Supervenience, Determination, and Dependence*

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ABSTRACT: I show how existing concepts of supervenience relate to two more fundamental ontological relations: determination and dependence. Determination says that the supervenient properties of a thing are a function of its base properties, while dependence says that having a supervenient property implies having a base property. I show that most varieties of supervenience are either determination relations or determination relations conjoined with dependence relations. In the process of unpacking these connections I identify limitations of existing concepts of supervenience and provide ways of overcoming them. What results is a more precise, flexible, and powerful set of tools for relating sets of properties than current concepts of supervenience provide. I apply these tools to a recalcitrant problem in the physicalism literature—the problem of extras.

1. Introduction

Supervenience, despite its many varieties, is a blunt tool. Consider the troubles supervenience has had capturing physicalism. Some say supervenience is too weak to capture physicalism, since it is compatible with non-physical properties (e.g. beliefs and desires) being unexplained.¹ Others say it is too strong to capture physicalism, since it rules out non-physical beings in non-actual worlds.² I shall argue that such difficulties arise in part from the fact that existing concepts of supervenience conflate two, more fundamental ontological relations: determination and dependence.

Determination is familiar from physics and mathematics, and says that future states are a function of initial states; or in this context (which focuses on sets of properties), that supervenient property distributions are a function of base property distributions. Dependence is less familiar, but has been developed as a philosophical concept by Edmund Husserl and others in his wake (e.g. Peter Simons). Dependence says

^{*} Penultimate draft of https://doi.org/10.1111/j.1468-0114.2007.00283.x

that if one type of thing exists then so must another: e.g. colors always coexist with extensions. In this context, dependence says that having a supervenient property implies having a base property.³

By clearly distinguishing these concepts—which are often run together or conflated with supervenience generally—it is possible to give more precise and illuminating analyses of metaphysical problems than is otherwise possible.⁴ In what follows I consider determination and dependence independently and relative to supervenience. I articulate variations, raise and answer problems, and consider applications, in particular the problem of characterizing physicalism in a manner which is neither too strong nor too weak.

In unpacking determination and dependence and illustrating the work they do, we shed light on the structure of supervenience as a philosophical concept, and go some distance towards making it more useful. Suppressing modal complexities, most varieties of supervenience on the market today have one of two general forms:

(S1) *A*-properties supervene on *B*-properties if things that are *B*-indiscernible are *A*-indiscernible.

(S2) *A*-properties supervene on *B*-properties if anything that has an *A*-property has some *B*-property such that anything that has that *B*-property also has that *A*-property.⁵

I shall argue that (S1) is a form of determination and that (S2) conjoins determination and dependence. I also show that those who use (S1) often assume it captures dependence, though it does not. In such cases the conjunction of determination and dependence–which

is equivalent to (S2)–is preferable, because it facilitates separate tuning of the determination and dependence components.

2. Determination

The most widely used formulation of supervenience, sometimes called its "core idea"⁶ or "canonical" form,⁷ is that things that differ in their supervenient properties differ in their base properties, or equivalently (by contraposition), things indiscernible with respect to their base properties are indiscernible with respect to their supervenient properties. This is the original and by far the most pervasive definition—the one we find in Hare, Moore, Davidson and Lewis–since it is the easiest to state, understand, and use.⁸ As Davidson puts it, in the context of mental-physical supervenience:

...supervenience might be taken to mean that there cannot be two events alike in all physical respects but differing in some mental respects, or that an object cannot alter in some mental respects without altering in some physical respects.⁹

This is typically formalized as follows (though not by Davidson himself): *B*-properties supervene on *A*-properties iff:

