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Chance, Determinism, and Unsettledness

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Abstract. A previously unrecognised argument against deterministic chance is introduced. The argument rests on the twin ideas that determined outcomes are settled, while chancy outcomes are unsettled, thus making cases of determined but chancy outcomes impossible. Closer attention to tacit assumptions about settledness makes available some principled lines of resistance to the argument for compatibilists about chance and determinism. Yet the costs of maintaining compatibilism may be higher with respect to this argument than with respect to existing incompatibilist arguments.

§1. Chance, Determinism, and Possibility

The recent literature on chance and determinism contains a number of defences of the **compatibilist** thesis that it is possible that an outcome is both determined to occur given the laws of nature and the facts about the past, while nevertheless having a chance strictly between zero and one (a *non-trivial* chance).

One primary motivation for the authors in this debate has been to understand the irreducible role of probabilities in classical statistical mechanics. This theory involves an underlying dynamics governing a system's trajectory through the state space which is (for all practical purposes) deterministic. But a probability distribution over these underlying states appears to play the theoretical role of an objective chance – specifically, being crucial to prediction and explanation of thermodynamic phenomena (Loewer 2001; Frigg 2016; Clark 1987). The structure of this example generalises. Indeed, Ismael suggests that any

acceptable physical theory must involve probabilities which can play the predictive and explanatory role typical of chance:

> a probability measure over the space of physically possible trajectories is an indispensable component of any theory – deterministic or otherwise – that can be used as a basis for prediction or receive confirmation from the evidence. (Ismael 2009, p 89)

Some extend this line of argument to 'higher-level' special science probabilities, not just physical probabilities (Glynn 2010; List and Pivato 2015). And even those who offer different grounds for their compatibilism still centre their argument around the ability of deterministic probabilities to adequately play the chance role (Eagle 2011), while the primary incompatibilist argument is that a correct understanding of the chance role shows that deterministic probabilities could **not** play it (Schaffer 2007).

These authors attend to many different aspects of the chance role in their discussions. But most emphasise that a connection between chance and **possibility** is a significant part of that role. Indeed, most agree that the following claim can be used to capture the constraint in question:

(1) 'if there is a nonzero chance of p, this should entail that p is possible, and indeed that p is compossible with the circumstances' (Schaffer 2007, p 124).

This principle is rather plausible. It is a fairly immediate consequence of the 'basic chance principle' (Bigelow, Collins, and Pargetter 1993). But what sort of possibility is involved in (1)? (How are we to read the notoriously context-sensitive expression 'possible' occurring in it?)

Schaffer's preferred suggestion is that 'possible' in (1) should have **physical possibility** as its content, where something is physically possible iff it is compatible with the laws and the boundary conditions. (Boundary conditions include any non-nomological facts required to ensure that questions about the physical situation are well-posed. This may include, for example, facts about the history up to the time of utterance of the possibility ascription.) Since determinism can be identified with the thesis that all the physical facts (past, present, and future) in a world with deterministic laws supervene on the laws and the boundary

conditions (Earman 1986) , it is straightforward to see that if (1) is true on *this* reading, then incompatibilism about chance and determinism must follow. Since every non-w future course of outcomes is not compatible with the laws and boundary conditions that hold in a deterministic world w, no such course of outcomes is possible, and hence, contraposing (1), no such course of outcomes can have any positive chance.

Unsurprisingly, compatibilists who accept that (1) can be used to capture the chance-possibility connection will not adopt Schaffer's reading of 'possible'. For example, (Glynn 2010) and (List and Pivato 2015) both argue, in effect, that the sense of 'possible' in question should be this: p is possible iff p is compatible with the laws and boundary conditions when represented at a certain 'level of description'.[1] Given some deterministic laws, a fine-grained representation of the boundary conditions may provide sufficient information to uniquely constrain the future compatible with the laws and boundary conditions at that point. But a more coarse-grained representation of the boundary conditions may not provide sufficient information to uniquely determine what will happen. If the boundary conditions tell us only that the prior trajectory of the system can be found in a certain macroscopically specifiable region, then it may well be that there are multiple future trajectories of that system compatible with that coarsely described boundary condition. According to these compatibilists, since it is an objective fact that there are multiple futures compatible with the laws and the coarse-grained boundary conditions (even if that multiplicity is an artefact of the chosen level of description), it is plausible to say that each of those multiple futures is objectively possible in a sense pertinent to (1), thus blocking the derivation of incompatibilism.

Appeal to levels of description has a rather epistemic flavour. That is Schaffer's own take on these sorts of proposals, when he says they involve 'objectively informed chance with scientific credentials' (Schaffer 2007, p 137), which he takes be a kind of 'epistemic chance',

[1] In particular, (Glynn 2010) offers an alternative precisification of Schaffer's 'realization principle' which explicitly takes possibilities to be level-relative, so that an outcome might be fundamentally impossible (ruled out by the fundamental laws) and non-fundamentally possible (compatible with the non-fundamental laws of some special science).

distinct from objective chance which is the subject of (1). Compatibilists of this sort retort that a probability with scientific credentials just is chance, and if statistical mechanics gives us incompatible outcomes with non-zero 'objectively informed' probability, then (1) tells us that those outcomes must be possible in some sense of possible. And at this point the debate reaches deadlock. All the participants offer something which is or could be the content of 'possible' in some context or other, ensuring that all parties accept that (1) can express a pertinent truth. But the disputants have not converged on the same truth as the pertinent truth expressed! Without some further constraint, the disputants will continue talking past one another, having each fixated on just one of the things expressible by the context-sensitive term 'possible'. The dispute about chance compatibilism, when conducted as a dispute about possibility, reaches stalemate.[2]

§2. Unsettledness

We can make progress by sidestepping this unfruitful dispute. We may do this, I claim, by identifying another constraint on the chance role which is in the general vicinity of (1) but which doesn't involve the expression 'possible', and doesn't commit us to any reduction of it to a principle involving possibility. It is this:

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[2] I'm tempted to think that compatibilists wish to start with examples of objectively informed deterministic probabilities, interpret them as chances, and then apply *modus ponens* to (1) to conclude that there must be some sense of 'possible' in which outcomes that are determined not to happen are nevertheless possible. Incompatibilists, on the other hand, start with a natural conception according to which what is possible is what is compatible with the laws and boundary conditions, and apply *modus tollens* to (1) to conclude that under determinism an objectively informed deterministic probability is insufficient for chance. If I'm right that this is the structure of the dispute, appeals to (1) are not going to be helpful in resolving it: each side will make use of (1) and their prior account of one side of the connection to **stipulate** how the other side must behave, with compatibilists introducing some stipulated sense of 'possible' and incompatibilists some stipulated sense of 'chance'. It is too easy for disputants to accept that (1) is a platitude about chance while rejecting their opponent's gloss on the 'real' content of the platitude.

