No Chances in a Deterministic World

C.D. McCoy

14 January 2019

Abstract

Despite the intuitive conflict between deterministic laws of nature and objective chances, philosophers have attempted to develop accounts which allow for the compatibility of determinism and chance. I offer an explicit argument for why this compatibility is not possible and also criticize the various notions of deterministic chance supplied by the compatibilists. Many of them are strongly motivated by the existence of objective probabilities in scientific theories with deterministic laws, the most salient of which is classical statistical mechanics. I show that there is no interpretational difficulty here: statistical mechanics is either an indeterministic theory or else its probabilities are not chances—just as incompatibilism demands.
Keywords: chance, probability, determinism

1 Introduction

There are no objective chances in a deterministic world. So believe *incompatibilists* about chance and determinism. While incompatibilism is presumably the default view among philosophers, a "small but vocal contingent" (Eagle, 2011, 269) of philosophers, the *compatibilists*, believes that it ought to be overturned in favor of the view that chances can exist in a deterministic world. Their intuitions are driven by ordinary language use of the term "chance" or by the presence of objective probabilities in deterministic settings in science; they find further motivation in the apparent lack of much explicit argument in support of incompatibilism, which they take as a sign of its vulnerability (Glynn, 2010; Eagle, 2011; Emery, 2015).[1]

Much of the discussion concerning chance in recent decades grows out of David Lewis's influential contributions to the topic. Lewis was explicit about his view of the issue at hand:

> To the question of how chance can be reconciled with determinism, or to the question of how disparate chances can be reconciled with one another, my answer is: *it can't be done*. (Lewis, 1986, 118)

I am in full agreement with Lewis, at least on this point. His approach to chance, however, brings together several considerations—for example, his famous "principal principle", the "best systems" analysis of laws, particular intuitions about the nature of chance, and more—which, from my point of view, have little to do directly with the irreconcilability of chance and determinism. To a significant extent they even obscure the particular issue. Indeed, I allow that many compatibilists have successfully criticized Lewis's views on chance, yet I do not think they have thereby brought incompatibilism into any doubt.

For Lewis, the connection between credences and chance, enshrined in the principal principle, is our best (and only) guide to chance—hence the title of his famous paper, "A Subjectivist's Guide to Objective Chance" (Lewis, 1981). Most commentators allow now that a lot more informs an analysis of chance than this connection, as argued particularly by Arntzenius and Hall (2003) and as witnessed by the several principles offered by Schaffer (2007). And while this connection is surely important—a complete account of chance should make plain how agents such as ourselves can come to know them and how we should set our beliefs in relation to them—the fundamental incompatibility of chance and indeterminism is independent of such merely agential considerations. If incompatibility is a fact, then it is an objective, metaphysical fact. Thus it should be explicable directly in metaphysical terms, without the encroachment of pragmatic considerations and the like. Accordingly, I aim here to offer something more like an "objectivist's" guide to objective chance.

[1] See, however, (Schaffer, 2007) and (Eagle, forthcoming) for some explicit arguments in favor of incompatibilism.

Already in these few paragraphs appear a number of ambiguous terms which have engendered considerable confusion within the philosophical literature: chance, probability, determinism, objective, subjective, etc. It is important for my arguments to be clear about what is meant by these notions. Thus, a preliminary task will be to specify how I intend them; two distinctions between kinds of probabilities will be especially important. Not only is this task necessary to appreciate my main point about compatibilism, but it is also important for bringing into sharper relief questions about chance and probability that genuinely do require further philosophical elaboration. Indeed, I should note that when their work is understood as being in pursuit of these further questions, rather than as arguments for compatibilism, compatibilists have made many insightful contributions, for example by drawing attention to the important role of explanation (Emery, 2015), the rigor of (List and Pivato, 2015)'s formal approach, and raising the admissibility of evidence bases as a crucially relevant issue (Handfield and Wilson, 2014).

In any case, as the intuitiveness of incompatibilism does not belie the argument for it, I shall waste no time in providing it. The *basic argument for incompatibilism*, as I see it, runs as follows:

1. Chance entails indeterminism.

2. Indeterminism is the contrary of determinism.

3. Therefore chance is inconsistent with determinism.

Properly interpreted, this argument seems to me quite compelling (and quite obvious, so I certainly claim no novelty by stating it).[2] It is, as said, an entirely metaphysical argument: chance here is to be understood in an ontic sense, and determinism is a metaphysical thesis about the world. Since I doubt that compatibilists deny the validity of this argument or the truth of the second premiss, it must be the case that they believe chance does not imply indeterminism. The burden of the remainder of the paper is to show that they are wrong to believe this—especially without falling into pointless disagreement over the "correct" meaning of chance.

In the first half of the paper I clarify the terminology mentioned above, then engage with the various compatibilist counter-arguments to the argument just given. I will take in turn the three main camps of compatibilists: the reductionists, the contextualists, and the relativists. In the second half I address a major sticking point for compatibilists: the presence of chances in apparently deterministic theories from physics, like Bohmian quantum mechanics and classical statistical mechanics. I dissolve this apparent scientific threat to incompatibilism by showing that these theories are either indeterministic or else not chancy. As many compatibilists (and philosophers more generally) think of the probabilities in these theories as chances, and since this is a guide to objective *chance* (not objective probability in general), I concentrate primarily on the former case. Characterizing these theories as indeterministic goes against what many philosophers of physics typically say, but this way of speaking is simply incorrect: While *some* of the laws of these theories are certainly deterministic, not all of them are. Thus worlds with these laws are indeterministic worlds, and hence do not threaten the thesis of incompatibilism.

2 Against Deterministic Chance

My first task is explaining what I mean by the terms in the basic argument for indeterminism. This is necessary because these terms are used in a variety of ways by philosophers and in everyday language, and it is important to avoid the danger of falling into a pointless terminological dispute. How I use the terms should not matter; what matters is the content of the argument. Thus I will fix terminology so that that content is clear.

