Exploring A New Argument for Synchronic Chance

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Abstract: A synchronic probability is the probability at a time that an outcome occurs at that very time. Common sense invokes synchronic probabilities with values between 0 and 1 (e.g., the probability right now that the top card of this deck is presently the ace of spades is 1/52), as do scientific theories such as classical statistical mechanics. Recently, philosophers have argued about whether any synchronic probabilities are best interpreted as objective chances. I add to this debate an underappreciated reason we might have to believe in synchronic chance; it might turn out that the best interpretation of our common sense and scientific theories is one in which the macrophysical properties of physical systems are partly determined by synchronic chance distributions over microphysical properties of those systems. Additionally, I argue against the common charge that synchronic probability fails to satisfy various platitudes about chance—most notably Lewis's (1986) Principal Principle.

0. Introduction

In normal conversational contexts, we casually refer to the probability that the top card of this fair deck is presently the ace of spades (which is about 2%), to the probability that most of the lemons on my tree are now ripe (which is high this time of year), and to the probability that an arbitrarily selected student from my introductory philosophy class is currently scoring a B- or better (which is about 50%). In other words, we speak as if there are non-extremal probabilities (i.e., probabilities with values between 0 and 1) at a time that an event occurs *at that very time*. And this phenomenon isn't limited to common-sense discourse: classical statistical mechanics, for example, assigns non-extremal probabilities at a time to various ways the particles of a gas might be arranged at that very time.

Following others (e.g., Sober 2010, Lyon 2010), I'll call a probability "synchronic" just in case it is a probability at a time of an event occurring at that very time. The ubiquity of non-extremal synchronic probabilities (particularly in statistical mechanics) has generated debate over how these probabilities should be interpreted. In one camp are "subjectivists" (e.g., Schaffer 2007, Frigg 2008), who maintain that all non-extremal synchronic probability ascriptions are ultimately about the doxastic states of subjects—claims either about what those states are or about what they should be. Perhaps, for example, my assertion that it is likely that most of the lemons on my tree are now ripe is simply a report that I am confident that most of the lemons on my tree are now ripe. Or, perhaps the probabilities of statistical mechanics tell us, say, what our confidence should be that the particles of a gas are arranged one way rather than another given that we know some features of the gas (such as its volume, total energy and number of particles) but are ignorant of other of its features (such as its precise molecular arrangement a moment ago).

In a second camp are "objectivists" (e.g., Loewer 2001, Sober 2010, Lyon 2010), who argue that at least some non-extremal synchronic probability ascriptions are about features of that world that are independent of how things are or should be with the doxastic states of subjects and that satisfy enough items on some list of desiderata to deserve the label "objective probability".[1] That list varies from author to author, but a common (though not universal) desideratum (found in e.g., Salmon 1967, Lewis 1986, Loewer 2001, Schaffer 2007 but disputed in e.g., Lyon 2010) is that objective

[1] What subject-independent features of the world are such non-extremal synchronic probability ascriptions about? There is little agreement on the answer to that question among objectivists, but that dispute is orthogonal to what follows.

probabilities are guides for rational belief—though what this connection between objective probability and rational belief amounts to is itself controversial. Following Lewis (1986), I use the term "chance" to refer to objective probabilities and I make the common assumption that objective probabilities are, in a sense that I clarify in section 3, guides for rational belief. The non-extremal synchronic probabilities of statistical mechanics are typically thought to be the most plausible examples of synchronic chances.

I'm not prepared to pledge allegiance to either camp. Instead, I aim to draw our attention to an underappreciated reason we might have to believe in non-extremal synchronic chances: it might turn out that the best interpretation of our common sense and scientific theories is one in which the macrophysical properties of physical systems are partly determined by synchronic chance distributions over microphysical properties of those systems. Clarifying and motivating that possibility will take a bit of work. First, one might assume that it is impossible, or at least impossible when considered in conjunction with other well-known facts, for the microphysical features of physical systems to underdetermine the intrinsic macrophysical features of those systems. In section 1, I aim to capture that assumption with a thesis that I call "Nearby Mereological Supervenience".[2] In section 2 I argue that, despite its *prima facie* appeal, Nearby Mereological Supervenience is false. I offer two counterexamples (one inspired by thermodynamics and the other by evolutionary biology) in which two distinct physical systems, governed by the same fundamental physical laws, have all the same microphysical properties but have incompatible intrinsic macrophysical properties. These cases do not take place in strange and "distant" worlds in which macrophysical

[2] In so doing, I clarify various terms such as "determine", "microphysical", "macrophysical".

properties somehow float freely from microphysical properties, but instead in worlds with laws and properties that (at least superficially) look a great deal like our own. In section 3, I argue that, in these cases, a system's macrophysical features are determined by its microphysical features in conjunction with non-extremal synchronic probability distributions. Since objective macrophysical features cannot be even partly determined by facts about subjects, these non-extremal synchronic distributions are chances to the extent that the macrophysical features they determine are objective. Finally, I conclude section 3 by defending the coherence of non-extremal synchronic chances against arguments that they violate various platitudes about chance—most pressingly, that chances are guides for rational belief.

Just as I won't take a stand on whether there are actually synchronic chances, I won't take a stand on whether microstates actually underdetermine macrostates; I claim only that both are possibilities with some important similarities to actuality. Why does it matter that there are possible worlds in which microstates underdetermine macrostates if the actual world is not among them? The answer is that if microstates determine macrostates in the actual world because of some idiosyncratic features of the non-fundamental laws and properties of our world, then it is inappropriate to assume that microstates determine macrostates when interpreting our best physical theories about the non-fundamental laws and properties of our world. Consider an analogy.[3] There was a time when philosophers assumed that all metaphysically possible worlds are (diachronically) deterministic and so ruled out interpretations of our best common sense

[3] I borrow this analogy (which is the inspiration of much of this essay) from Elliott Sober, who writes, "Quantum mechanics has forced philosophers to take seriously the possibility that the diachronic thesis of determinism may be false. Perhaps the synchronic determination thesis... should be re-evaluated as well...". (Sober 2010, pg.144)

and scientific theories that indicated otherwise. Correcting that mistake and developing a coherent metaphysics for (diachronically) indeterministic worlds was important philosophical work even if the actual world does turn out, after all, to be deterministic; understanding the metaphysics of indeterministic worlds allows us to make sense of, and so treat as live options, indeterministic physical theories. Analogously, understanding the metaphysics of worlds in which microstates underdetermine macrostates is important philosophical work even if the actual world is not among them. I argue that synchronic chance distributions allow us to make sense of, and so treat as live options, interpretations of our best common sense and scientific theories according to which microstates do not determine macrostates. To the extent that we have reason to endorse some such interpretation, we have reason to believe in synchronic chance.