(2) Necessarily, and always, if there is a nonzero chance of p, then it cannot (already) be **settled** that $\neg p$.

Contrapositively, if it is already settled that $\neg p$, then p has no chance of being true. It follows that if there is some chance that p and some chance that $\neg p$, it must be presently unsettled whether or not p. (It is settled that p iff it is settled whether p, and p.)

This principle, that non-trivial chance requires unsettledness, is at least as plausible as the similar one connecting chance and possibility. It is a platitude about both chance and unsettledness that they are connected in this way. So this would be another aspect of the chance role, not previously explicitly articulated as far as I know. The picture of chance captured by (2) is very natural: that as chance processes occur, various matters that were unsettled as to how they would turn out as the process was initiated become settled, precisely when they turn out some way or another. As you enter the labyrinth at 11:00, it is not yet settled whether you will reach the centre by noon (D. Lewis 1986, p 91). As you twist and turn, your chance of doing so ebbs and flows, but never becomes settled one way or another, until you reach the centre at 11:49. When you do so, it becomes settled that you did reach the centre by noon, mirroring the fact that the chance of your doing so simultaneously climbed to 1. To reject (2) would be to think that some outcome might have a chance of coming to pass even when it is already settled or fixed that it will not. (I say more in defence of (2) in §4.)

I don't wish to offer an analysis of the notion of **unsettledness** that appears in (2). I have no firm opinions (at least, none that matter here) about what the analysis would be. I do not think, for example, that we need to assume any analysis of unsettledness in terms of possibility in order for (2) to be in good standing and to be of some use in the dispute over chance compatibilism. In the end, we understand the notion of unsettledness – and its pertinent contrasts such as fixity and immutability – well enough to be going on with, even without yet (or ever) possessing a satisfactory account of it in other terms. I contend that the fact that chanciness requires unsettledness (2) should be taken as an initial constraint on accounts of unsettledness and chance, not as a novel by-product obtained after providing philosophical theories of those notions. But I will try to say something to help you fix on the

relevant notion, and distinguish it from other notions in the vicinity, even though what I have to offer falls well short of an analysis.[3]

The Epistemic Import of Unsettledness

Unsettledness is not an epistemic phenomenon: it is not mere **ignorance**. A matter can be settled while we do not know it is, if we are ignorant of the facts which settle it. (We can be surprised when arriving late to a meeting only to find that the substantive issue under discussion has already been voted on and resolved.) Similarly, a matter can be unsettled while we believe it to be already settled. If there can be knowledge of the unsettled future – for example, if I couldn't easily have falsely believed that p, even though it is not already settled that p (Hawthorne and Lasonen-Aarnio 2009) – then it might even be that one can know that p while p remains unsettled. I assume here that something's being unsettled doesn't analytically entail the falsehood of classical logic, so that future unsettledness of p may well be compatible with the truth of p.[4]

There is some epistemic import to unsettledness, though it is a little more indirect than the naïve epistemic view of unsettledness would have it. When there is some nonzero chance that p, it can't be settled that p won't occur, by (2). Thus it might really, actually, turn out that p, given how things have already turned out. In that case, typically, p is the kind of thing that deserves to be taken into consideration in deliberation and evaluations of risk, and likewise

[3] I think that (2) already helps in this regard – being settled is just the kind of thing that closes off live possibilities. But this is perhaps not enough.

[4] I am inclined to accept a classical account of unsettledness, but here I only assume that we are not obliged to give a non-classical account of it. I note in passing that orthodox accounts of chance employ classical logic, and a non-zero chance of p is consistent with p's being true. By (2), the unsettledness of p must also be consistent with p's being true (if ϕ and χ are consistent, and necessarily if ϕ then ψ, then ψ and χ are consistent).

is a matter that is pertinent to consider when forming beliefs.[5] Such a matter is what we might call a **live option**. While a live option is functionally specified as a factor that ought to be considered during theoretical and practical deliberation (at least when the agent is aware of it), the notion of unsettledness that typically gives rise to live options is not merely epistemic. There is some genuine prospect, given what's already occurred, that a presently unsettled outcome will turn out to occur, even if it isn't the kind of thing that anyone could take into consideration or that it would be epistemically blameworthy for someone to neglect. For example, suppose someone had 'crystal ball' information, via a wormhole or some such, concerning the presently unsettled future. Such a person might well be justified in neglecting fact that some future outcome is unsettled, having another source of evidence that trumps the typical epistemic significance of unsettledness.

Unsettledness and Indeterminacy

There is some fairly intimate connection between unsettledness and **indeterminacy**. But it is not the kind of indeterminacy some have believed to be involved in vagueness. Such indeterminacy stems from imprecise representation or imprecise knowledge of a reality which may itself be completely settled. There may be borderline cases to which the word *blue* applies, but that's not because we are awaiting reality to settle whether those cases are really blue or not.[6] Cases of apparent indeterminacy which by contrast do involve unsettledness

[5] So a live option that an agent is aware of, and which they have considered appropriately, will be what Levi has called a 'serious possibility' for that agent (Levi 1980).

[6] There are also some mathematical cases which have been said to involve indeterminacy: those where the accepted axioms are consistent with a claim and its negation, and the claim is said to be indeterminate. A famous such case involves ZFC set theory and the continuum hypothesis CH. The mathematical case is closer to our intended notion, since the axioms of ZFC do not fix the truth value of CH. But there is no sense in which it objectively might turn out to be either true or false. CH is either at best epistemically contingent, or the indeterminacy might be semantic, in that there isn't enough content in the axioms to fix the intended domain of discourse.

include some quantum theories (P. J. Lewis 2016), and the 'open future' (Barnes and Cameron 2011; Barnes and Cameron 2009).