I begin with the less controversial notion in this debate: determinism. Determinism concerns the metaphysics of worlds. It is the thesis that the world is deterministic. Accordingly, the first premiss, "chance entails indeterminism", expresses the claim that a world with chances is an indeterministic world. Occurrent facts about a single world do not make it deterministic or indeterministic. The usual thinking has it that it is the laws of the world that do. That is to say, a world is deterministic if and only if the laws at that world are deterministic (Lewis, 1983, 360). The laws are deterministic if and only if any two nomologically possible worlds (with respect to the laws) which agree on the relevant facts at one time agree for all times (Earman, 1986, 13). Although this latter definition may not be entirely satisfactory, it is a definition that participants in the present debate have been willing to accept (in some form or another). The laws are indeterministic, then, if and only if there exist nomologically possible worlds (with respect

[2](Eagle, forthcoming) makes an argument which runs more or less like this. He first invokes the intuition that chance entails "unsettledness", then argues that unsettledness entails indeterminism. The detour through unsettledness seems convoluted and unnecessary to me, so I choose to make the direct argument.

to the laws) which agree on the relevant facts at one time but do not agree for all times. If the laws are indeterministic, then the laws allow what one might call "branching": different futures may occur given the state of the world at a particular time. Another useful way to capture the idea is as a reduction thesis: if determinism is true, then each nomologically possible history can be reduced to a state of the world at an individual time; if indeterminism is true, then only (non-singleton) collections of possible histories can be reduced to a state of the world at an individual time (Schaffer, 2007).

Although I define determinism here in terms of laws, laws are not the only metaphysical "whatnots" that a metaphysician might invoke in characterizing determinism. Indeed, some philosophers repudiate the existence of laws of nature altogether (Cartwright, 1983; van Fraassen, 1989; Giere, 1999; Mumford, 2004), in some cases replacing them with causal powers or capacities. A world of causes and capacities may be deterministic or indeterministic, depending on whether they fix the evolution of the world by their action or not. I will prefer to speak of determinism in terms of laws rather than any alternative, however, mainly for the sake of simplicity. I presume that the anti-realist about laws will be able to translate my definitions and stipulations into her preferred ontology.

Now, compatibilists believe that chance is consistent with determinism, so they believe that a world with deterministic laws can have chances. Chances are usually modeled as probabilities. There are, of course, many things that can be modeled by probability theory, not all of them reasonably considered probabilities. Among the things modeled by probability theory that are reasonably considered probabilities, however, two distinctions, seldom made together, will be important for what follows.

First is the distinction between ontic (or metaphysical) probabilities and non-ontic probabilities. Ontic probabilities are often described as probabilities which are part of the "furniture of reality" and which exist in the world whether anyone is around to know about them or not. These descriptions are not precise enough, since what I will call "objective probabilities" could also be characterized in these terms. If ontic probabilities are truly "in the world", then it is because they derive from some "probabilistic" element in the world, a degree of fundamental randomness in the nature of things, according to which states of affairs come to be. In nomological terms, the existence of genuine ontic probabilities indicates that there is a law of nature which mandates that possible outcomes are realized only randomly (in proportion with the probabilities assigned to those outcomes). One might call these particular kinds of ontic probabilities "nomic probabilities" (Emery, 2017). Such non-trivial nomic probabilities entail indeterminism, since only a (non-singleton) collection of possible histories (those to which a non-zero probability is assigned) can be reduced to states of the world at times under the action of this law.

I will use the term "chance" to refer exclusively to real (ontic) probabilities (including probabilities that purport to be *real*, such as Humean chances). This is how the term is typically used in metaphysics; it is a (semi-)technical term. Obviously not everyone uses the term in this sense. Indeed, it is usually not used in this sense in everyday contexts, as some compatibilists have been quick to point out. Nevertheless, one is free to adopt common language terms for technical concepts, as metaphysicians do in this case. My argument does not rest on this terminological choice however. My argument shows that incompatibilists are right to think that chances in this sense are incompatible with determinism. If one wants to call non-ontic probabilities "chances", then one is welcome to do so (although one thereby adds to the confusion of concepts already in the literature). But then one is not (necessarily) making a metaphysical point when one says that such chances are compatible with determinism.

It is worth saying something briefly about reductionist accounts of chance, such as the frequentist and "best systems" interpretations of probability. Both of these interpretations reduce probabilities to certain facts about the world: to frequencies of outcomes in the case of frequentism and to facts acceptable to Humeans, the best systematization of which produces probabilistic laws, in the best systems case. That there are frequencies of outcomes is obviously compatible with both determinism and indeterminism, since frequencies of outcomes have nothing to do with laws. They merely aggregate occurrent facts in a particular way. Thus they are ontic only in the (irrelevant) sense that the facts they describe are ontic; they are clearly not ontic chances in the relevant sense described above. Humean chances, however, derive from probabilistic laws (Lewis, 1981; Loewer, 2001, 2004), which are the output of the best systematization of Humean-sanctioned occurrent facts. Humeans deny that laws and chances have an independent existence from the occurrent facts whence they come. Nevertheless, it is reasonable to consider their laws and chances ontic insofar as they do in fact suitably reduce to these facts. Since they are meant to play the same roles as ontic laws and probabilities, it is "as if" Humean laws are ontic laws, and it is "as if" Humean chances are ontic probabilities. In any case, since Humean chances derive from probabilistic laws, Humean chances are clearly incompatible with determinism.[3]

[3]Hoefer (2007) proposes an account of chance motivated by Humean considerations, but Hoefer's chances are not ontic Humean chances as just described; instead they fall within the category of probabilities which I will be calling objective epistemic probabilities. Since this paper is about

I take it that all non-ontic probabilities are rightly considered agential probabilities: probabilities that agents may use to describe and explain facts about the world, but which are not amenable to an ontic interpretation. They are often used to represent justified degrees of belief (of a rational agent), but they can also represent "objective" evidential support for propositions about the world or can be the probabilities obtained from some kind of theoretical abstraction, like frequencies or the method of arbitrary functions (von Plato, 1983; Strevens, 2006; Myrvold, 2012). In these cases it is appropriate to describe such agential probabilities as epistemic probabilities (insofar as these probabilities are justified, of course). Less-than-rational agents may have degrees of belief (credences) as well, but these degrees of belief are not necessarily epistemic probabilities, since sometimes agents believe things (to a certain degree) that they do not know (to that degree). It is widely assumed that if an agent does know the probabilities representing appropriately objective evidential support for some proposition, then she should set her credences (degrees of belief) in accord with these probabilities (in keeping with some appropriate version of the principal principle). These personal probabilities may derive from genuinely ontic probabilities or they may derive from other objective sources like those just mentioned.