1. Two Supervenience Theses

In Minnesota's Mall of America, there is a 34-foot model robot that is made entirely of Lego bricks. The relationship between this model, called "Herobot 9000", and the approximately 2.8 million Lego bricks that compose it is, in many ways, a mystery to me. For example, if I were given a complete description of Herobot 9000 merely in terms of the properties of its Lego bricks (such as their shape, size, color and interlocking relations), I would have no idea that Herobot 9000 is a model robot. Furthermore, I have no idea how to make a model robot (let alone Herobot 9000) out of Lego bricks. Interestingly, despite my ignorance of how various properties of Herobot 9000's bricks manage to determine its particular robot shape, I am sure that they do; more carefully, I am sure that if I were to have an object composed of Lego bricks that were perfect duplicates of the bricks that compose Herobot 9000 and that were arranged in the exact same way as are the bricks that compose Herobot 9000, I'd have an object that is a perfect duplicate of Herobot 9000.

Call "fundamental" whatever laws of nature govern the behavior of particles that compose a physical system. Let a "microstate" be a state of a physical system characterized by an exhaustive list of the microphysical properties of, and relations among, the particles that compose that system (i.e., the properties and relations that feature in the fundamental laws). Let a "macrostate" be a state of a physical system characterized by any collection of its intrinsic macrophysical properties (i.e., the intrinsic properties of the system that feature in the non-fundamental physical laws). Given that I understand so little about how various properties and arrangements of Legos determine other properties of Herobot 9000 (such as its robot shape), what could justify my confidence that they do? The following thesis that, following Elliott Sober, I call "Mereological Supervenience" would do the job:

> **Mereological Supervenience (MS)**: No two physical systems (be they two systems in the same possible world or two systems in different possible worlds) that are in the same microstate (over some span of time) and governed by the same fundamental laws are in different macrostates (over that same span of time).[4]

[4] My formulation of Mereological Supervenience is slightly different from Sober's (2010).

Mereological Supervenience is motivated by the thought that the properties of the parts of systems determine the properties of those systems.[5] Just as Herobot 9000 is composed of Lego bricks, Lego bricks are themselves composed of further objects. Lego bricks are a mixture of pigment and plastic that is composed of various chemical compounds, and those chemical compounds are in turn composed of atoms held together by chemical bonds, are so on. According to MS, a complete description of Hereobot 9000 in terms of its microphysical properties (whatever those may be) determines the correct description of Hereobot 9000 in terms of its somewhat-more-macro atomic properties, and in terms of its still-more-macro chemical properties, and in terms of its even-more-macro shape and color properties. Given MS, were I to have some Lego bricks arranged so that the microstate of this arrangement is the same as is Herobot 9000's microstate, I would have an object that is in all and only Herobot 9000's macrostates.[6] Furthermore, if I know MS then I need not know anything all about what

[5] I use "determine" in the following way: a microstate (or microphysical property) "determines" a macrostate (or macrophysical property) at a world exactly on the condition that there is no possible world— with the original world's same fundamental laws— in which a system is in that microstate (or has that microphysical property) but not in that macrostate (or lacks that macrophysical property). Crucially, my use of "determine" does not imply any relationship of metaphysical priority (e.g., a "grounding" relation).

[6] Intuition pumps for MS have this step-wise character. Sometimes, then, I will refer to some state as a "microstate" even though its properties are not those mentioned in microphysics, but rather those referred to by some higher-level science that is nevertheless a lower-level science than is the one that corresponds to the macrostate. One might worry about this shortcut since from the fact that an upper-level macrostate is underdetermined by a mid-level macrostate it does not follow that the upper-level macrostate is underdetermined by the most fundamental microstate. Let me say explicitly, then, that I believe that the cases I will examine are counterexamples to Mereological Supervenience (and NearbyMS, which I introduce below) irrespective of whether the "microstate" in question is genuinely a fundamental microstate of the worlds described. For example, it is only for ease of exegesis that I will allow myself to refer to a description of a gas in terms of the positions and velocities of its molecules as a

properties are instantiated in the actual world or about how microphysical properties give rise to more-macro properties to know that Herobot 9000's microstate determines all of its macrostates.

Before evaluating MS, it will be helpful to clarify its content. First, uncontroversial examples of "physical systems" include rotating spheres, boxes of gas, human bodies, and ecosystems, but perhaps more gerrymandered "systems" such as the right side of my desk minus the pen drawer count as well. None of the discussion that follows involves controversial applications of the predicate "physical system", so we need not settle this issue to proceed.

Second, MS is a non-starter unless macrostates are descriptions of only intrinsic properties of systems. To see why, suppose that objects are models (of e.g., robots) partly in virtue of their relation to the intentions and beliefs of the agents who create them. Though Hereobot 9000 has the property of being a model, a particle for particle duplicate of Hereobot 9000 that coincidentally falls together after a tornado passes through LegoLand might not be a model of anything. That said, the possibility of a duplicate Hereobot 9000 that lacks the property of being a model is no threat to MS since being a model is an extrinsic property. We no more suspect the extrinsic macrophysical properties of systems to be determined by their microstates than we suppose that my being taller than my mother is determined by my height alone.

"microstate", rather than reserving the label "microstate" for its quantum-mechanical state. If it turned out that appeal to genuinely fundamental microstates somehow dissolved my cases, then this would be an interesting result— but there would still be a possible world, superficially similar to the actual world, where my cases hold.

Third, MS does not entail that all properties of a system are determined by its microstate. For example, MS does not entail that the nomic property "is governed by the thermodynamic laws" is determined by a system's microstate.[7] Relatedly, MS states that a system's macrostates supervene on its microstate in conjunction with the fundamental physical laws rather than, say, all nomic facts. This feature of MS allows it to play a non-trivial role in arguments about what the nomic facts of a system might be (e.g., whether a system could be governed by probabilistic non-fundamental laws).

Finally, notice that MS is very strong— too strong, I think, to be plausible. It says that it is not even possible (no matter what the physical laws and properties are like) for the macrostate of a system to be underdetermined by its microstate and the fundamental laws, but I think I can imagine a world in which the macrophysical properties of systems float freely from the microphysical properties of their parts.[8] Still, such scenarios are merely remote possibilities; it is easy to see that in worlds like ours, laws that govern macrophysical properties are constrained in some way by laws that govern microphysical properties. Surely our world would be radically different if the macro-behavior of physical systems were in no way set by their micro-behavior. As things actually are, the fundamental laws somehow "get a grip" on the macrophysical properties, and a natural thought about how this "grip" is gotten is that the fundamental laws govern the microphysical properties and the microphysical properties set the macrophysical

[7] Here I assume that the nomic property "is governed by the thermodynamic laws" does not feature in any non-fundamental natural laws (at least, not any first-order ones).

[8] The reader need not agree with me that MS is obviously false to agree that, in light of the cases that follow, MS is false.

properties.[9] This line of thought motivates a weakening of MS that I'll call "Nearby Mereological Supervenience" or "NearbyMS". The only difference between NearbyMS and MS is that the former (unlike the latter) is restricted to worlds that we (correctly) believe to be "closer" to the actual world than are other possible worlds:

> **Nearby Mereological Supervenience (NearbyMS)**: For all worlds in which every macrostate is constrained by some microstate, no two physical systems (be they two systems in the same world or two systems in different worlds) that are in the same microstate (over some span of time) and governed by the same fundamental laws are in different macrostates (over that span of time).