(DET) $\forall x \forall y (x =_B y \rightarrow x =_A y)$

where ' $x =_B y$ ' is shorthand for 'x and y share all *B*-properties', that is, ' $\forall X \in \mathbf{B}$ ($Xx \leftrightarrow Xy$)' (similarly for ' $x =_A y$ '). When x and y share all *B*-properties one also says that they are '*B*-twins,' or that they are '*B*-indiscernible.' So (DET) can be thought of as claiming that *B*-twins are *A*-twins, or that if x and y are *B*-indiscernible then they are *A*-

indiscernible. Supervenience in this sense is plausibly construed as a form of determination (hence the label "(DET)" above).¹⁰

The concept of determination is familiar from mathematics and physics, where a deterministic law is one where the future states of a system are fixed by an initial condition. The same usage carries over into philosophy, where determinism is the view that there is a single unique way the future will unfold given some fixed start state.

Supervenience in the sense of (DET) is deterministic in a similar way: it entails that a distribution of base *B*-properties over a thing implies a unique distribution of supervenient A-properties over that thing.¹¹ Although I shall not prove this entailment here, it is worth briefly considering what determination in this sense looks like. We must first shift our attention from properties *simpliciter* to "distributions" of properties.¹² A distribution of properties can be produced by concatenating each atomic property in a set of properties, or its negation, into one long conjunctive property, subject to the conditions that the resulting property is consistent and nonnegative (i.e. it is not a conjunct of negated atomic properties). These are known as "maximal properties."¹³ If we allow the relevant property-formation operators, we can associate any arbitrary set of properties X with the set of all maximal properties constructible from properties in X—we call this set X^* . The claim, then, is that if a set of properties **B** determines a set **A** (DET), then there is a function $f: \mathbf{B}^* \to \mathbf{A}^*$, where f associates each base maximal property in \mathbf{B}^* with a unique supervenient maximal property in A*, such that anything which has that base maximal property has that supervenient maximal property. I call f a "supervenience" function." So, (DET) for sets of properties **B** and **A** entails the existence of a supervenience function f, whereby a distribution of B-properties over a thing (a maximal

property B^{M} in **B***) uniquely specifies a distribution of *A*-properties (a maximal property $f(B^{M})$ in **A***) which applies to that thing.

If ethical properties supervene on physical properties, for example, then distributions of physical properties determine unique distributions of ethical properties; ethics is a function, literally, of physics. God's putting the world in a certain physical configuration, on this view, leaves no doubt about the ethics of the world. But, since the relevant function is most likely many one (many physical configurations of the world could produce the same distribution of ethical properties), the converse does not hold: if God only specified the ethics of the world he would have work left over.

The determination relation is sometimes also called a "covariation" relation, insofar it entails that variations in the *A*-properties of a thing imply variation in its *B*properties. If physical states determine mental states, then as a person's mental state varies, so too does his or her physical state (but not vice-versa: a person's physical state can vary slightly without that affecting his or her mental state). In functional terms, as the values of a supervenience function vary, so too must its arguments, but not vice versa.

Most varieties of supervenience can be thought of as varieties of determination relation. For example, the distinction between strong and weak supervenience can be thought of a distinction between strong and weak determination, depending on whether distributions of *B*-properties determine the same distributions of *A*-properties across all worlds (strong determination), or within individual worlds (weak determination). In functional terms, strong determination posits a single map from base to supervenient distributions of properties, whereas weak determination posits a family of maps, one for each world.

Global supervenience, another popular formulation of supervenience, is also a determination relation (I shall also refer to it as "global determination" in what follows), where the things taken to be A- and B-indiscernible are not objects in worlds but rather whole worlds. The advantage of global supervenience is that it allows for supervenient properties to be determined not by local conditions of an individual thing, but rather by some wider spatiotemporal distribution of things and properties (e.g., if externalism is true, then my mental state is not determined by my brain state alone, but by a widely dispersed variety of features of the world I occupy). We can again posit a map, this time from distributions of base properties over the objects of a world to distributions of supervenient properties over the objects of a world. However, care must be taken. In saying that two worlds instantiate the "same" distributions of base or supervenient properties and are thereby base or supervenient indiscernible, it must be the case that supervenient properties are distributed over the objects of the two worlds in the same way. In the recent literature this is typically captured using "property isomorphisms": 1-1 and onto functions ("bijections") between the objects of worlds such that if an object in one world instantiates a property, its image under the map in the other world instantiates the same property, and similarly with relations. (Strong) global determination then becomes the claim that any B-isomorphism between worlds is an A-isomorphism.¹⁴