A couple of examples will help illustrate this distinction. Consider, first, the probabilities of quantum mechanics as standardly interpreted. These probabilities are usually thought to be ontic probabilities—that is, thought of as genuine chances. The indeterminism of quantum mechanics is not typically thought to be a matter of, say, a lack of knowledge on our part of some non-chancy reality. In contrast, consider the drawing of an unknown playing card from a full deck of cards. Suppose the drawer elects to take the top card of the deck. Then there is no (non-trivial) ontic probability involved in the top card being or being revealed as a certain card. It is already determined. Nevertheless, for all the drawer knows, the card does have a probability of 1/52 of being a particular card, such as the ace of spades. This probability is an agential probability. If the drawer thinks the probability of drawing the ace of spades is 1, then he has an unreasonable degree of belief given what he knows; in this case the agential probability is not an epistemic probability.

One also finds in the literature a distinction made between objective probabilities and subjective probabilities. To some the distinction is interchangeable with the previous one. For example, Popper claims that "objective physical probabilities are incompatible with determinism" (Popper, 1982, 105). Now, if there are objective agential probabilities (epistemic probabilities) as well as objective ontic probabilities, then this claim is false. Thus it seems that Popper must hold that all agential probabilities are subjective, in which case this distinction would collapse into the distinction between ontic and agential probability. A second example is (Schaffer, 2007, 117). Schaffer marks a distinction between objective chance and epistemic chance, but it is clear that he means to contrast ontic and agential probabilities with this distinction, merely using "objective" to specify ontic and using "chance" here equivocally. Further examples can be easily found in the literature.

"Objective" and "subjective" are surely heavily overloaded terms in philosophy, which makes it fraught to indulge in their use in this debate. There is, however, an important distinction relevant to the issue of incompatibilism which is usefully captured using the objective/subjective distinction and should be marked. That is a distinction in how probability is grounded or justified. We should say that subjective probabilities are probabilities determined (substantively) by an agent's choice and that objective probabilities are determined (substantively) by facts about the world. Roughly this distinction is one made in the context of Bayesian probability. It is not a sharp distinction, since probabilities can be more or less objective, more or less subjective. Nevertheless, it should be clear that agential probabilities may be subjective or objective in this sense, whereas ontic probabilities are necessarily objective, as they are grounded in lawlike features of the world (or, more generally, other ontic features of the world, like powers).

Let me now revisit the previous examples and employ the new distinction. First, the probabilities derived from quantum mechanics, as standardly interpreted, are described in this terminology as objective ontic probabilities (as all ontic probabilities are necessarily objective). If we set our credences in accord with these probabilities, then it seems right to regard them as objective agential probabilities—epistemic probabilities. Similarly, it might be reasonably said that assigning the ace of spades a probability of being drawn of 1/52 is objective (because of, say, some principle of indifference, if that be justified by the facts), despite there being no genuine chances involved in determining what the drawn card is. To permit room for rational disagreement, however, it is plausible to suppose that there is some freedom in assigning degrees of belief in general, such that agential probabilities are not always completely determined by the available evidence. In the extreme case, it might be supposed that assigning any probability of drawing the ace of spaces is rationally permissible given the evidence available. But then it seems right to describe such probabilities as subjective, as this degree of subjectivity would surely undermine their standing as epistemic probabilities.

ontic probabilities, I will not discuss Hoefer's account further.

To illustrate these distinctions further in the context of the literature on "deterministic chance", consider the claim of Lyon (2011, 414) that there are probabilities which are neither chances nor credences. In introducing the "paradox of deterministic probabilities", that is, the problem of interpreting the probabilities of ostensibly deterministic theories like classical statistical mechanics, Lyon describes chances as objective probabilities and credences as subjective probabilities (which include, he rightly notes, the "objective" degrees of belief of impermissive Bayesians). Since he accepts that chance is incompatible with determinism (understanding chance in what appears to be the ontic sense) but also believes that there are objective probabilities that are not chances, he suggests that there is a third kind of probability besides chance and credence, which he calls "counterfactual probability". Given what I have said, clearly I agree with Lyon that there is this third kind of probability. Although it is not my concern to argue it here, I believe his third kind of probability naturally falls within the general category of objective epistemic probabilities. Note too that this example illustrates again the potentially troublesome usage of terminology in the context of this debate, since Lyon uses objective and subjective in a way that overlaps in an unclear way with the distinction between chance (which he calls objective probabilities) and credences (which he calls subjective probabilities).

It seems that making these two distinctions in the way that I have would helpfully clear the ground of the seeds of confusion which have unfortunately spread and sprouted throughout the literature. These are not novel distinctions, but they are distinctions which should *both* be made in this context. In any case, with these distinctions in mind I may restate my claim more precisely: it is that chances—objective ontic probabilities—are incompatible with determinism. This does not deny that objective probabilities can be compatible with determinism, since it is possible to justify non-trivial objective degrees of belief, that is, epistemic probabilities, in a deterministic world.

With the content of the argument fixed, I can now turn to criticizing the compatibilists that intend to dispute this claim. I have already pointed out that reductionist chances are either incompatible with determinism (for example, Humean chances) or are not ontic in the relevant sense (for example, frequentist probabilities), so there are two remaining camps of compatibilists to address: the contextualists and the relativists.