Earlier we saw that if I know MS, I need not know anything at all about what properties are instantiated in the actual world or about how microphysical properties give rise to more-macro properties to know that e.g., Herobot 9000's microstate determines all of its macrostates. If I merely know NearbyMS, then I have to know a little bit about the actual world to know that microstates determines macrostates— I have to know that microstates constrain macrostates. Still, presumably we already know enough about actuality to know that microstates constrain macrostates. So, thanks to NearbyMS, I can know that e.g., Herobot 9000's microstate determines its macrostates without understanding, say, how it is that the fundamental physical behavior of systems gives rise

[9] What does "constrain" mean? The rough idea is that if microstates "constrain" macrostates then macrostates are not independent of microstates but may nevertheless be underdetermined by microstates. NearbyMS says that, for all metaphysically possible worlds, every macrostate (in that world) is determined by a microstate or there is at least one macrostate (in that world) that is not even partially determined by a microstate.

to their atomic properties, or how it is that monomers are polymerized to create plastics, or how to make a 34-foot model robot out of Lego bricks.

NearbyMS has many positive instances.[10] The familiar macrophysical properties of Lego bricks (such as their shape, color, texture and durability) seem somehow determined by whatever are the microphysical properties of the constituents of Lego bricks, the fact that I am in pain seems somehow determined by my brain state, and the color of my eyes seems somehow determined by the amount of melanin in my irises. Confirming examples are easy to multiply. Nevertheless, NearbyMS is false.

2. Counterexamples to NearbyMS

Below I'll present two counterexamples to NearbyMS: a case inspired by thermodynamics (2.2) and a case inspired by evolutionary biology (2.3). We have a counterexample to NearbyMS when we have two physical systems in the same microstate but in different macrostates, provided that both systems are governed by the same fundamental laws and located in worlds in which macrostates are constrained by microstates. In each case, I stipulate that the two physical systems in question are in the same microstate and governed by the same fundamental laws; the substantive issue is whether the two systems described really are in different macrostates. To be in different macrostates, recall, two systems must be different with respect to at least one intrinsic macrophysical property. My cases invoke macrophysical properties such as

[10] It is sometimes argued (e.g., Teller 1986, Karakostas 2008) that quantum mechanics creates trouble for some supervenience theses (e.g, Humean supervenience, physicalism). I think NearbyMS is consistent with (a realist interpretation of) quantum mechanics, though "physical system" needs to be cashed out with more care. At any rate, none of my cases appeal to quantum mechanics.

“equilibrium” and “fitness”, and though my understanding of these properties is drawn from the disciplines in which they are used, I don’t pretend to give anything close to a thorough enough argument to establish that each is an intrinsic macrophysical property (of the relevant system) found in the actual world. Instead, the cases are simplistic toy models designed to illustrate how microstates might fail to determine macrostates in worlds in which macrostates are nevertheless constrained by microstates. To reject my counterexamples is not to merely deny that each describes actuality or even that each describes physical possibilities, but is rather to deny that there could be worlds with laws and properties like the ones I describe. Accordingly, the philosophical upshot of the following cases does not depend on the many difficult and otherwise important intricacies that are essential to an accurate understanding of actual properties such as equilibrium and fitness.

2.1 Equilibrium

Imagine a gas confined to a box. The laws of thermodynamics govern various macrophysical properties of the gas, such as equilibrium, heat, temperature, pressure, and volume. The kinetic-molecular theory of gasses treats gasses as collections of particles that are constantly moving at different velocities and occupying different spatial positions, and attempts to derive their thermodynamic behavior from the behavior of those constituent particles. For simplicity, I stipulate that a gas’s microstate is given by a specification of the locations, velocities, masses, and other intrinsic properties of each of its particles, and that the time-evolution of the gas’s microstate is governed by Newtonian mechanics. Because many of the thermodynamic properties are not properties of particles, part of the project of the kinetic-molecular theory of gasses is to find correlates for these properties that can be described in the language of the underlying physical theory. For example, "heat" is a thermodynamic concept that does not appear in Newtonian mechanics; to derive statements about the nature of heat from statements about the behavior of particles, the kinetic-molecular theory of gasses associates heat with the total energy of a gas's molecular motion. If that association is correct, it seems that the heat of a system is determined by its microstate. But it is not so obvious that all thermodynamic properties are similarly determined by microstates.

Consider first the property of being at thermodynamic equilibrium. Lawrence Sklar (1993, pg. 350) describes one traditional understanding of equilibrium when he writes, "In thermodynamics, [equilibrium] is posited primarily as a state that, in the axiomatic theory, obeys the Zeroth Law [i.e., the law that "is in thermal equilibrium with" is an equivalence relation]. In our more generalized macroscopic picture, it is the end state of spontaneous evolution. The constitutive equations characterize the interrelations among the other posited characteristics of a system when it has the characteristic of being in equilibrium."[11] So, equilibrium is a macroscopic state that obeys the Zeroth law, and that all energetically isolated gases tend toward, and at which the constitutive equations hold.

Consider next the microstates that are consistent with a gas's being at equilibrium. Sklar continues, "Within statistical mechanics we could think of the equilibrium states as being those overwhelmingly most probable distributions of microscopic conditions that

[11] There are other influential statistical-mechanical interpretations of "equilibrium" (e.g., Gibbs 1960), but to insulate NearbyMS from counterexamples by insisting that only these rival interpretations depict possible worlds is exactly the sort of tactic that I claim is pernicious.

lead to the usual equilibrium constitutive equations. We would then expect the principle that systems approach equilibrium and stay there to be replaced by a modified law that allows for... fluctuational behavior." (pg. 350) At the micro-level, then, there are many different microstates that an energetically isolated gas can be in, but the microstates that are consistent with the gas's being at equilibrium are those in which the most likely microscopic conditions obtain. As Sklar describes, the association of equilibrium with likely distributions of microscopic conditions does not preserve the idea that gases at equilibrium never leave equilibrium, but it comes close; an energetically isolated gas at equilibrium is overwhelmingly likely, though not guaranteed, to be at equilibrium at any particular later moment.

Now consider a one-liter box. Suppose that it is filled with some quantity of gas and then energetically isolated until the gas reaches equilibrium. Call the microstate that this gas is in, at some particular moment during which it is at equilibrium, *m* (for "microstate"). Microstate *m* is exactly the sort of microstate in which we would expect to find this gas.[12] Next, consider a five-liter box filled with the same quantity of gas and energetically isolated. It is overwhelmingly likely that (at any particular moment) the gas is at equilibrium, but it is nevertheless possible that (at any particular moment) the gas is far from equilibrium. Suppose, then, that this second gas is in microstate *m*. Though *m* (i.e., a microstate in which the particles of gas are bunched into a one-liter space) is not the sort of microstate in which we expect to find this second gas (in part because we expect it to be at equilibrium) nothing in the fundamental physical laws prevents the

[12] Of course, one would not expect that the gas is in *m*, or in any other *particular* microstate, since the chance of any particular microstate obtaining is vanishingly small. Rather, *m* is the sort of microstate we expect.

particles of gas from being bunched into a one-liter space and arranged precisely into *m*. We have now arrived at our first challenge to NearbyMS. We have two systems (i.e., two quantities of gas) that are both in microstate *m* but that are in different macrostates: the first gas is at equilibrium but the second gas is not.