1. The quantum mechanical phenomenon of interest is illustrated by this sort of situation:

> In quantum theory, it is more typically the case that the degree to which the particle's momentum is specified allows us to say, for example, that the particle is located *somewhere in this room*, although it is not possible to say that it is located at any particular point in the room. In other words, while it makes sense to talk about the particle having the property of position (that is, to say that the particle is in the room) that property cannot be ascribed a definite (precise) value. (Bokulich 2014)

An attractive way of regimenting quantum ideology is to posit that a system exhibits some indeterminacy (what Bokulich calls 'indefiniteness') in some observable quality just when the underlying quantum state of that system has a specific mathematical form with respect to that observable. Specifically, there should be a strictly intermediate probability that the system will exhibit that observable quality on measurement.[7] In such cases it is natural to say that it is not entirely settled how the system observably is – and that conclusion is unavoidable if we accept that quantum probabilities are chances and we accept (2). In the above example it is unsettled, given

[7] Specifically, given the Born rule, the idea is that we adopt the eigenstate-eigenvalue (E-E) link: 'A system has a determinate value for a given determinable property if and only if its state is an eigenstate of the operator corresponding to the property' (P. J. Lewis 2016, p 76). Whether a particular quantum theory accepts the E-E link turns partly on issues about indeterminacy. On non-classical views of indeterminacy (where its being indeterminate whether p entails that p isn't true), for example, Bohmian mechanics will not endorse the E-E link: every Bohmian corpuscle always has a position, even if its quantum state isn't in an eigenstate of position; the E-E link would then entail that position is both determinate and indeterminate.

the quantum state, where in the room the particle is, though it is settled by the quantum state that the particle is in the room.

2. In the case of the open future, we note that the past appears to be a 'unique, settled, immutable actuality' (D. Lewis 1979, p 459), in sharp contrast to the unfixed future, which is open to our influence, so that how it is at some future moment depends on how intervening matters happen to go. This contrast is captured, as Lewis foreshadows, by saying that when the future is open, it is 'unsettled … what will happen' (Skow 2015). Given (2), we may partly explain this asymmetry of settledness by noting that there is also an apparent asymmetry of chance: that non-trivial chances are found at each moment only for future outcomes, and not for past outcomes (Eagle 2014).

In these cases we have unsettledness because how things are ('reality') appears to be poised between live options. A distinguishing feature of unsettledness, however, is that this undecidedness is **resolvable**, one way or the other. This makes unsettledness quite unlike mathematical indeterminacy or vagueness. If we perform a position measurement on a system, we find the system in a settled state of position. But the prior state was one that was capable of being resolved into various determinate states. That is a reason to accept that prior to the measurement, the system was in an unsettled state of position. In the case of the open future, this unsettledness also ends up being resolved: sooner or later what is unsettled tends to become settled, as it becomes progressively clearer how the totality of actual history will be.[8]

In light of these observations, it is tempting, but not obligatory, to take the objective notion of unsettledness to be a species of **metaphysical indeterminacy**, a notion which has recently been much discussed (J. M. Wilson 2013; Williams 2008; Barnes 2010). But I do not wish to

[8] In the quantum case, of course, each settling of an unsettled observable will create unsettledness in its conjugate observable.

rely on this hypothesis, or to rely on specific details of any of the various rival accounts of metaphysical indeterminacy that have been offered.

Unsettledness and Contingency

Logically speaking, unsettledness is a variety of contingency. The formal logic of unsettledness is at least as strong as the modal logic **T**, when that is formulated using contingency as the basic modal operator (Routley and Montgomery 1966, p 319), in that all the axioms of that system appear to be true when the operator ∇p is interpreted as the operator *it is unsettled whether* p.

That observation leaves open whether we should attempt to reduce or analyse unsettledness in terms of some more substantive non-formal notion of contingency, such as physical contingency (compatibility with the physical laws). Certainly unsettledness is temporally asymmetric and dynamic in a way that many substantive notions of contingency are not. We could propose an analysis that steals the time-dependence of unsettledness from somewhere else. One such proposal is this:[9]

(3) 'It is unsettled whether p' expresses a truth at t in w iff the laws of w and the history of w until t are compossible with both the truth and falsity of p.

These truth conditions may be correct. But I do not think they can be **analytic**, and hence someone who denies that settledness can be reduced to compossibility in this way is not making a conceptual mistake. If these truth conditions were correct, it would follow, given (2), that non-trivial chance required indeterminism. Since the chance compatibilist accepts (2), they are thereby committed to rejecting the truth conditions posited in (3). Those truth conditions may be correct, for all that – but they cannot be analytic, on pain of thinking that the dispute over chance compatibilism is purely a conceptual dispute.

[9] I thank an anonymous referee for inviting me to consider this proposal more explicitly.

Even if (3) is true, it would be dialectically inappropriate to endorse it in the present context since it is tantamount to endorsing incompatibilism in the presence of (2). The argument mounted by compatiblists that we considered in §1 can be transformed into an argument against (3): that objectively informed probabilities with scientific credentials are deserving of the label 'chances', so the existence of deterministic theories with such probabilities shows, given (2), that some matters can be unsettled even when they are determined.

The above observations show that any significance of (2) for the debate over chance compatibilism is going to come because of the existence of a direct argument that there is no deterministic unsettledness. To avoid rehashing the dispute rehearsed in §1, that argument must not presuppose any particular analysis of unsettledness in terms of possibility. I do think such an argument exists, making use of premises that are plausible about unsettledness, regardless of how or whether that notion is analysed. In fact, it relies on premises that are themselves more certain that any analysis they might subsequently be used to justify. In the next section, I will give the argument.

§3. An Argument Against Deterministic Chance

It seems about as plausible as anything in philosophy that **in a deterministic world, how the past is settles how the future will be**. Many philosophical arguments have been founded on premises with less *prima facie* appeal than this claim. It has its initial plausibility completely independently of any analysis that may or may not be given of its constituent expressions – and so is a premise that may allow the incompatibilist to sidestep the stalemate over whether determinism and the past trivialise possibility.