The first camp of compatibilists that I will criticize is the contextualists (Eagle, 2011; Handfield and Wilson, 2014). They would (I presume) object to the basic argument for incompatibilism by alleging that "chance" in this argument is equivocal: some kinds of chance imply indeterminism, but not all meanings of chance imply that it does. As Eagle observes, "the possibility of such equivocation is good evidence that an expression is *context sensitive*" (Eagle, 2011, 283). Quite right. So too, though, is the meaning of the word "law" equivocal between "law of nature" and "law of the land". Natural language words, as is well-known, tend to have a variety of meanings which vary based on context. The relevant context of debate here, however, is clear: it is an issue of metaphysics. So it would seem that all parties should take care to remove irrelevant equivocation from consideration in order to avoid pointless semantic disagreement. Indeed, this is why I took care above to specify what I mean by the relevant terms in my argument. That being accomplished, it would seem that the basic argument should go through without possible objection from the contextualists.

Nevertheless, let us look a bit further into the contextualist position to be sure this dismissal is not too hasty. Salient in the contextualist line is the thought that the incompatibilist thesis has a greater burden of proof than what the basic argument for it suggests. To see this, observe how Eagle renders the incompatibilist thesis:

> **IC** If a world is deterministic, then no possible outcome in that world has any chance other than 1 or 0. (Eagle, 2011, 286)

He then claims that "compatibilism will be defensible if there exists some context in which the proposition expressed by IC is false." This is plainly a low bar for the compatibilist to vault over, given the ubiquity of pragmatic factors affecting the semantics of natural language words. Similarly, Handfield and Wilson offer this rendering of the incompatibilist thesis (for any proposition φ):

> If 'the chance of φ is x' is true at [time] t, then 'the chance of φ is y' is true at t, iff $x = y$. (Handfield and Wilson, 2014, 5)

Indeed, they take this to be the central commitment of the incompatibilist position and argue against it by allowing "chance" to refer to any kind of objective probability. In both cases these authors introduce an irrelevant and unreasonable standard for incompatibilism, since I expect few (and probably no) incompatibilists would be so bold as to claim that epistemic probabilities are incompatible with determinism. Such a claim would require that only ontic probabilities ground or justify epistemic probabilities, a view which I suspect most philosophers would find quite indefensible. In any case, the source of objectivity for epistemic probabilities is plainly a matter that is logically independent of the thesis of incompatibilism, hence it is an irrelevant consideration which is raised by the contextualists.

Perhaps what contextualists have in mind, though, is that the meaning of chance is "up for grabs", and they think that we should not presuppose or stipulate a particular meaning for it in advance. This would be in keeping with the generally "functionalist" and "subjectivist" approach adopted by most authors who have written on chance. To decide the matter, they might say, we need to look at all the available evidence, including the use of the word in ordinary and scientific contexts. Handfield and Wilson, for example, find the ontic conception of chance to be a poor fit with its usage in these contexts. They believe that by making chance a contextually relative concept they can do justice to the varied meanings of the term, including the semi-technical version I adopt. As a matter of semantics alone, no doubt they can.

Relativizing the meaning of chance to context, however, makes it easy to overlook philosophically important distinctions, especially those mentioned above: that between ontic and agential probability and that between objective and subjective probability. Handfield and Wilson choose to run together such distinctions at the outset of their paper, saying that they "will use 'objective probability', 'objective chance' and 'chance' interchangeably" (Handfield and Wilson, 2014, fn. 1). Yet it is surely an important matter for metaphysical investigation whether the ontology of the world includes genuine chances. Handfield and Wilson evidently agree, pointing out that their contextualist framework can easily be made to accommodate these investigations by supplying the relevant contexts. No doubt it can, but then their use of contextualism is ultimately irrelevant to incompatibilism, the metaphysical thesis.

Handfield and Wilson do, however, offer something more than the dialectically inert contextualism in arguing against incompatibilism. They also fall within the second camp of compatibilists, the chance relativists (Glynn, 2010; Emery, 2015; List and Pivato, 2015), who allege that there exist different "levels of reality" where one may locate chances. The relativists would apparently object to the first premiss of the basic argument for incompatibilism by alleging that chances may exist on some levels despite the world (or at least some more fundamental level) itself being deterministic. Yet, as List and Pivato (2015) recognize, there is a significant danger in relativizing chances to levels, since it may be argued that higher level probabilities, insofar as they are inconsistent with probabilities on lower levels, are at best merely epistemic probabilities, in which case the incompatibilist thesis would stand.

To the question of whether this danger can be avoided, my answer is: *it can't be done*. List and Pivato not only recognize the danger but supply the best attempt to avoid it. Their attempt fails however, and its failure illustrates well why it cannot be done. They assume that higher levels are related to lower levels in such a way that there is a surjective projection map $\sigma : L \to H$ from lower level states L onto higher level states H (List and Pivato, 2015, 131-2). This map is used to capture the idea that "macroscopic" states of the world at the higher level are multiply realized by "microscopic" states of the world at the lower level.[4] Once they connect higher levels to lower levels via σ in this way, though, they have sown the seeds of their attempt's destruction. They believe, though, that the higher level probabilities are immunized from the danger of lower level determinism, for they insist that there are independent probability spaces on each level—that is, the independent probability spaces built on L and H. Their "key insight" is that "*only higher-level language is available*" (List and Pivato, 2015, 134) when evaluating chance and determinism on a particular higher level. Indeed, they say that it is a "conceptual error" and a "category mistake" to employ a lower-level probability function to evaluate probabilities of higher level events (List and Pivato, 2015, 135). What they say is literally true, I suppose; however, the conceptual error is entirely on their side and their key insight is a confusion. By assuming that higher levels are related to lower levels in the way they do, via the projection map, they have introduced all the relevant language needed to translate facts between levels, including facts about chances. Therefore, their higher level chances are not at all immunized from what the lower level chances are.