Let's take stock. Suppose the particles of some gas are arranged into microstate *m*. Is it at equilibrium? A safe bet is that it is, but if the above reasoning is correct, a gas in microstate *m* could be either a gas at equilibrium in the sort of microstate we expect or a gas not at equilibrium in a very surprising sort of microstate. Furthermore, though this case describes an extremely unlikely state of affairs, it does not seem to describe an outlandish possible world where macrostates are unconstrained by microstates; the macrophysical properties and laws describe in the case seem utterly familiar.

No doubt those sympathetic to NearbyMS will have some objections to my purported counterexample. The objection that immediately comes to mind denies that equilibrium is an intrinsic property of quantities of gas.

Objection 1: *The counterexample supposes that being at equilibrium is an intrinsic property of a gas, but equilibrium is instead an extrinsic property a gas has (or lacks) partly in virtue of features of its container. No surprise, then, that microstate m, which includes the positions and velocities of the particles that compose the gas but not the positions and velocities of the particles that compose the box that contains the gas, fails to determine whether the gas is at equilibrium. But that failure is no threat to NearbyMS if equilibrium is an extrinsic property.*

According to this objection, part of what it is for a gas to be at equilibrium is for it to be confined to a space of a certain volume and shape (and part of what it for a gas to not be at equilibrium is for it not to be confined to a space of a certain volume and shape). In response, note that nothing in the standard thermodynamic characterizations of equilibrium as, say, the end state of spontaneous evolution, the state at which the constitutive equations hold, and the state at which the system undergoes no macroscopic change, indicates that equilibrium is an extrinsic property of a gas. That said, there is obviously some important sense in which the gas's being at equilibrium partly "depends" on features of its container. However, that platitude does not settle whether the dependence in question is causal or constitutive. It might be that the gas's being confined to a space of a certain volume and shape is a cause of its being in equilibrium, rather than a partial constituent of the fact that the gas is at equilibrium. How can we tell whether equilibrium is an extrinsic property of a gas that is partly determined by features of its container or an intrinsic property of a gas that is caused by features of its container? Only through a more careful investigation than I have offered here; one that is sensitive to the empirical and theoretical intricacies of thermodynamics and the kinetic-molecular theory of gasses.

And that is exactly my point. I am entirely open to the possibility that such careful study would reveal that equilibrium—the property instantiated in the actual world—is, in fact, an extrinsic property of a gas that is partly determined by features of its container. What I am not open to is any broadly metaphysical argument that equilibrium must have this extrinsic character on the grounds that NearbyMS is true (and that our world is one in which microstates constrain macrostates). The counterexample indicates that there are possible worlds, perhaps with laws and properties that are in some ways different from our own, in which microstates underdetermine macrostates. To defend NearbyMS along the lines of the above objection requires not only that equilibrium is actually an extrinsic property of gasses, but the much stronger claim that any world with an intrinsic property of gas that plays a role similar to the role played by equilibrium in the actual world is a "distant" world in which microstates do not constrain macrostates. In section 3, I use synchronic chances to show that this stronger claim is false. First, however, I turn to one more counterexample to NearbyMS.

2.2 Fitness

A single counterexample suffices to demonstrate that NearbyMS is false. However, if there is only one such counterexample, it is tempting to suppose that fault lies with the particulars of the case rather than with NearbyMS. Perhaps, for example, I am wrong that there could be a property at all like equilibrium that behaves in the way described above. But counterexamples to NearbyMS are not unique to cases inspired by thermodynamics. My second example is drawn from evolutionary biology.

An organism's Darwinian "fitness" is a property that reflects its ability to survive and reproduce.[13] Many philosophers and biologists (e.g., Mills and Beatty 1979, Brandon and Carson 1996, Bouchard and Rosenberg 2004,) have given fitness a

[13] The case that follows concerns the fitness of individual organisms rather than the fitness of traits. For a recent account of the fitness of individuals and a defense of the importance of individual fitness to ecology and evolutionary biology, see Pence and Ramsey 2013.

probabilistic interpretation.[14] On one simple and well known understanding of fitness (found in Mills and Beatty 1979), the fitter an organism is relative to its environment the more copies of its genes we expect to find in the subsequent generations.[15] A probabilistic interpretation respects the intuition that an organism with high fitness may nevertheless, because of "bad luck", fail to pass on many copies of its genes (or, because of "good luck", may pass on very many more copies of its genes).

Organisms do not have fitness levels full stop, but instead are fit or unfit relative to an environment. For example, a butterfly's capacity for flight (which is an important contributor to its overall fitness) is determined not only by some of its intrinsic features (such as wingspan), but also by its surrounding environment. Two butterflies that are intrinsically identical but live in different climates, for example, may nevertheless differ with respect to their ability to fly (since warmer climates are more conducive to flight in coldblooded creatures than are cooler climates), and so differ with respect to their fitness. Because of the extrinsic nature of fitness, NearbyMS does not predict that an organism's fitness supervenes on the microstate of the organism alone, but rather on the microstate of the organism taken together with the microstate of its surrounding environment.

Suppose that some butterfly lives in an environment with a climate that is optimal for its flying capabilities. For simplicity, let us focus exclusively on the contribution that climate makes toward the butterfly's ability to fly and on the contribution that flight

[14] What this probabilistic interpretation amounts to is heavily disputed, but it is widely agreed that an organism's having a high fitness is consistent with its not actually leaving many (or any) copies of its genes behind. For a discussion of the available options, see Millstein 2003.

[15] Counterexamples (see e.g., Gillespie 1977) have shown that this mathematical definition of fitness is too simple to be adequate, but the important point for my purposes is that an individual's fitness is no guarantee of how it will fare with respect to survival and reproduction.

makes to the butterfly's overall fitness.[16] Call this first butterfly's fitness "*H*", for "high". Tragically, a falling tree kills our butterfly after only a single day of its life. As it happens, the temperature on this day is 70 degrees Fahrenheit.

Now imagine a second butterfly that lives in an environment largely the same as the first, but with a climate less suited to flight. Again for simplicity, let us focus only on the contribution that climate makes to flight and that flight makes to overall fitness, and so assume that our two butterflies would be equally fit if they were born in the same climate. However, since the second butterfly is born in a cooler climate, its fitness is lower than is the first butterfly's. Call this fitness level "L" for "low relative to the first butterfly's". A falling tree also kills this butterfly after being alive for only a single day. That day's temperature is 70 degrees Fahrenheit, which is unusually warm for the climate.

It is consistent with our story that the two butterflies themselves are (intrinsically) identical on the micro-level at every instant of their existence. As we have already seen, that fact does not threaten NearbyMS since fitness is an extrinsic property of an organism. But NearbyMS is threatened by the fact that it is consistent with our story that not only the butterflies themselves but also their environments are identical with respect to their microphysical properties. The difference in the two scenarios in virtue of which the two butterflies have different levels of fitness is (I have stipulated) the different climates. But the climate of the environment, in this case, is not determined by the microstate of the environment. Even though the climate in the second case is cooler than

[16] As is hopefully obvious, the choice to focus on flight and climate rather than, say, speed and terrain, is entirely arbitrary. Choosing different coarse-grained environmental features that contribute to fitness can generate many more counterexamples to NearbyMS.

in the first case, the temperature on the sole day of our butterflies' lives is the same in both scenarios. At the micro-level, our two butterflies and the environments they find themselves in may be indistinguishable over the course of their lives even though one butterfly is more fit than is the other.