If we accept this premise, we can mount a challenge to the cogency of deterministic chance. It might go something like this. If determinism is compatible with non-trivial chance, then there is a possible world and a time at which some outcome is determined to occur while having a chance less than 1. Since it is determined, it is already settled whether it will occur. But since the outcome has some chance of occurring, and some chance of failing to occur, it is not already settled whether it will occur (as we just noted). So if there could be deterministic chance, there is a possibility in which the following contradiction is true at a

time: *It is both settled and unsettled whether the outcome will occur*. But since contradictions are not even possibly true, there cannot be deterministic chance.

We may lay out this argument more explicitly as follows.

(4) When there is a non-trivial chance that p, it should at that time be unsettled whether p. [Assumption, consequence of (2)]

(5) If a possible world is deterministic, then at each time, the past history of the world and its laws settle every fact about the future of that world. [Assumption]

(6) If deterministic chance is possible, there is a world w which is deterministic, and a time t such that some outcome p has, as of t, a non-trivial chance in w. [Definition of deterministic chance]

(7) In w, p is unsettled at t. [By (4) and (6)]

(8) In w, p is settled at t. [By (5) and (6)]

(9) If deterministic chance is possible, then there is a possible world in which p is both settled and unsettled at t. [By (6)–(8)]

(10) Therefore, deterministic chance is not possible. [From (9) and logic]

The incompatibilist will urge us to accept the conclusion of this argument: the chance role requires that chancy outcomes be unsettled (4), and determinism requires that determined outcomes be settled (5). So there simply could not be an outcome that meets the conditions for being chancy, while also being determined.

This argument from settledness has some advantages for the incompatibilist over that canvassed in §1. It is more obvious that chancy outcomes aren't already settled than that any particular reading of (1) is true, compatibilist or incompatibilist. If the incompatibilist can make use of this argument, they can conclude that deterministic chance is not consistent. This will then bolster the argument in §1, since that will show that whatever objectively informed probability with scientific credentials might be, it is not chance, and hence is not the sort of thing that could motivate us to postulate some other kind of possibility as the relevant species mentioned in (1).

A level-relative notion of possibility might be defensible, but a level-relativising response to the argument of this section is less prima facie plausible. If some matters are settled, that seems to be a fact about them regardless of how they are described. Stratification into levels may obscure the fact that a given claim is settled, but will not render what has been settled unsettled again. If determinism is true, then it appears there are prior facts that manage to settle each future outcome, whether or not we are currently acknowledging those prior facts, and whether or not we have adopted for practical reasons some high level theories which omit them. That is what (5) amounts to.

This is **not** to say that (5) is non-negotiable. There appear to be only three options for the compatibilist to respond to this argument: deny (4) – which is *a fortiori* to deny (2) –, deny (5), or to argue that the argument is invalid. In the remainder of this paper I explore the options for the compatibilist. I conclude that there is no single best option for all compatibilists, but that orthodox compatibilists about chance and determinism should probably respond in the end by rejecting the claim (5) that what is determined by present facts is settled by those facts. This rejection can be seen to follow in a principled way from commitments that many compatibilists already incur. But incompatibilists may take heart from this discussion too. If the best option for compatibilists is to deny the extremely plausible (5), then perhaps the best option for neutral parties is to accept the incompatibilist conclusion.

§4. Chance and Unsettledness

I briefly sketched some reasons in favour of (2) at the beginning of §2, before clarifying the notion of unsettledness involved. But a compatibilist might wish to revisit whether (2) is ultimately acceptable.

Rejecting it involves denying the platitude that settled outcomes are no longer a matter of chance. To deny this platitude involves being willing to assert, for some p, that while it is already settled that p is true, nevertheless there is still some chance that p it is false. But to speak of things being already settled, despite there being some chance that things will turn out otherwise than how they are settled to be, just sounds contradictory. If there is, at some stage, some chance of two incompatible outcomes coming to pass, then it cannot be settled

at that stage **which** of them comes to pass. If it were settled, then it couldn't be chance that was involved, but at best ignorance (even if of a particularly difficult-to-remedy variety).

Another argument for (2) begins with the temporal asymmetries of chance and unsettledness. If being chancy is not a way of being unsettled, we have no explanation for why the asymmetries of chance and settledness accompany one another, as they actually do. If we suppose that being chancy is one way of being unsettled, then we have the beginnings of an explanation: the temporal asymmetry of chance entails the temporal asymmetry of openness, since when other sorts of unsettledness are absent, only future outcomes have any non-trivial chance and only such outcomes can be unsettled.

> The asymmetry of fixity and of chance may be pictured by a tree.... The single trunk is the one possible past that has any present chance of being actual. The many branches are the many possible futures that have some present chance of being actual. (D. Lewis 1986, pp 93-4)

The relevance of this explanation to (4) if of course that if being chancy is a way of being unsettled, then (4) turns out to express this obvious claim: 'When there is unsettledness due to chance whether p, it should at that time be unsettled whether p'.

These observations seem to me to demonstrate that part of the chance role is to be characterised by the unsettledness of outcomes with non-trivial chance. If there are non-trivial special science probabilities for settled outcomes, that is evidence that these probabilities cannot fully satisfy the chance role. I suggest accordingly that if compatibilism about chance is to be a viable strategy, its defenders ought to accept the platitude (4), and find some other way around the argument of §3.

§5. Determinism and Settledness

Assumption (5) at first glance looks as unassailable as assumption (4). While we no longer think of determinism as a causal thesis, there was nevertheless something right about thinking of determination as providing the same sort of guarantee that q holds, given p, as obtains when p is a complete sufficient cause of q. The occurrence of a complete sufficient cause settles whether the effect occurs; so too, the occurrence of a determining outcome settles whether the determined outcome occurs.

More sophisticated theories of determinism view it as a supervenience thesis (Schaffer 2007, p 115). A physical theory is deterministic iff throughout the set of possible worlds whose laws are the laws of that theory, the whole trajectory of a physical system through the state space supervenes on any instantaneous physical state (Earman 1986). No two worlds governed by the theory can agree on any instantaneous state without agreeing on every instantaneous state. In particular, if some deterministic theory specifies the laws of some world, then any state of that world suffices (together with the laws) to uniquely identify which possible world it is a state of, and hence to uniquely identify the whole history of that world. If the past is settled, and the laws are settled, then that whole history is also settled.[10]

If the past and laws are settled in every possible world, then if determinism is true of that possible world, then the future of that world is settled. So on the assumption that, necessarily, the past and laws are settled, we can derive (5). The asymmetry of settledness we noted above (in §2 and §4) makes it at least *prima facie* plausible that, necessarily, the past as of t is settled as of t.[11] So the incompatibilist need only argue that, necessarily, the laws of nature are settled to conclude that (5) is always true.