Here is how the translation is done. Let us represent a lower level state $s \in L$ subject to deterministic laws as a trivial probability distribution ρ on the probability space representing that lower level L: $\rho(s) \mapsto 1$ and $\rho(t) \mapsto 0$ for all $t \in L, t \neq s$. Then the projection map σ can be used to translate that lower level probability space to the higher level, where the measure will of course remain trivial. If we call μ the probability distribution on the higher level H, then $\mu : \sigma(s) \mapsto 1$ (where $\sigma(s)$ is the unique higher level state to which σ maps s) and $\mu : u \mapsto 0$ for all $u \in H \neq \sigma(s)$.[5] This is a trivial probability measure on the higher level in the "higher-level language". There can be no objection to pushing probability measures forward in this way, from lower levels to higher levels, as List and Pivato have provided all the tools needed to do it. No additional choices have been made in defining μ; it is just the translation of σ from L to H using the translation manual they furnished by positing σ.

It is clear that the trivial probability measure pushed forward to the higher level probability space will be inconsis-

[4]The inverse image $\sigma^{-1}(h)$ of a higher level state h is the set of lower level states that project to h.

[5]More elegantly, we may define $\mu = \rho \circ \sigma^{-1}$, so that the higher level probability distribution is the composition of the lower level probability distribution and the inverse of the projection map from lower to higher levels (extended in the obvious way to the sigma algebras of the relevant probability spaces). It is easy to show that the composition exists and is a probability measure associated with H.

tent with any probability measure that differs from it. If the probabilities of the lower level are ontic, that is, chances, then we cannot consider the higher level probabilities to be chances too on pain of contradiction. If the lower level is deterministic, then we cannot consider the higher levels probabilities chances either. In short, List and Pivato's "emergent chance" at higher levels can only be epistemic and hence not chance. Their framework therefore supports incompatibilism rather than compatibilism. Mutatis mutandis, the same will be true of other chance relativists. Therefore, the only way to preserve independent chances on different levels is to give up on plausible relations (like σ) between the levels. Although a "disunified level" picture is, I suppose, conceptually possible, it is quite irrelevant to the thesis of incompatibilism, which necessarily assumes that it is meaningful to say that the world is deterministic.

I conclude, therefore, that the general arguments of the contextualists and relativists against incompatibilism fail. The basic argument for incompatibilism can only be overturned by arguments which deny the terms which give it any meaning. Perhaps this is actually what some compatibilists aim to provide; they do not, however, make this particular disagreement explicit. Thus, insofar as it is meaningful to discuss the thesis of determinism and the reality of chances, incompatibilism is unquestionably correct. That said, I take it that compatibilists are more often motivated to their aim by a wish to understand the nature of objective probabilities, especially those which arise in apparently deterministic contexts. For the sake of these compatibilists, I accept that more must be said, since the arguments of this section will have done little to assuage compatibilist intuitions regarding such cases. I address these cases in the next part of the paper.

3 Apparent Conflicts Between Chance and Determinism

There are many cases from science and everyday life that are said to involve "chance". Particularly salient for the case of the compatibilists are probabilistic scientific theories that are described as deterministic (like classical statistical mechanics) and also apparently chancy events, like coin flips, which can be modeled by a fully deterministic mechanical dynamics. To firmly establish the incompatibilist thesis it is necessary to explain away seeming conflicts of chance and determinism in these cases. Assuming that the probabilities in such cases are properly thought of as objective, there are two main alternatives available to the incompatibilist: either these theories are not really deterministic, or their probabilities are merely non-ontic epistemic probabilities.

Many (perhaps all) of the cases plausibly fall into the latter category. While the probability of a coin flip landing heads is reasonably thought of as an objective probability, it is surely not best described as genuinely chancy. Instead it is best characterized as an objective agential probability. These probabilities are theoretically justified and useful to agents. For example, according to the method of arbitrary functions (von Plato, 1983; Strevens, 2011; Myrvold, 2012), the utility of modeling coin flips probabilistically can be accounted for by first coarse-graining of the space of possible mechanical initial conditions into the coarse-grained outcomes "heads" and "tails", then noticing that nearly any suitably random distribution of initial conditions will result in half "heads" and half "tails". Thus one has good reason to expect that the probabilities (or, better, frequencies) of heads is 1/2 and of tails is 1/2.

To fully understand the nature of these probabilities, however, one must ask, "from where does the relevant element of randomness come?" There are two ways to take the question, depending on whether one asks the question in the context of the given "chance setup" (the theoretical setup of the coin flip) or about the conditions that give rise to the particular chance setup itself.

On the one hand, the randomness imposed in the context of the chance setup to justify the use of probabilities is purely on the part of the agent: one picks "random-looking" initial conditions or chooses a "reasonable" probability distribution over these conditions. Since this randomness is not ontic, involving as it does an element of agential choice, the probabilities are agential probabilities. In the method of arbitrary functions one applies various probability measures to the set of initial conditions and observes that the coarse-gained outcomes are robust under almost all of them. Yet the structure of the space of initial conditions and the coarse-grained outcomes (as just described) are fully objective, which is why such probabilities are rightly considered to be (to a sufficient extent) objective. This is why they are properly characterized as objective agential probabilities, that is, epistemic probabilities.

On the other hand, there is the further question of why the initial conditions of actual coin flips have the "random-looking" distribution that they evidently do. That question can only be answered in a different theoretical context. Perhaps the correct answer is to be found in fundamental chances; perhaps it is merely to be found again in initial conditions in this theoretical context. There is obviously much more to be said about how to understand cases of epistemic probability than what I offer here; a more complete account, however, clearly deserves a separate treatment. The topic of *this* paper is objective *chance*. Hence, the more pressing cases are those that we might tend to think

of as involving genuine chances, especially cases from physical theory (classical statistical mechanics and quantum mechanics).

