. Pargetter (1993). "The Big Bad Bug: What are the Humean's Chances?" *British Journal for the Philosophy of Science* 44:443–462. Hall, Ned (1994). "Correcting the Guide to Objective Chance". *Mind* 103:504–517. Lewis, David (1980). "A Subjectivist's Guide to Objective Chance", reprinted in *Philosophical Papers Volume Two*, 1986, Oxford: Oxford University Press. For some of the background on causes, see Pearl (2000) *Causality*. Cambridge University Press. And Spirtes, Glymour and Scheines (2000) *Causation, Prediction and Search*. 2nd edition. MIT Press.Woodward (2003) *Making Things Happen*. Oxford University Press

xvii See Hájek, Alan, "Interpretations of Probability", *The Stanford Encyclopedia of Philosophy* (Winter 2012 Edition), Edward N. Zalta (ed.), URL = <http://plato.stanford.edu/archives/win2012/entries/probability-interpret/> for a summary of criticisms of frequency accounts.

xviii 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. All of this needs to be argued at the level of fine detail, and the details can be dauntingly intricate but see my "Causation, Free Will, and Naturalism" in *Scientific Metaphysics*, Kincaid, H., Ladyman, J. and Ross, D. (eds.), Oxford University Press, 2012, and background see Pearl (2000) *Causality*. Cambridge University Press. And Spirtes, Glymour and Scheines (2000) *Causation, Prediction and Search*. 2nd edition. MIT Press.Woodward (2003) *Making Things Happen*. Oxford University Press

xix One might think of causal beliefs as encoding implicit, conditional practical imperatives whose practical consequences that 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 $\{z_1…z_n\}$ and none of $\{z^*_1…z^*_n\}$ obtain as well', … you get the idea.

xx This insight is captured succinctly in Alison Gopnik's lovely dictum: "past counterfactuals are the price we pay for future conditionals" (*The Philosophical Baby: What Children's Minds Tell Us About Truth, Love, and the Meaning of Life* by Alison Gopnik Farrar, Straus and Giroux). Counterfactuals and future conditionals are both species of hypothetical. Science deals generically with hypotheticals, and although hypotheticals give us the logical resource to define counterfactuals, it is the future conditionals have the most basic cognitive function.

xxi On the logic of these imaginative explorations and what distinguishes them from purely epistemic reasoning, see Joyce, J. (2002), "Levi on Causal Decision Theory and the Possibility of Predicting One's Own Actions", Philosophical Studies 110: 69–102, Anscombe, E., *Intention*, and my "Decision and the Open Future", in *The Future of the Philosophy of Time*, Adrian Bardon (ed), Routledge, 2011.

xxii There are well-defined probabilities only when there are stable relative frequencies across arbitrary subselections from the class. If the class doesn't have the right structure, or we have specific information about the instance in question, then chances aren't relevant in the same way.

xxiii This isn't 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.
xxiv And if asked what the specifically modal content represents/stands-for/or 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 doesn't 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, ibid., and Thomassen, The Descent of Metaphysics, Oxford University Press, forthcoming, for discussion of the deflationary alternative. In either case, I deny that either reduction or reification is needed for realism about these structures.

xxv The phrase occurs in "Cognition in the Wild". He remarks that the phrase also has currency in computer science.
xxvi Lewis, ibid.

xxvii The take-home lesson is that reifying these quantities in the fabric of the world is not the right view. If we actually look at the details of how they are defined and the role they play, they have the status of what I've called Partially Prepared Solutions to Frequently Encountered Problems. The master 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.

xxviii There seems to be a confused idea that if chances and laws aren't 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 exactly right. Chances are not descriptive of anyone's degrees of belief. They are structures meant rather 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 and the chances.

xxix For further discussion, see my How to be Humean", in *The Philosophy of David Lewis*, Oxford University Press, Barry Loewer and Johnathan Schaffer (eds.), forthcoming, "Metaphysics on the Sydney Plan", in *Philosophical Methods*, Routledge, edited by Mathew Haug, forthcoming.

xxx Here is a characteristic statement of the options (reading 'categorical' for 'non-modal') due to Scott A. Shalkowski, ("The Ontological Ground of the Alethic Modality' *Philosophical Review*, Vol. 103, No. 4 (Oct. 1994), pp. 669-688: "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 nonmodal in virtue of which reality possesses modal characteristics–there are no nonmodal 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 nonmodal facts that wholly constitute modal facts."

[xxxi] Peter Godfrey-Smith, "Dewey and the Subject Matter of Science", in J. Shook and P. Kurtz (eds.), *Dewey's Enduring Impact*, Prometheus Books, 2010..

[xxxii] Some clues are contained in my "Against Globalism" (ibid.) and "Simplicity" (ms.).