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[10] Here we assume that the *it is settled that* operator Δ validates this rule: when $(\phi \wedge \psi) \vDash \chi$, then $(\Delta\phi \wedge \Delta\psi) \vDash \Delta\chi$. This holds because Δ is a necessity-like operator and its logic is a normal modal logic at least as strong as **T**.

[11] A referee was struck by unequal discussion of the hypothesis that the past might be unsettled as compared to the hypothesis that the laws might be unsettled. In light of that fact that one of the paradigm cases that help us getting fix on the notion of unsettledness is precisely that it is implicated in the temporal asymmetry of the open future, I would have grave doubts about whether I was competently evaluating (2) if I thought that a reasonable response might be to take the past to be unsettled in any systematic way. Given that (2) is true, those unusual worlds where there is a chancy past will also involve an unsettled past (Eagle 2014). But I don't think we can take seriously the idea that the past might be unsettled in any widespread way and still be endorsing the basic picture of unsettledness given by the examples discussed in §2.

On many conceptions of laws of nature, that conclusion is nearly inescapable. Many theories of laws of nature subscribe to this thesis that we may dub **Future Independence of Laws**:

(11) If $\mathcal{L}$ specifies the laws of nature in w, and f_t is any proposition consistent with $\mathcal{L}$ which is about the future of w as of t, then this is true at t: *if it were to turn out that* f_t*, it would still be that* $\mathcal{L}$.[12]

This falls out immediately from accounts like that of (Lange 2009), which defines the laws of nature as those truths the status of which **as laws** remains stable under arbitrary consistent counterfactual suppositions. Since *it is a law that* is factive, this stability entails (11). But future independence is a consequence of most other views of laws of nature too. For on any view on which the laws of nature provide substantive grounds for the truth of counterfactuals, the laws must be held fixed under counterfactual assumptions, and so will turn out still to be true under such assumptions. For example, consider Armstrong's view that the lawhood of the laws of nature is grounded in relations of necessitation between universals $N(F;G)$ (Armstrong 1983). While Armstrong thinks this necessitation is contingent, nevertheless he thinks it non-contingent enough that it explains true conditionals like *if it will be that* a *is* F*, then it will be that* a *is* G. If so, then the guarantee linking a's being F to a's being G must hold counterfactually too, so *if it were to turn out that* a *is* F*, then it would still be that* $\mathrm{N(F;G)}$, i.e., (11) holds. Similar remarks hold for other non-reductionist 'governing' views of natural laws. Such views tend to accept that laws play a role in the semantics of counterfactuals that requires holding the laws fixed when evaluating counterfactuals that are not counterlegals, which is pretty much sufficient for (11). Future independence might be a way of cashing out the metaphor of 'governing' laws without too much metaphysical baggage: for it says that no variability in how things might turn out to go could affect the laws, which certainly means that the laws are not in any way subject to the contingencies of particular matters of fact.

[12] At any close possibility in which f_t is realized, the actual laws are still truths: in which case, that possibility must differ from actuality in how its past is.

If future independence (11) is true, then no matter what the future turns out to hold, the actual laws still obtain. Accordingly, there is no contingency in the laws that could be resolved by one future course of events rather than another. If those laws are presently unsettled, because a number of mutually inconsistent potential laws remain live possibilities, they will remain unsettled. (I assume that when p comes to be settled, that is because something happens which eliminates some formerly live possibilities concerning whether p, and thus settles the truth value of p.) On the assumption that the laws will end up settled, future independence entails that the laws themselves are thus always already settled.[13]

This conclusion runs counter to an argument made by Barnes and Cameron to the effect that even Armstrong-style anti-reductionists could accept the unsettledness of laws. Their argument turns on the premise that if 'it is as yet unsettled what will happen, [it is] thus unsettled whether the particular universals involved in $[\mathrm{N}(\mathrm{F};\mathrm{G})]$ are related in a law-like way' (Barnes and Cameron 2009, p 301). This premise is undermined by future independence, since no unsettledness is what happens could (on such views of laws) make a difference to what laws obtain.[14]

The settledness of the laws and past, and the deterministic character of the laws pertinent to our discussion, entails the settledness of the future entailed by the laws and past. If the compatibilist wants to resist this argument for (5), they will need to reject future independence.

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[13] We may reject the assumption; perhaps some worlds have laws of a permanently indeterminate character. But I wonder whether that hypothesis requires rather more metaphysics to be built in to the notion of unsettledness that I am assuming. I will leave it to others to explore this prospect. I will continue to assume that laws, like other claims, can be unsettled at a time only if the facts that end up resolving them lie to the future, and hence that (11) is the crucial contested principle.

[14] Anti-reductionism about laws coupled with a denial of future independence may for all that be a coherent option, and if it is, there is scope for even some anti-reductionists to avail themselves of the arguments of the following section.

Determinism and Classical Unsettledness

Another argument for (5) should be considered before we proceed. That argument is this: *if the future is unsettled, there is no fact of the matter about how the future is. But deterministic laws and the actual past guarantee that every future claim has a truth value, so there is a fact of the matter about how the future is. So the future cannot be unsettled if determinism is true.* Something more or less along these lines is offered by (Belnap and Green 1994).