Indeed, compatibilists have often pointed to classical statistical mechanics (in particular) as a place where ineliminable, objective probabilities must somehow be compatible with deterministic mechanical underpinnings. As standardly understood, statistical mechanics describes and explains macroscopic (thermodynamic) phenomena by way of the microscopic physics of atoms and molecules. This microscopic physics of classical statistical mechanics is described by classical mechanics; hence, it is conventionally understood to be a fundamentally deterministic theory at the microscopic level. Although some interpreters of the theory would be happy to characterize statistical mechanical probabilities in agential terms (Jaynes, 1957), many others feel that there is some awkwardness in describing them as merely "subjective" or agential, for example because they play a crucial role in generating the empirical content of the theory. They conclude that there must be deterministic chances—non-agential probabilities in a deterministic world—in order to explain the success of the theory.

This apparent conflict between statistical mechanics being a deterministic theory yet possessing non-agential probabilities has been called, as noted, the paradox of deterministic probabilities (Loewer, 2001; Winsberg, 2008; Lyon, 2011). The most prominent solution, discussed by Loewer (2001), is in effect to push all probabilities back to an initial time in order to avoid conflict with the underlying deterministic microscopic dynamics. What is "chancy" on such a view, then, is the initial microscopic state of the system. This state is (because of the large number of atoms or molecules involved) obviously epistemically inaccessible. Accordingly, the "chanciness" inherent in the realization of the actual microscopic initial conditions is translated into an agential probability, due to epistemic uncertainty over which of the initial conditions was actually realized (in accord, say, with some sort of principal principle). These agential probabilities can then be carried forward through the deterministic evolution of the system after the initial time to make statistical predictions of a system's properties (conditionalizing on other admissible evidence along the way) (Albert, 2000). In short, the epistemic uncertainty in our predictions is ultimately a consequence of uncertainty over the outcome of the initial chance event, this chance event, however, accounting for the epistemic objectivity of these predictions. Loewer claims that this resolves the paradox of deterministic probabilities, and I agree that it does.

Of course, Humeans like Albert and Loewer generally take these initial chances to be descriptive of and reducible to the actual matters of occurrent fact. There was, as an ontological matter of fact, no "chance event" associated with the creation of an individual system or world, just as Humeans take it that there are no laws actually pushing and pulling objects around. Fundamentally speaking there are only the actual matters of occurrent fact, the "Humean mosaic". Nevertheless, Humeans wish to recover the apparent objectivity of laws and chances (to use them in explanations, for example) and usually do so by arguing that they are part of an objective overall best theoretical system (Lewis, 1973, 1994; Loewer, 1996; Cohen and Callender, 2009). The features of the best systematization of some set of occurrent facts should, moreover, be considered to be metaphysically real, for if they were not real in this sense, then it would be difficult to see how they could play their important roles of prediction, explanation, etc. (Loewer, 2001).

Since there is some pressure to globalize statistical mechanics (Callender, 2011), it is common for Humeans to conceive of the entire world as a statistical mechanical system with its own chancy initial conditions. In this picture, the universe began in some particular macro-state corresponding to a hot, dense "big bang" beginning (the so-called "past state"), the probabilities of which pertain to the particular micro-state instantiated in the initial creation event. Just as one may take the view that there are genuine, irreducible governing laws , one may also take these initial chances to involve a genuine ontic randomness; that is, these chances are full-fledged features of reality. In this case one would describe this story in essentially the same way, but one would say that the world began—as an actual matter of fact—with an initial chance event, as argued, for example, by Demarest (2016).

I suggest that this latter, non-reductive point of view on ontic probability clearly reveals that statistical mechanics is not a deterministic theory, as is almost universally proclaimed. When chances are characterized nomologically, as I described them previously, statistical mechanics is seen to involve both an indeterministic law, which governs the initial chance event, and a deterministic law, which governs the evolution of the system at all other times ever afterwards. Recall that a world is only a deterministic world if *all* its laws are deterministic; otherwise it is an indeterministic world. A statistical mechanical world is therefore not deterministic; the initial chances of statistical mechanics (interpreted this way) imply that the world is indeterministic. Although the laws of statistical mechanics are almost always deterministic, they are not *always* deterministic: the evolution of the system is indeterministic at the initial time and deterministic (ever) afterwards.

Furthermore, since the only thing that differs between the non-Humean and (ontic) Humean accounts is a difference over whether the chances, laws, etc. are reducible to other parts of the ontology, both accounts should understand statistical mechanics as an indeterministic theory. Indeed, Loewer (2001) clearly states that the initial probability

distribution should be considered a law because of its essential "law-like" role in the theory. I completely agree. This probability distribution pertains to an initial chance event, which when interpreted nomologically describes a dynamical, law-like transition of state.

Therefore Loewer solves the paradox of deterministic probabilities *not* by adopting compatibilism (as many compatibilists seem to interpret him) but by showing how its indeterministic evolution can be compatible with its deterministic evolution. Hence, Loewer's approach does not run aground on the basic argument for incompatibilism at all, since at no time do the chances (and their attendant indeterminism) conflict with the deterministic laws. It is true that Loewer himself and others have described this story as an account of deterministic chance, but this is just a terminological choice. One is, of course, welcome to call it as such, yet it is so only in the sense that it neatly separates the chanciness of the theory from its determinism. Yet this solution is surely not an argument for compatibilism or a compatibilist account of chance.

This is, to repeat, a point on which Humeans and non-Humeans should agree, despite their differing ontological interpretations of laws and chances. Some Humeans (in the broader sense) are made uneasy, however, by the idea of initial chances (Hoefer (2007); Frigg and Hoefer (2013) for example), especially the idea of an initial chance for the entire world. However, if they wish to consider the chances of statistical mechanics to be genuine, real, *ontic*, then they are forced to be committed to the ontic interpretation of statistical mechanical probabilities. Otherwise they must consider their probabilities as purely epistemic—in which case they will have to explain why such probabilities can play the roles that they usually play in statistical mechanics. There is no middle road between chances and epistemic probabilities.