However, the use of property-isomorphisms has metaphysically unsatisfying results, for it requires that worlds have the same number of objects to be indiscernible with respect to a set of properties. For example, for two worlds to be ethically indiscernible, they must contain exactly the same number of objects. But then worlds just like ours but for the addition of morally innocent particles and gusts of interstellar wind are not ethically indiscernible from our world. Or consider a world just like ours but for the addition of a single Cartesian spirit (an individual with mental properties but no physical properties). This world should count as physically indiscernible from our own, but the definition in terms of isomorphisms rules that out. This in turn spells disaster for the new breed of global determination relations, for (to consider just one of several problems) such worlds, in failing to be base-indiscernible from one another, are allowed to be as different at the supervenient level as one likes.

To remedy the problem we introduce the concept of a restricted isomorphism, a bijection which only applies to objects with the relevant properties. Global *X*-indiscernibility can then be redefined in terms of there being an *X*-isomorphism between the *X*-objects of the two worlds (where an "*X*-object" is an object with an *X*-property). Two worlds are ethically indiscernible if there exists an ethical isomorphism between the ethical objects of the two worlds. Two worlds are physically indiscernible if there exists a physical isomorphism between the physical objects of two worlds. Global determination is then the thesis that any restricted base isomorphism between worlds is a supervenient isomorphism.¹⁵ We will see this revised definition of indiscernibility, and corresponding variants of global determination, to be valuable for other reasons later.

3. Dependence

Supervenience is widely held to be a dependence relation. Davidson, for example, says that "mental characteristics are in some sense dependent, or supervenient on physical characteristics,"¹⁶ while Kim, summarizing work on supervenience through the

1970s, says, "the idea that supervenience is a dependency relation has become so firmly entrenched that it has by now acquired the status of virtual analyticity."^{17,18}

However, (DET), the de facto definition of supervenience in most quarters, fails to capture the core metaphysical commitments of ontological dependence. To see this, it will be useful to consider the literature on dependence which has grown out of Edmund Husserl's work in metaphysics from the turn of the nineteenth century. Husserl says, for example, that colors depend on extensions insofar as colors cannot exist without extensions.¹⁹ Or again, tone dependence is taken to have existential commitments: if colors exist, so too must extensions.

Those in the metaphysics literature who discuss dependence typically mean a relation between individuals, whereby if one object exists then so must another. As Peter Simons puts it, ontological dependence is "the inability of an object to exist at all unless another object exists."²⁰ Given Simons' goal, which is to understand the nature of the dependence between the mereological parts of robust individuals (as opposed to arbitrary mereological sums), his formulation makes sense, as does his decision not to discuss dependence relations between quantities or magnitudes (which are plausibly construed as properties of things), an area which he calls "underdeveloped."²¹ But this is precisely what we need.

In the context of supervenience we require a dependence relation between sets of properties, since sets of properties are the relata of the supervenience relation. We do not require that one object's existence implies the existence of another, but rather that an object's instantiating one kind of property implies that it instantiate another kind. A person's instantiating a mental property, the champion of mental-physical dependence might say, implies that person's instantiating a physical property. Or, to mirror Simons' definition, dependence in this sense is "the inability of a property of one sort to be instantiated by an object unless a property of another sort is also instantiated by that object." Formally, *A*-properties depend on *B*-properties iff:

$$(\mathsf{DEP}) \ \forall x \forall X \in \mathbf{A} \ (Xx \to \exists Y \in \mathbf{B} \ (Yx))$$