I do not wish to endorse this argument. The unsettledness of the future is not the existence of a third way for things to be, neither true nor untrue. It is rather that, while there is a way the future is, nothing presently settles which way that is. This is perhaps most easily seen in the case of chance, thought of in line with (4) as a species of unsettledness. A coin toss will land heads or it will not land heads but will land some other way – there is not some other outcome between those two options. It's being partly a matter of chance how it lands is not incompatible with there being an outcome of the coin toss. The standard semantics for chance reflect this: it is propositions which possess chances, and propositions have as their extensions sets of possible worlds. A proposition has a non-trivial chance if the corresponding extension has a non-trivial volume in the space of possibilities. That chance is, of course, a chance of **being true**: it is the chance that the actual world is contained in the extension of that proposition. But if a scenario contains neither a heads nor non-heads outcome, then it is not complete, so is not a possible world, so has no chance at all of being in the set of possible worlds corresponding to the proposition expressed by *the coin lands heads*. Since that proposition does have a chance of being true, the actual world must be a possible world, and hence must contain some future outcome, heads or not. That suffices to ensure that the proposition has a truth value. It does not suffice to ensure that the proposition has a **settled** truth value, since, of course, it is still chancy. I therefore accept – along with others (Barnes and Cameron 2009; Barnes and Williams 2011; Greenough 2008) – the possibility of **unsettled truth**. Unlike them, I offer a relatively mundane case of it: **chancy truth**.

§6. Undermining Futures

Luckily for the compatibilist, not every account of laws satisfies the requirement of future independence. **Reductionist** accounts of laws, according to which the facts concerning which truths are laws supervene on the total pattern of particular truths, typically violate it, because they will claim that that 'laws hold in virtue of patterns spread over all of space and time' (D. Lewis 1994, p 479). Barnes and Cameron argue that such accounts will typically make the laws unsettled. They introduce the name '{Futures}' for the set including those worlds such that it is presently unsettled which of them will be actualised:[15]

> Consider the set of worlds in {Futures} at time *t*. Different regularities will hold in different worlds. Thus, if what laws obtain is determined by what regularities hold, which world is in fact actualized will determine what the laws of nature are. It may be the case, then, that no matter which laws obtain, those laws are deterministic … but it still be the case that there is variation across the worlds in {Futures} concerning how things will be. (Barnes and Cameron 2009, pp 300–1)

Their argument as stated does not extend to more sophisticated reductionist views than the naïve regularity theory, because even if the supervenience basis of the laws is unsettled, that does not mean that the laws themselves will be unsettled. Perhaps the kinds of future facts which are unsettled are such that the supervening facts are insensitive to their unsettledness. (Perhaps it could be settled that the frequency of As amongst the Bs is 0.5, even if it is not settled which particular Bs are As. In such a case, the chance law

[15] The argument is a bit different than what they actually need, since their hypothesis that 'no matter which laws obtain, those laws are deterministic' actually ensures that the laws are settledly deterministic, even though it is not settled what they are. But what is needed at this point is only that the laws are deterministic, so that there is just one world sharing those laws and the actual past, even while it is not settled that those are the laws, because there are other worlds in {Futures} with different laws which remain live possibilities. It might even be that some of the worlds in {Futures} have indeterministic laws; that is perfectly compatible with the actual true laws being deterministic, so long as we permit (as Barnes and Cameron do) unsettled truths.

$\mathrm{Ch}(A \mid B) = 0.5$ might be settled because the frequencies are, even if the set of {Futures} is non-singleton.)

I acknowledge that Barnes and Cameron have already noticed that reductionist laws could inherit unsettledness from their subvening particular events. But is not obvious that their brief argument manages to show that every reductionist account of laws will allow that the actual laws are deterministic while it is a live possibility that they are different. And they provide no reason why we might entertain an unsettled future in a deterministic world – they simply assume that to be possible.[16] The final reason for considering this issue at greater length here than Barnes and Cameron do is to show that there is a very illuminating and substantive connection between their discussion with the existing literature on undermining futures.

What we need explicitly to establish to fill out their brief argument is to establish that there is a reductionist account of laws, acceptable and attractive to compatibilists, such that according to it, there can be a deterministic world w and proposition f, where

- f is compatible with the laws $\mathcal{L}_w$ and wholly about the future of w as of t;
- it is not at t settled that $\neg f$; and
- the future independence counterfactual *if it were to turn out that* f*, it would still be that* $\mathcal{L}_{\mathrm{w}}$ is false.

If so, even though $\mathcal{L}_w$ is true of w, whether or not $\mathcal{L}_w$ is an unsettled contingency, and the deterministic laws are unsettled. This would enable the compatibilist to deny (5): in at least one possibility, the laws are deterministic but unsettled, so that their consequences need not be settled either.

[16] One reason for doubt: according to the incompatibilist, a deterministic theory assigns probability 0 to every future other than the one compatible with the theory and the past. So there is no chance of any non-actual future, so it is settled how the future will be, unless something else unsettles it – and what could that be?

Undermining Futures and Future Independence

It is fairly easy to see that reductionist views have the resources to deny future independence. Suppose that f specifies some non-actual future which remains consistent with the actual past. There is an alternate possibility w in which f holds together with that actual past. Supposing the actual laws to be deterministic, the past and the laws entail $\neg f$, so the actual laws cannot be true in w. Nevertheless, w may be among those possibilities with respect to which the future independence counterfactual *if it will be that f, it will still be that $\mathcal{L}$* is to be evaluated. In which case, that counterfactual turns out to be false, contrary to (11).

Why should we think that w is a close world, one of those with respect to which the counterfactual should be evaluated? Non-reductionists about laws will not think so: for while w shares its past with actuality, it doesn't share the separate non-particular facts which ground the laws, and this latter difference is enough to make it strictly more distant than a possibility which shares those law-grounding facts but which differs from actuality in its past. By contrast, reductionists maintain that the only facts which can contribute to evaluations of closeness are facts about the past and future (the total history of particular fact) – there are no separate law-grounding facts to be taken into consideration. Since that future is precisely what is being counterfactually supposed away, the only factors which may contribute to closeness are those concerning the past – and w matches actuality perfectly in respect of their shared past.