Though the microstates themselves are identical in the two scenarios, our expectations about those microstates are not. Given that a system is in *H*, there is some probability that it is in a microstate that will evolve in a way that is consistent with the butterfly's leaving behind many copies of its genes. Given that a system is in *L*, it is somewhat less likely that the system is in a microstate that will evolve in a way that is consistent with the butterfly's leaving behind many copies of its genes. Structurally, the fitness case is much like the gas case; we are presented with two systems that are in different macrostates but the same microstate, and the only other (relevant) difference between the two systems appears to be that one system is in a likely sort of microstate while the other system is in a less likely sort of microstate.

An advocate of NearbyMS might respond that if the climates are truly different in the two scenarios, this difference must eventually show up on the micro-level. Here is one way to flesh out such an objection[17]:

[17] There is a possible worry about this second case that is an analog to the objection ("objection 1") posed in the gas case: might climate be an extrinsic property between an environment and factors outside that environment (e.g., proximity to oceans, mountains, etc.)? My answer is analogous to the response I gave to objection 1 in the previous section. Factors outside an environment might either be causes of an environment's climate or partly constitutive of an environment's climate. As in the gas case, I only insist that there are possible worlds in which a property that is superficially similar to climate is an intrinsic property of environments.

Objection 2: *All that this case shows is that fitness is not determined by microstates that merely span an organism's lifetime. But fitness may nevertheless be determined by microstates considered over a longer period of time. If we consider a sufficiently long sequence of microstates in two environments with different climates, we will see that the temperatures in the two environments are* eventually *different since the two climates are different. That there is at some time this difference in temperature is what makes for a difference in the two climates, and ultimately what makes for the difference in the fitness level of the two butterflies.*

While I agree that it is very likely that there will be a temperature difference between the two environments if we consider a sufficiently long span of time, it is nevertheless possible that there is no such difference. The fact that the two climates are different is, as far as I can see, consistent with their having identical temperatures for as many days as we care to imagine. Rainy climates suffer draughts, cold climates have unseasonably warm stretches, and deserts go through cold spells. The longer the odd weather lasts the less likely it becomes, but at no point does it become impossible.

To be sure, if one witnesses (say) 10,000 consecutive cold days in a supposedly warm climate, one may reasonably question whether the area is actually warm. But that which we reasonably believe given our evidence need not be true. If we witness a supposedly fair coin land heads 10,000 times, we reasonably doubt that the coin is fair. But, it is nevertheless possible that we are, in fact, observing a fair coin on an incredibly unlikely run of heads. And, just as a fair coin can land heads 10,000 times (or one million times, or an infinite number of times), so too can a warm climate experience a long consecutive string of cold days. [18]

Furthermore, we can (brutally) cut the objection off before it begins by adding to the case the supposition that Earth and the universe pop into existence when the butterflies are born and cease to exist when they die. On this version of the case, there are no further facts about the temperature on other days, since there are no other days. Still, even if the planet were to exist for only one day, the butterfly's fitness would be high in the one case and low in the other. If that is right, then (given the simplifying stipulation that only climate matters to fitness) the climate in the two environments must differ.

Or maybe not. As should now be familiar, I don't insist that this case is even physically possible since it might involve a crucial mischaracterization of an actual property such as climate or fitness. Perhaps, for example, a closer study of climatology will reveal that a cool climate is inconsistent with some very long run of hot days and is not instantiated at all by environments that exist for only very short periods of time. Nevertheless, the case describes a metaphysically possible world with macrophysical properties that are similar to those of the actual world (i.e., similar to fitness, climate, etc.) in which macrostates are underdetermined by microstates. In the next section, I argue that this case describes a world in which fitness is determined by microphysical features in conjunction with a synchronic chance distribution over microstates.

[18] Hájek (2009) gives convincing arguments that non-extremal probabilities (e.g., a probability of ½ that a coin lands heads) are consistent with any long run sequence of outcomes (e.g., an infinite run of heads).

3. Synchronic Chance

3.1 The cases revisited

So far we have seen two cases involving worlds in which macrostates are somehow constrained by microstates without being determined by them. How could this be? One promising answer is motivated by the structural similarity between the two cases. In the thermodynamics case, we considered a gas in equilibrium and a gas out of equilibrium and noted that it is possible for these two gases to be in the same microstate *m*. However, the probability that each gas is in a microstate such as *m* (i.e., a microstate in which the particles are more or less evenly dispersed throughout a one-liter space) is much lower for the gas out of equilibrium than for the gas in equilibrium. In the evolutionary biology case, we noted that a butterfly's having a high fitness in a warmer climate and its having a low fitness in a cooler climate are both consistent with the exact same microphysical description of the butterfly and the environment in which it lives. But, the probability of this sort of microstate is higher when the butterfly is fit and in a warm climate than it is when the butterfly is less fit and in a cool climate. In each case, we have systems in different macrostates that vary not in their microstates, but in the probability of their being in such microstates. Impressed by this fact, I propose that there are worlds in which macrostates are determined by microstates in conjunction with the synchronic chance of that microstate and of all other microstates.[19] In such worlds, there are (at least) two different kinds of chance distributions that obtain: chance distributions described by fundamental physics, which I'll call "micro-chances", and synchronic

[19] On a standard analysis of probability, it is a probability density function over microstates that determines the macrostate since each microstate may have probability zero. For ease of exegesis, I ignore this detail and write as if there are only ever a finite number of microstates consistent with a given macrostate.

chance distributions. Micro-chances are indexed to times to reflect the fact that micro-chances evolve as time passes. Similarly, synchronic chances are indexed to times and levels.[20] The synchronic chance that a system is in a particular microstate at a time may vary depending on whether we consider the biological synchronic chance at that time, the thermodynamic synchronic chance at that time, the chemical synchronic chance at that time, and so on.[21] My proposal is that there are worlds in which the system's microstate at a time and the various levels of synchronic chance distributions that hold for that system at that time determine its macrostates at a time.[22]

To clarify my proposal, let's reconsider the thermodynamics case. There are a huge number of microstates that a particular gas can be in at a given time, consistent with its thermodynamic properties. Each of these microstates is assigned some value by a thermodynamic synchronic chance distribution. Furthermore, these microstates have various microphysical properties in common. For example, some microstates are ones in which the particles of the gas are all close together, whereas other microstates are ones in which the particles are more spread out. Facts about whether various microphysical

[20] Indexing chances to times and levels does not require that they be fundamentally conditional, since unconditional chances may have values that vary as background conditions vary. For a helpful discussion of the difference between conditional probability and probabilities that vary with background conditions, see Easwaran 2011.
[21] The question of what these different levels amount to is partly empirical and partly metaphysical, just as the question of what different times amount is partly empirical and partly metaphysical. I won't address either question here, but answering each is important to developing a full account of synchronic chance. Furthermore, whether indexing to a particular time makes a difference to what synchronic distribution holds is a largely empirical matter that depends on e.g., whether the synchronic distribution that obtains when a gas starts out at equilibrium is the same as the synchronic distribution that obtains when a gas ends up in equilibrium.
[22] Once again, my use of "determine" implies only modal covariance and not any sort of metaphysical priority. For example, synchronic chance distributions may hold "in virtue of" the macrostates of a system rather than the other way around.