Alas, I expect many will remain unconvinced by my characterization of Loewer's account as actually incompatibilist and my argument that statistical mechanics is actually indeterministic. Fortunately, the case can be made stronger, since the initial chance interpretation of the theory is not the only way to resolve the paradox of deterministic probabilities which preserves the ontic nature of the probabilities. These other resolutions strengthen the case that probabilistic physical theories like statistical mechanics are indeterministic (when the probabilities are interpreted ontically) and incompatibilist.

Let us call a particular "chance interpretation" of statistical mechanics one that resolves the paradox of deterministic probabilities. From Loewer's account we learn that this depends merely on a choice of how to separate the deterministic and indeterministic parts of the theory. There are, as one might imagine, several possibilities. The "initial chance" version simply pushes all the indeterminism of the theory to one particular time, the initial time. This version is perhaps appealing in our world, since the standard model of cosmology suggests that our universe had a beginning in the big bang. Yet, just as there is no least positive number, there was actually no one time when the universe came into existence—no earliest time. Supposing that there was only one chance event, the universe necessarily evolved deterministically before and after this event. This bi-directional evolution is, it seems, somewhat paradoxical. Consider also the possibility that our universe could have conceivably existed eternally; in this case it would not make sense at all to talk of an initial time. If one wishes to maintain a "one time" chance interpretation, then an alternative to assigning the chance event to a time within the universe is to assign it as being, in a sense, "outside of time", much as if a metaphorical "Creator" selected the possible universe to actualize (in accord with the appropriate probability measure associated with these possibilities).

Besides these "one time" chance interpretations, there are other alternative chance interpretations available.[6] The easiest place to find them is in interpretations of quantum mechanics, the quintessential "chancy" theory, thanks to the intensive interpretational work on the theory in the last several decades. Quantum mechanics is usually characterized as indeterministic, despite its main equation of motion, the Schrödinger equation, being deterministic. Conventional views of quantum mechanics suppose that quantum systems undergo "collapses" under measurement, an indeterministic change in state. It is because of these collapses that the theory is usually taken to be indeterministic. Thus one can raise a sort of "paradox of deterministic probabilities" for quantum mechanics as well, and, unlike in statistical mechanics, the variety of chance interpretations which solve it are well-known.

There are, I suggest, strong interpretive analogies between statistical mechanics and quantum mechanics in how they may handle chance and determinism. First, the various collapse interpretations of quantum mechanics have statistical mechanical cousins, which may collectively be described as "stochastic dynamics" interpretations. The laws on such accounts are partially (or even fully) indeterministic. They solve the paradox of deterministic probabilities by making particular choices about how to partition of determinism and indeterminism (chance) in an indeterministic, probabilistic theory, that is, statistical mechanics. The Bohmian interpretation of quantum mechanics, according to

[6]Cf. (Maudlin, 2007).

which the initial state of a collection of quantum particles is probabilistically related to the quantum wave function in much the same way as the initial microscopic state of a statistical mechanical system is probabilistically related to its macrostate, supplies a second. The interpretations of chance and determinism are largely identical between the Bohmian interpretation and Loewer's solution: there is an initial chance event, after which the system (or world) evolves deterministically. Thus, Bohmian mechanics is properly characterized as indeterministic—despite popular claims to the contrary![7]

To push the point from a different direction, observe that the "one chance" interpretations of quantum mechanics and statistical mechanics are just a special case of the general class of chance interpretations: they merely locate all the chanciness of the theory at one time, namely, the initial time, rather than at finitely many, countably many, or uncountably many times. Now, since it is obvious to all that collapse theories of quantum mechanics are indeterministic (and stochastic dynamics theories of statistical mechanics as well), it stands to reason that the initial chance interpretations (Bohmian mechanics and Loewer's solution) are just a special case of stochastic dynamics; hence they are indeterministic too.

Therefore, I conclude that the paradox of deterministic probabilities can be decisively resolved in a wide variety of ways. This requires, however, appreciating the importance of incompatibilism in understanding the role of probability and determinism in our probabilistic theories. It is conceivable that a probabilistic theory may be best interpreted as deterministic, but then it follows that it cannot involve chances. Its probabilities may instead be interpreted as chances, but then it follows that the the theory is indeterministic. Such a theory may feature both deterministic and indeterministic laws, as I have shown, but to avoid inconsistency (running afoul of incompatibilism) one must cleanly separate the operation of the laws and the chances.

4 Conclusion

I have argued for the thesis of incompatibilism: chances are incompatible with determinism. Although the thesis is intuitively correct, the thesis has recently been denied by several authors. I have given an explicit defense of it. The basic argument for this claim is that chance entails indeterminism, and indeterminism is inconsistent with determinism. Chance and determinism are meant in an ontic sense, hence this is an entirely metaphysical thesis. Some compatibilists argue that the notion of chance is contextual in a way that makes it (potentially) compatible with determinism, but I argued that the other contexts they imagine are irrelevant to the thesis of incompatibilism. Some compatibilists argue that chances are relative to levels, but I argued that it is not possible to insulate the levels from the activity of chances on other levels, at least without giving up on a plausible metaphysics of relations between levels. I conclude that such general arguments do not undermine the basic argument for incompatibilism.

In the second part I turned to consider apparent cases of conflict between determinism and chance, cases which have motivated compatibilists. I argued that these are resolved in most cases by understanding the relevant probabilities as objective epistemic probabilities—"counterfeit chances" as Lewis calls them. Physical theories, however, are often naturally understood to involve ontic probabilities, that is, genuine chances, so the ostensible conflict between determinism and chance becomes acute. I argued, however, that a proper understanding of the probabilities in these theories makes it clear that their presence makes the theories in question indeterministic (despite them often involving some element of deterministic evolution). Only some of the laws of probabilistic physical theories may be deterministic; interpreters have merely incorrectly inferred that these theories are deterministic on the basis of the deterministic subsets of their laws.