This is a case where a future, strictly logically consistent with the actual laws, is such that were it be actualised, those laws would be false. A special case of this phenomenon has been discussed before in the case of laws about chances, where such futures have been called **undermining futures** (D. Lewis 1986).[17] In the case of chance laws, an undermining

[17] The **phenomenon** of undermining is distinct from the **problem** of undermining. That problem arises for reductionist theories of chance laws when combined with Lewis' Principal Principle (PP), and is a problem for the PP in its original form, not for reductionism (Hall 2004). If we are reductionists who acknowledge the phenomenon of undermining, we ought to regard information about the chances as carrying information about the future, which blocks any application of the PP

possibility is one which is assigned some positive chance of coming to pass by the actual laws, but which is such that were it to come to pass, the actual chance laws would be false. On any Reductionist view of chance laws,

> according to which a statement about the t-chances places some constraint – no matter how weak – on post-t history, the statement will be undermined by a history which violates the constraint. … To disallow undermining altogether, an account of chance must completely sever the link with actual history; worlds with identical histories must sometimes differ with respect to the chances.(Ismael 1996, pp 82-3)

But as we have just seen, this phenomenon arises for reductionists whenever there is a law-violating possibility that must be considered when evaluating claims about what would happen given some future outcome pattern. Let us call a future **undermining in the general sense** when it is consistent with the laws but where the conjunction of it and the actual past is not consistent with the laws. For reductionists about laws, futures that are undermining in the general sense may occur in close possibilities which share the actual past, and thus entail the falsity of future independence of laws (11).

If the actual future is determined by the actual laws and the past, then undermining futures in the general sense are determined not to occur. (Given the fixed past, any future determined not to occur will be an undermining future if it is compatible with the past.) Non-reductionists will conclude that any possibility in which they do occur is one where the past differs from actuality (and where that future is determined by that different past in accordance with the same laws). Since any such possibility differs in a matter of settled fact from actuality, it is settled not to actually obtain.

But, again, reductionists will not accept this line of argument. An actually determined future outcome can fail to hold, even in a close possibility sharing its past with actuality, if its occurrence undermines the laws which would otherwise determine its non-occurrence. So undermining futures can be possible even if determinism is true. (D. Lewis 1981) in effect

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that relies on the unrestricted admissibility of propositions about the chances. Not featuring any such reliance, the New Principle avoids the problem of undermining while retaining the phenomenon (D. Lewis 1994).

observes that undermining futures often arise when we consider counterfactuals about my future free action under determinism. There are many actions I might have performed, because I am able to perform them. In fact I won't perform most of them. Had I performed one of the ones I will not, the possibility in which I do will undermine the actual laws – if I will raise my arm tomorrow, it will not still be that the actual laws obtain.

Undermining Futures and Deterministic Unsettledness

We need not consider cases of undermining in general further, because the existence of undermining futures in the case of **chance laws** is enough to show that compatibilists can have principled grounds for denying (5) (that determinism entails settledness). If there is non-trivial deterministic chance, then there is an outcome u which is (i) determined not to occur by the laws, and so is such that if u did turn out occur given the actual past, the actual laws would turn out to be false, so u is undermining, but (ii) u has some chance of occurring given the actual laws and past, and so is a possibility that we must consider when evaluating what would happen were it to turn out that u. In particular, given (4), u's having some chance means that u is unsettled, which suffices for it to be a close possibility that u come to pass. Accordingly, the conditional *if it will be that* $\mathfrak{u}$*, it will still be that* $\mathcal{L}$ is false, and so we have a violation of the future independence of laws (11). Since the argument we considered in §5 for the settledness of determined outcomes relied on that principle, compatibilists have a principled way of blocking that argument. Talk of 'undermining futures' simply dramatizes the following consequence of reductionism about chances: very often, there is some chance that the laws could be different. By (4), that means reductionism entails that very often it is unsettled what the laws are. This fills out existing arguments that reductionist laws may be unsettled.

In fact cases of undermining futures directly show the falsity of (5). Consider a toy example: suppose we have a deterministic world in which the pattern of actual overall outcomes is such that the frequency of coins landing Heads is about 0.5. Let us grant that (for whatever reason – maybe we are frequentists, or near enough) this suffices for the chance of Heads to be 0.5. (We cannot assume incompatibilism about chance at this point, as we are evaluating a premise in an argument for incompatibilism.) At some time t midway through this pattern, there is a small but non-zero chance that all future coin tosses could be Heads,

and if that outcome were realised, the chance law in that possibility would give a higher chance to Heads than 0.5. So 'all Heads from t' is an undermining future as of t. If it is chancy whether or not that all-future-Heads outcome occurs, then it is unsettled, by (4). So the actual future as of t, despite being determined to happen, doesn't have chance 1, and so it is unsettled whether it will come to pass.

It is moreover unsettled whether the laws assign each Heads outcome a chance of 0.5 – it will only be settled what the laws are once the future unsettledness is resolved. These future unsettled outcomes will not just undermine chance laws: they will undermine any law that depends on a specific future pattern coming to pass, given the past. In particular, if the underlying fundamental laws are deterministic, then not just the general character, but the specific makeup of future outcome sequences is determined by the past. If we hold that past fixed, any unsettledness in that pattern of outcomes will unsettle the laws. And if the laws can be unsettled (i.e., a live possibility that they are otherwise), then the actual fact that they are deterministic is not enough to settle the actual future, even given the fixed past.

§7. Reductionist Deterministic Chance

The upshot of the previous section is that reductionists about laws of nature have a principled reason to reject the claim that deterministic laws are always settled and hence that determinism by itself suffices for the fixed past to lead to a settled future. The relevance of this observation to the argument in §3 is that **almost all compatibilists about chance and determinism are reductionists**.

Most extant compatibilists start with a particular version of reductionism about laws: Lewis' **best systems theory**:

> Take all deductive systems whose theorems are true. Some are simpler, better systematized than others. Some are stronger, more informative, than others. These virtues compete: an uninformative system can be very simple, an unsystematised compendium of miscellaneous information can be very informative. The best system is the one that strikes as good a balance as truth will allow between simplicity and strength. … A regularity is a law iff it is a theorem of the best system. (D. Lewis 1994, p 478)

The general strategy involves attempts to show that the best system can contain probabilistic laws even when there also exists a deterministic system of laws for the very same body of truths.[18] The best system might be better than the deterministic system by being simpler overall despite being a little less strong – if the regularities are particularly baroque, a deterministic system of laws will be complex enough to capture that detail, and it may be that only a small sacrifice of informativeness accompanies a large decrease in complexity. If the initial conditions are complex enough, the deterministic system might be simple but very weak, unable to derive any truths without being supplemented by a non-lawful initial fact, while there could nevertheless be patterns in the total sequence of outcomes that allows the probabilistic system to be more informative. Different reductionist accounts differ on which of these alternatives they take to be more plausible a source of probabilistic laws, but all agree that the probabilistic laws can come out as part of a superior system even when a deterministic description of the same body of facts exists.