properties are likely or unlikely are determined by the sum of the synchronic probabilities of each microstate that shares those microphysical properties. The case from thermodynamics prompted the intuition that whether a gas is in equilibrium has something to do with both its microstate and what sorts of microstates are likely.[23] I propose that, if equilibrium is as the case describes, whether a gas is in equilibrium at a time is determined by its microstate and the thermodynamic chance distribution that obtains at that time; the latter determines whether or not *m* is a likely sort of microstate (for any sort relative to microphysical properties) and also what other sorts of microstates are likely and unlikely. In the gas case, though the two systems are both in *m*, the thermodynamic chance distribution over microstates associated with the two gasses is very different. So, in that case, the fact that the system is in equilibrium seems determined its microstate combined with a synchronic chance distribution over microstates.[24]

Thinking about the thermodynamic synchronic chance distribution might reawaken worries that equilibrium is an extrinsic property of a gas.[25] The various canonical distributions of statistical mechanics hold only for gasses confined to containers of fixed volume, one might argue, and are not meaningfully assigned to gasses considered independently of facts about their containers. That makes it seem as though

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[24] Of course, nothing I have said sheds any light on how we might rationalize our attribution of one distribution over another to a particular system, or about where synchronic chance distributions come from. Issues such as these, which are discussed in detail in the philosophy of thermodynamics, are left unaddressed here. My point is merely that if there is an objective synchronic distribution in a world (whatever it may be and wherever it comes from), it is the right sort of thing (when combined with the microstate that obtains) to determine whether a system is in equilibrium in that world.
[25] Thanks to an anonymous referee for bringing this objection to my attention.

the only conceivable thermodynamic synchronic chance distributions obtain with respect to a gas and its container, rather than with respect to a gas itself. If equilibrium is determined by a chance distribution that holds with respect to a gas and its container, equilibrium only makes sense as an extrinsic property of a gas after all and the counterexample to NearbyMS is dissolved.

But this objection overlooks another option: we can understand thermodynamic chance distributions as holding for gasses of fixed volume and leave out any mention of the volume of the gas's container. Of course, the immediate response will be to deny that gasses have their volumes intrinsically. That might be true of the actual world, though I'm not sure. Solids and liquids have their volumes intrinsically; why not gasses? Like equilibrium, the volume of a gas is importantly dependent on features of its container, but again like equilibrium, that dependence might be causal rather than constitutive. Settling this issue is, however, far beyond the scope of this paper. As usual, I only insist that there are possible worlds, perhaps with laws and properties different from our own, in which a property like volume is an intrinsic property of gasses and in which thermodynamic chance distributions hold for gasses of fixed volume.[26] Such worlds depict coherent possibilities, even if our best interpretation of our scientific theories ultimately rules them out.

The evolutionary biology case gets a similar treatment. In that case, the difference between our butterfly's having a high fitness and its having a low fitness seemed to correspond to differences in whether various microphysical details of its life are likely. Biological and ecological synchronic chance distributions over microstates

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[26] In fact, volume is a good candidate for being a property that is underdetermined by the microstate of a gas.

can determine how likely these various microphysical features are. Once the microstate of the butterfly and its environment, as well as the relevant synchronic chance distributions over those microstates is fixed, so too is the butterfly's fitness.

Notice that, though it is possible for two different synchronic chance distributions to assign the same microstate a non-zero probability (which gives rise to counterexamples to NearbyMS), it is also possible for there to be only one synchronic chance distribution that assigns a particular microstate a non-zero probability. So, that there is a synchronic chance distribution over microstates does not, by itself, imply that a single microstate is consistent with more than one macrostate. The sorts of example that I used to motivate MS and NearbyMS in section 1, such as Herobot 9000's microstate determining its robot shape, are consistent with there being a synchronic chance distribution over microstates.

What justifies interpreting these synchronic probabilities objectively? To the extent that a particular macrophysical property is instantiated in a world independent of any facts about subjects, the synchronic probabilities that determine that property must be interpreted as being similarly objective. That said, "antirealist" interpretations of various macrophysical properties allow for subjectivist interpretations of synchronic probabilities. As a realist myself about many actual macrophysical properties such as equilibrium and fitness, I focus here on an objective interpretation of synchronic probabilities— but all my reasons for favoring realism are familiar and open to dispute by committed anti-realists.

Realists who wish to maintain that microstates actually determine macrostates must respond to the above cases by arguing that, as far as things go with the macrophysical properties instantiated in the actual world, each case is one in which either

(i) there is no intrinsic macrophysical difference between the two systems (as Objection 1 has it) or (ii) there is no macrophysical difference at all between the two systems (as Objection 2 has it). The moral I wish to impart is not that claim (i) or (ii) incorrectly characterize equilibrium, fitness, or any other actual property, but rather that claim (i) and (ii) are not the realist's only viable options. Instead, our world might be one in which some objective macrostates are determined by microstates in conjunction with synchronic chance distributions.

3.2 Synchronic Chance and the Principal Principle

The synchronic chance distributions I posit behave quite differently from more familiar micro-chance distributions, which have non-extremal values now only if they are about future outcomes. This unfamiliarity can give rise to any number of concerns about the coherence of synchronic chance. The metaphysics of chance is a vexing enough topic without synchronic chance thrown in the mix, and so I will not be able to alleviate all such concerns here. That said, I offer a few considerations that (hopefully) make synchronic chance seem less mysterious.

First, one might worry that there is something formally inconsistent about non-extremal synchronic chance. Of course, there is no general reason to think that the probability at a time that some event occurs at that time must be either 0 or 1. My current subjective probability that my dog is on the porch right now is only .5, even though (as it happens) my dog is currently on the porch. However, philosophers have traditionally thought of chances (unlike probability more generally) as evolving over time in such a way that what is present or past is no longer chancy. Consider, for example, micro-chances. A natural thought is that, at some time *t*, the value of the unconditional micro-chance that microstate *m* obtains at *t* is equal to the value of the micro-chance of *m* conditional on (among other things) the entire history of the world up to and including *t*.[27] According to the standard probability calculus (i.e., Kolmogorov's axioms and the definition of conditional probability), the conditional chance of *m* given *m* is equal to one and so, at *t*, the value of the unconditional chance that *a* obtains at *t* must be equal to one. However, it is philosophical conjecture rather than mathematical fact that all unconditional chances at a time are equal to chances conditional on (at least) the history of the world up to and including that time.

A second worry might be that it is impossible for it to be now true that *m* obtains and for the objective chance now that m obtains to be non-maximal. But we are already familiar with the idea that there are now truths about outcomes that are nevertheless presently chancy. Consider, for example, the proposition that the Royals will win next year's World Series. Many philosophers believe that if that proposition is true then it is true right now, even though the chance right now that the Royals will win next year's World Series is (unfortunately) very low. All that synchronic chances add to this familiar situation is that it can also occur with propositions that are about the present.[28]

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[27] Some philosophers (e.g., Lewis 1986 and 1994, Loewer 2004) maintain that all chances evolve in this way, not just the micro-chance distribution. Of course, that is precisely what I deny.