Appreciating the distinctions used here, that is, between ontic and epistemic probabilities and between objective and subjective probabilities, suggests interesting directions of further work. Concerning ontic probabilities, the arguments made here suggest that it would be worthwhile to investigate more fully the different solutions of the paradox of deterministic probabilities and evaluate them. However, since so many of our probabilistic theories about the world are not fundamental, it is far more pressing to inquire into the nature and justification of objective epistemic probabilities. Particularly crucial here is better understanding the seeming randomness of outcomes (Hoefer, 2007, 563) which leads us to conclude that it is as if they were "chancy"—I expect that explanatory considerations (not psychological ones) will be central to explicating this notion successfully.

[7] A third well-known case is the many worlds interpretation of quantum mechanics. The interpretation of probability in this interpretation is controversial and requires more development to fit into the account on offer here. I discuss it in more detail here: (ref removed).

References

Albert, David. *Time and Chance*. Cambridge, MA: Cambridge, MA: Harvard University Press, 2000.

Arntzenius, Frank, and Ned Hall. "On What We Know About Chance." *The British Journal for the Philosophy of Science* 54, 2: (2003) 171–179.

Callender, Craig. "The Past Histories of Molecules." In *Probabilities in Physics*, edited by Claus Beisbart, and Stephan Hartmann, Oxford: Oxford University Press, 2011, 83–113.

Cartwright, Nancy. *How the Laws of Physics Lie*. Oxford: Oxford University Press, 1983.

Cohen, Jonathan, and Craig Callender. "A Better Best System Account of Lawhood." *Philosophical Studies* 145: (2009) 1–34.

Demarest, Heather. "The Universe Had One Chance." *Philosophy of Science* 83, 2: (2016) 248–264.

Eagle, Antony. "Deterministic Chance." *Noûs* 45: (2011) 269–299.

———. "Chance, determinism, and unsettledness." *Philosophical Studies* .

Earman, John. *A Primer on Determinism*. Dordrecht: D. Reidel Publishing Company, 1986.

Emery, Nina. "Chance, Possibility, and Explanation." *The British Journal for the Philosophy of Science* 66, 1: (2015) 95–120.

———. "A Naturalist's Guide to Objective Chance." *Philosophy of Science* 84, 3: (2017) 480–499.

Frigg, Roman, and Carl Hoefer. "The Best Humean System for Statistical Mechanics." *Erkenntnis* 80: (2013) 551–574.

Giere, Ronald. *Science Without Laws*. Chicago: University of Chicago Press, 1999.

Glynn, Luke. "Deterministic Chance." *The British Journal for the Philosophy of Science* 61: (2010) 51–80.

Handfield, Toby, and Alastair Wilson. "Chance and Context." In *Chance and Temporal Asymmetries*, edited by Alastair Wilson, Oxford: Oxford University Press, 2014, chapter 1, 19–44.

Hoefer, Carl. "The Third Way on Objective Probability: A Sceptic's Guide to Objective Chance." *Mind* 116: (2007) 549–596.

Jaynes, Edwin. "Information Theory and Statistical Mechanics." *Physical Review* 106: (1957) 620–630.

Lewis, David. *Counterfactuals*. Cambridge, MA: Harvard University Press, 1973.

———. "A Subjectivist's Guide to Objective Chance." In *IFS*, edited by William Harper, Robert Stalnaker, and Glenn Pearce, Dordrecht, Netherlands: D. Reidel Publishing Company, 1981, volume 15 of *The University of Western Ontario Series in Philosophy of Science*, 267–297.

———. "New Work for a Theory of Universals." *Australasian Journal of Philosophy* 61, 4: (1983) 343–377.

———. *Philosophical Papers*, volume 2. Oxford: Oxford University Press, 1986.

———. "Humean Supervenience Debugged." *Mind* 103: (1994) 473–490.

List, Christian, and Marcus Pivato. "Emergent Chance." *The Philosophical Review* 124, 1: (2015) 119–152.

Loewer, Barry. "Humean Supervenience." *Philosophical Topics* 24, 1: (1996) 101–126.

———. "Determinism and Chance." *Studies in History and Philosophy of Modern Physics* 32: (2001) 609–620.

———. "David Lewis's Humean Theory of Objective Chance." *Philosophy of Science* 71, 5: (2004) 1115–1125.

Lyon, Aidan. "Deterministic probability: neither chance nor credence." *Synthese* 182: (2011) 413–432.

Maudlin, Tim. "What could be objective about probabilities?" *Studies in History and Philosophy of Modern Physics* 38: (2007) 275–291.

Mumford, Stephen. *Laws in Nature*. London: Routledge, 2004.

Myrvold, Wayne. "Deterministic Laws and Epistemic Chances." In *Probability in Physics*, edited by Yemima Ben-Menahem, and Meir Hemmo, Berlin: Springer, 2012, The Frontiers Collection, chapter 5, 73–85.

Popper, Karl. *Quantum Theory and the Schism in Physics*. Totowa, NJ: Rowman and Littlefield, 1982.

Schaffer, Jonathan. "Deterministic chance?" *The British Journal for the Philosophy of Science* 58: (2007) 113–140.

Strevens, Michael. *Bigger Than Chaos*. Cambridge, MA: Harvard University Press, 2006.

———. "Probability Out of Determinism." In *Probabilities in Physics*, edited by Claus Beisbart, and Stephan Hartmann, Oxford: Oxford University Press, 2011, chapter 13, 339–364.

van Fraassen, Bas. *Laws and Symmetry*. Oxford: Oxford University Press, 1989.

von Plato, Jan. "The Method of Arbitrary Functions." *The British Journal for the Philosophy of Science* 34: (1983) 37–47.

Winsberg, Eric. "Laws and chances in statistical mechanics." *Studies in History and Philosophy of Modern Physics* 39: (2008) 872–888.