The grounds for belief in the possibility of deterministic chance for most compatibilists rests on a reductionist account of chance laws. So it is principled for those compatibilists to appeal likewise to reductionism to argue for the unsettledness of the resulting chance laws in circumstances where undermining futures have some chance. They may thus offer a principled resistance to assumption (5) above.

[18] There is a potential difficulty here. If the best system doesn't itself contain the deterministic regularities, then in what sense does that world contain deterministic laws – and if it doesn't have deterministic laws, how is that world deterministic? Maybe the fact that the world could be given a deterministic systematisation which is not too far from the best system is enough for determinism to be true? But that doesn't seem to fit with the reductionist spirit. Better are proposals to avoid this problem by suggesting that there is not one best system, but many, for different factual domains – and that any law of any best system is a law simpliciter (Glynn 2010). That way there can be both deterministic and probabilistic laws in a world even though they do not belong to just one system.

§8. Chance and Context

It is worth noting another route to the possibility of deterministic chance with a less straightforward connection to reductionism about laws. Some authors have recently defended **contextualist** accounts of chance (Eagle 2011; Handfield and Wilson 2014). Contextualism says that chance ascriptions like *there is some chance that* p express different propositions in different contexts. The evidence given for this linguistic claim is that the expression *there is some chance that* behaves very much like a modal expression – like *possibly it is the case that* – and in particular chance operators also exhibit the well-known context-sensitivity shown by modal expressions. The orthodox account says that modal expressions are sensitive to a 'conversational background', so *possibly* p is true in a context when p is compatible with the conversational background, and false otherwise (Kratzer 1991). Since which facts are in the conversational background can vary without the totality of facts varying, different propositions will be expressed by different utterances of the very same expression.

Contextualists about chance think the same thing about chance ascriptions. They have not tended to offer very detailed accounts of how context fixes a particular probability function to be the referent of *the chance* in a context. But what they have said indicates that they accept principles like this:

> (12) If the conversational background excludes p, only those probability functions which do not assign p a positive chance are eligible referents of *the chance function* in that context.

What is interesting for our purposes is that contextualism holds out the prospect that some non-trivial chance ascriptions can be true in a context even when the laws are deterministic and **even if our account of laws is not reductionist**. So long as the deterministic laws are not themselves in some conversational background, even the settled past needn't suffice for the conversational background to exclude either or p or $\neg p$. In which case, principle (12) will entail that the probability function which plays the chance role in that context does not assign a trivial chance to p even if determinism is true.

Since we've already argued that reductionists can mount a principled resistance to the argument against deterministic chance, let's assume now a non-reductionist account of laws. Suppose we accept that (4) is true in every context, so that the truth of non-trivial chance ascription suffices for unsettledness. The possibility of deterministic chance for the compatibilist means that there are true non-trivial chance ascriptions while determinism is true. Even if determinism is true, there may exist a context in which the truth of determinism is not in the conversational background. If so, an outcome may be truly said to be chancy, and truly said to be unsettled, in a context where determinism is true. So (5) does not express a truth relative to every context. If so, there are contexts relative to which the argument is unsound – in just those contexts where the sentence *there are non-trivial chances* is truly utterable despite the fact that the underlying laws are deterministic.

Alternatively, the contextualist might offer a different diagnosis. They might start by noting that if *chance* is context-sensitive, it is natural to couple that with the hypothesis that *unsettled* is also context-sensitive – indeed, that it is in fact a *possibly*-like modal. In a context relative to which (4) is true, that is because *it is unsettled whether* p expresses a tuth about the compatibility of both p and its negation with a certain body of facts. In a context relative to which (5) is true, that is because *it is unsettled whether* p expresses a falsehood about the compatibility of both p and its negation with a different body of facts, facts that now include determinism and the past. But then there is no one referent of (*un*)*settled* in (7) and (8). What looks like a contradiction between those claims is in fact an **equivocation**.

However, any **actual use** of the argument in §3 will probably serve to make determinism a salient part of the conversational background. (That is why, just above, I was careful to talk of contexts relative to which (4) is true, rather than contexts in which it is truly assertable – there may be no contexts in which (4) is truly assertable alongside (5).) If so, the contextualist should predict that the argument should be sound **when it is given**, even though there are contexts where it is not given and relative to which it is unsound. The argument is thus what Stalnaker calls a 'reasonable inference':

> an inference from a sequence of assertions or suppositions (the premisses) to an assertion or hypothetical assertion (the conclusion) is *reasonable* just in case, in every context in which the premisses could

> appropriately be asserted or supposed, it is impossible for anyone to accept the premisses without committing himself to the conclusion. (Stalnaker 1975, p 273)

If so, the apparent strength of the argument for the non-reductionist is explained even if contextualism is true. If determinism is salient, incompatibilism is pragmatically unavoidable.[19]

§9. Conclusion

I have offered what I regard as a novel variant on existing challenges to deterministic chance, in some ways more difficult to resist than extant incompatibilist arguments, but of interest in its own right. I've also explored possible compatibilist lines of response to that argument. I considered responses starting from reductionism about laws, and from contextualism about chance ascriptions. All prominent defences of deterministic chance do accept at least one of these assumptions antecedently to recognising the present challenge, so it is not *ad hoc* for them to appeal to those assumptions once again. I conclude that there are principled grounds, and not without some plausibility, on which compatibilists may resist that argument.

The defences also show, however, the limits of compatibilism. Both assumptions are at least controversial. The contextualist account, in particular, is predicted to be very concessive to the challenge from incompatibilists – some may wonder whether such an ephemeral defence of compatibilism as the contextualist offers is compatibilism enough. So while the compatibilist resistance is principled, it is not cost-free. The discussion may seem to fall prey to the same observation I made in §1: that it reinforces existing battle lines, rather than providing new traction on resolving the dispute between compatibilists and incompatibilists. It is nevertheless instructive to see how this issue projects into the debate over indeterminacy and unsettledness. (And it is particularly interesting for connoisseurs of

[19] (Eagle 2011, p 287) makes a similar point.

reductionist chance to see the centrality of undermining to this apparently unrelated debate.)

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