[28] It is not obvious that any contingent propositions about the future are presently true. The so-called "problem of future contingents" dates back to Aristotle. My point is merely that synchronic chances do not introduce the idea that a proposition that is now true may now have a probability other than 1 or 0.

Philosophers have nevertheless argued that there is a crucial disanalogy between the possible chanciness of the future and the possible chanciness of the present and past. The most pressing version of this argument starts with Bishop Butler's insight that chances are "the very guide to life"; if we are behaving rationally, we typically align our degree of confidence in the truth of propositions with the chance values of those propositions. If, for example, I know that the chance of rain tomorrow is .8, then my confidence in rain tomorrow should be .8. Only typically, however, because aligning degrees of confidence with chances is not always the right thing to do. If I know that the chance of rain tomorrow is .8, but, say, an all-knowing being who I trust tells me that it will not rain tomorrow (despite the high chance), then my confidence in rain tomorrow should be low rather than equal to .8. So, chances are the sorts of things with which we should align our degrees of confidence provided that we have only a certain sort of "admissible" information. The most famous codification of this insight about the connection between chance and degree of confidence, or "credence", is David Lewis's Principal Principle (henceforth PP):

> **PP**. Let C be any reasonable initial credence function. Let t be any time. Let x be any real number in the unit interval. Let X be the proposition that the chance, at time t, of A's holding equals x. Let E be any proposition compatible with X that is admissible at time t. Then, $C(A|XE)$=x. (Lewis, 1986)

The essential characteristic of chance is, according to Lewis, that it obeys the PP (hence the principle's name), and so any probability ascription (i.e., anything that can be substituted in for *X*) that violates the principle is not a genuine chance ascription.

The rub for synchronic chance is that it apparently violates the PP.[29] Lewis writes that "as a rule" propositions about the past and present (relative to *t*) are admissible. Suppose I'm rational (i.e., that my opinions can be represented as having come from a reasonable initial credence function by conditionalizing on my total evidence) and that I'm certain that the synchronic probability that a system is presently in microstate *m* is low but greater than 0. Will I align my degree of confidence in *m* with the synchronic probability of *m* no matter what admissible information I learn? If the proposition that the system is in microstate *m* is admissible, then clearly not; my rational degree of confidence that the system is in *m* given that the system is in *m* is equal to 1. So, because it does not obey the PP, the synchronic probability of *m* is not a chance value.
If chance must obey the PP and historical propositions (i.e., propositions about the future and the past) are always admissible, then there are no synchronic chances with values other than 1 or 0.

Is there any way to defend synchronic chance? We could give up on the idea that its connection to degree of confidence is an essential characteristic of chance, but then we risk losing a grip on the very concept of chance. Instead we might argue that historical information is sometimes inadmissible. It seems very plausible that, when it is the micro-chances at *t* that we have in mind, the complete history of the world up until *t* is typically

[29] Lewis 1986 does not consider synchronic chance explicitly, but argues that there is only one chance distribution. The argument that synchronic chance and the PP are mutually inconsistent is given in Schaffer 2007 and endorsed by Lyon 2010.

admissible. [30] But perhaps the rules are different for different sorts of chance functions. One could, for example, modify the PP by counting as inadmissible any historical information about microstates and then argue that satisfying the modified PP is sufficient for synchronic probabilities to count as chances.[31] That would handle the above argument, since microstate *m* (as well as all prior microstates) would be inadmissible. The problem is that, if unchecked, this strategy will accommodate an objective interpretation of far too many probability ascriptions. There's a perfectly good sense, for example, in which Oswald only probably killed JFK, but Lewis's original account of the PP (rightly) rules out an objective reading of this "only probably" since the historical fact that Oswald killed JFK is admissible (and so the only objective chance that Oswald killed JFK is 1). However, if satisfying a modified version of the PP is all that is demanded of synchronic chance (as far as objectivity is concerned), why isn't it enough that the probability that Oswald killed JFK satisfies a modified version of the PP on which, say, historical facts from 1955 and onward count as inadmissible? What advocates for

[30] Though for a somewhat different opinion, see Hoefer 2007. Hoefer suggests that we take Lewis's intuitive (and to my mind metaphorical) characterization of admissible information as information that does not "go by way of" chance values to be the correct and precise definition of admissibility. Because Hoefer does not take chance to be essentially time indexed, he can accommodate the view that the proposition that an outcome occurred is always inadmissible; it always provides information about a chance outcome that does not "go by way of" the chance of that outcome. However, I prefer an account on which at least some chance functions (e.g., micro-chances) are essentially time indexed and on which admissible information is relativized to chances at times.
[31] Loewer 2001, for example, advocates a version of the PP called "PP_{macro}" on which only macrophysical information is admissible. Schaffer 2006 criticizes Loewer's revision of the PP for being unmotivated.

synchronic chance need is a non-arbitrary justification for only sometimes counting historical information as admissible that does not overgeneralize into absurdity.[32]

I think we can find such a justification if we think more carefully about the core difference between inadmissible and admissible information. Though Lewis tells us that information about the present and the past is admissible "as a rule", he admits that some historical information is indeed inadmissible. When considering the outcome of a coin toss, for example, that a reliable crystal ball currently predicts that the coin will land heads is information about the present that is nevertheless inadmissible. That the coin is evenly weighted, on the other hand, is admissible information. The relevant difference between the two, it seems to me, is that the former but not the latter is explanatorily irrelevant evidence about the outcome of the coin toss.

Elsewhere ([redacted]), I've argued that the PP holds at least partly in virtue of explanatory role that chance plays. The rough idea is that chances are (or are parts of) explanations, and so (as the PP predicts) chance values screen off, or "swamp", all explanatorily relevant evidence about that which is being (at least partly) explained by the chance value.[33] However, because it is in principle possible to have information about whether an outcome occurs, prior to its occurrence, that is not explanatorily relevant to the occurrence of that outcome (e.g., by having access to a reliable crystal

[32] Emery 2015 makes a similar point in discussing the relationship between chance and possibility. For Emery, the non-extremal chance of some outcome implies that both the occurrence and nonoccurrence of that outcome are compossible with some privileged set of facts. But, which facts? Anyone who argues for non-extremal chances of any sort, argues Emery, must find a non-arbitrary answer to that question.

[33] Unfortunately, I have no precise account of when information is "explanatorily relevant" to offer, but see [redacted] for a more thorough discussion of explanatory relevance, its connection with admissibility, and a view of what is explained by the chances of future outcomes.

ball), chance values do not swamp everything; information about the future is an obvious source of such evidence, but any evidence that is explanatorily irrelevant to what is being explained is inadmissible on my view regardless of whether that evidence comes in the form of a proposition about the past, present, or future.

In that earlier paper, I was exclusively concerned with the chances of future outcomes, but the motivating idea behind the account of admissibility I sketched there is naturally extended to other cases. If the world is fundamentally deterministic, all (well-defined) micro-chances have values equal to 0 or 1. Nevertheless, there is an intuitive difference between the micro-chance now that a system will be in *m* in the future and the micro-chance now that the system is in *m* now, even if both values are equal to 1. The former chance values feels substantive or "real", whereas the latter seem trivial—merely a way of marking that *m* obtains or that it does not. This intuitive difference agrees with the verdict that no sense can be made of the micro-chance now of *m* obtaining now being anything other than 0 or 1. That verdict, I think, is correct with respect to micro-chance. What gives chance ascriptions their substantive feel is that they are explanatory, and the micro-chance now that the system will be in *m* in the future is (or is part of) a causal explanation of why the future is as it is.[34] In contrast, the micro-chance now of *m* obtaining now is no explanation at all of *m*'s now obtaining. That's how things go with causal explanation in our world (as far as we know); the order of explanation is from past to future, and not ever from future to past or present to present. Because micro-chances

[34] A crucial feature of my view is that even low chance values can be explanatory. While controversial, the view is not without precedent (see Salmon 1971) and avoids the problematic consequence that probabilities with high values are somehow more apt to be chances than are probabilities with low values. For a recent account that accommodates non-extremal synchronic chance while attempting to maintain neutrality on the question of whether low chance values explain, see Emery 2015.

provide causal explanations, no sense can be made of the idea that the micro-chance now of *m* obtaining now is anything other than 0 or 1. Is *m* admissible in this case? Whether or not information is admissible is relative to what is being explained by the chance value, and in this case nothing is being explained by the chance value. When nothing is being explained, we need not worry that the presence of explanatorily irrelevant evidence will mask the connection between chance and rational degree of confidence (since there is nothing to which any evidence is explanatorily irrelevant) and so no motivation for restricting the PP's application to agents with only a certain sort of information. When nothing is explained, everything (including *m*) is admissible. By the PP, then, the micro-chance now of the present and past is either 0 and 1.

The situation is quite different, however, when we leave aside the micro-chance distribution and consider synchronic chances. Many authors (e.g., Albert 2000, Loewer 2001, Lyon 2010, Emery 2015) have argued that the synchronic probabilities of statistical mechanics (like those in the gas example) are explanatory.[35] Though they have received much less philosophical and scientific attention, the synchronic probabilities associated with, say, climate in the fitness example are also plausibly explanatory. For example, though we can give a causal explanation of why it is 70 degrees Fahrenheit today by citing a complete description of the world at some prior time conjoined with the micro-chances at that time, we can also perfectly well explain why it is 70 degrees Fahrenheit

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[35] Why not take macrostates, rather than microstates, to be the outcomes of synchronic chances? The answer is that I think the "direction" of chance goes with the "direction" of scientific explanation, which I take to be from past to future in the case of micro-chance and from macro to micro in the case of synchronic chance. If there is a sense in which the micro "explains" the macro, it seems to me to be a metaphysical rather than scientific sense of "explains". (For a recent discussion of metaphysical versus scientific explanation, see e.g. Loewer 2012, Lange 2013)

today by citing the fact that 70 degrees Fahrenheit is a likely temperature in this temperate climate. To be sure, this latter explanation, which invokes synchronic probabilities, is of a different sort than is the causal one provided by the micro-chance distribution, but it is an explanation nonetheless. [36]

Much more needs to be said than I have here about what sort of explanation is given by various synchronic probability distributions.[37] The present point is merely that, if synchronic probabilities provide a different sort of explanation than do micro-chances then, given my understanding the PP, synchronic probabilities are apt to be interpreted as chances. If different kinds of chance distributions can provide different kinds of explanations of the same phenomena, then an account of admissible information in terms of explanation should be relativized not only to what is being explained but also to what kind of explanation is being given. Suppose that the synchronic macro-level chance at *t* that *m* obtains at *t* provides (or is part of) a non-causal explanation of why *m* obtains. The fact that *m* obtains is evidence that *m* obtains (indeed, it's the best kind) but is clearly explanatorily irrelevant to the fact that *m* obtains. Furthermore, arguably all information about prior (and subsequent) microstates is similarly explanatorily irrelevant to the kind of non-causal explanation provided by the synchronic chance. Just as there is a way of asking, "Why doesn't the round peg fit into the square hole?" to which a full micro-physical description of the peg and hole is irrelevant (to borrow Putnam's famous (1975) example), so too there is a way of asking, say, "Why is it 70 degrees Fahrenheit today?"

[36] Salmon (1989, Ch. 5) offers examples of causal-mechanical and unificationist explanations that peacefully co-exist as non-competing explanations of the same phenomena. The differing explanations provided by synchronic probabilities and micro-probabilities similarly co-exist.

[37] For a sketch of such an account, see Lyon 2010.

to which all causal-historical information about prior states of the world is irrelevant; it's 70 degrees Fahrenheit today because that temperature is likely in this climate. Though explanatorily irrelevant, information about prior (and future) microstates is evidentially relevant to the current microstate, and so inadmissible.[38]

Finally, an understanding of admissibility as relativized in part to the sort of explanation in question does not problematically overgeneralize. There is no sense in which, for example, the present high probability that Oswald killed Kennedy is even part of an explanation of Kennedy's death (though the prior high probability that Oswald killed Kennedy is), and so no pressure to treat the historical fact that Oswald killed Kennedy as inadmissible. (Since nothing is explained by that probability, everything is admissible relative to it.) If synchronic chance distributions and the more familiar micro-chance distributions work together to provide non-competing explanations of why various microstates obtain, then the PP (as I understand it) is in no conflict with synchronic chance. Synchronic chances, like all chances, are a guide to life for rational agents who have access to only a certain sort of information.

4. Conclusion

If NearbyMS is true, it doesn't take much to know that the actual world is one in which a system's macrostate is determined by its microstate; we only need to know that microstates at least constrain macrostates. I've argued that NearbyMS is false; with the help of synchronic chance functions, microstates can constrain macrostates without

[38] Notice that, on this account of admissibility, a single proposition may be admissible relative to one chance function but inadmissible relative to another. For example, the proposition that *m* obtains now is admissible relative to the micro-chance now that *m* obtains now, but inadmissible relative to the synchronic chance now that *m* now obtains.

determining macrostates. Once this possibility is taken seriously, the question of whether microstates determine macrostates in the actual world is not settled by broad generalizations, such as that microstates constrain macrostates, but rather by answering discipline-specific questions about particular macrophysical properties, such as whether equilibrium is an intrinsic property of a gas or whether an environment that is only every cool could nevertheless be located in a warm climate. It remains to be seen whether the best interpretation of our common sense and scientific theories is one on which microstates determine macrostates, but realists should not despair at either outcome; by positing synchronic chance distributions over microstates, we can understand how microstates constrain macrostates without determining macrostates. Synchronic chances are admittedly less familiar than are their micro-chance counterparts, but, because synchronic chances satisfy the PP, they are equally well deserving of the name “chance”. Worlds where macrostates are determined by microstates in conjunction with synchronic chances distributions look importantly similar to the actual world, and so we should be alive to the possibility that synchronic chances will prove to be indispensible posits of any adequate theory of how the macrophysical and microphysical relate.

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