That is, if an object instantiates an *A*-property it will also instantiate a *B*-property. Assuming mental-physical dependence, for example, the having of a mental state (instantiating an *A*-property) implies the having of a physical state (a *B*-property).²² Note that property dependence, like determination, is asymmetric. That mental states depend on physical states does not entail that physical states depend on mental states: one may (indeed most of us do) hold that all mental states are embodied but that most bodies are mindless.²³

Supervenience as determination (DET) fails to capture both the intuitive content and the core ontological commitment of dependence, insofar as it allows "free floating" supervenient property instances (that is, objects which exemplify a supervenient property but no base property). For example, mental-physical determination can be true in worlds populated merely by Cartesian spirits. To see this, consider a pair of mentallyindiscernible spirits. They are mentally indiscernible by hypothesis and physicallyindiscernible since they both lack physical properties altogether. If these spirits are all that populate a world, then in that world physical-mental determination trivially holds, but mental physical dependence does not.

Thus, (DET) allows possibilities which traditional proponents of supervenience, insofar as they take it to be synonymous with dependence, would presumably resist. It sounds wrong to say that mental states supervene on physical states when mental states can be exemplified by individuals lacking in physical properties altogether. Similarly, one who claimed that effects supervene on causes would not allow uncaused effects; one who claimed that beauty supervenes on physical properties would not allow disembodied pulchritude.²⁴ This suggests that (DET) should be conjoined with (DEP), resulting in a formula equivalent to (S2) above, as we shall see.

This point applies to every form of determination described above; in none of those cases are free-floating supervenient entities ruled out. Consider again our indiscernible ghosts. They clearly show dependence to be lacking in the case of weak determination. Now move one of them to another world (we shall assume, the only other world), where it, like its counterpart, is sole occupant. We now satisfy strong determination, but again, not dependence. We also satisfy global determination as traditionally defined: there is only one bijection ϕ between the domains of the two worlds (each of which contains a single ghost), it is a *B*-isomorphism (neither ghost instantiates any *B*-property so the condition that if *x* has a *B*-property so too must $\phi(x)$ is trivially satisfied), and ϕ is also an *A*-isomorphism, since we are assuming the ghosts are *A*-indiscernible and thus share all *A*-properties. Thus, all *B*-isomorphisms between these worlds are *A*-isomorphisms.

What then of the claim that supervenience relations are dependence relations? The most charitable way to read those who view supervenience as being a dependence relation is that they think of dependence in terms of 'dependent variation,' where variation in *A*-properties 'depends' on variation in *B*-properties.²⁵ 'Dependent variables' are dependent in this sense. In that case, 'dependence' is just a synonym for 'determination' (DET) or 'covariation,' but an unfortunate synonym since, as just discussed, the concept of dependence carries existential commitments which are lost by this usage.

However, I think many who take supervenience to be a dependence relation simply fail to realize that in doing so they are allowing free-floating supervenient property instances. In such cases dependence should be explicitly conjoined with determination.

There are a number of objections one might make to this definition of dependence. The first is that it does not say anything about the relationship between the base and supervenient properties which are co-instantiated in a given individual. Dependence (DEP) only says that any object which instantiates a supervenient property instantiates some base property. However, it is not specified how that base property relates to that supervenient property. For example, (DEP) could be satisfied in a desert world devoid of living beings but replete with "haunted" physical objects. In this world every rock, pebble, and stone is inhabited by a ghost. Thus, for every object with a supervenient property there is some physical property it also has, and so (DEP) is satisfied. But insofar as the world is inhabited by ghosts, it seems wrong to say that mental-physical dependence holds in this world. This is related to what some have called the "problem of extras," which we return to below.

We can address this concern by formulating a variant of dependence; indeed, one advantage of distinguishing determination and dependence is that we can begin to formulate variants of each and use them to address metaphysical issues with greater precision. The most obvious move is to require that the instantiation of the base property which is co-instantiated with a given supervenient property *explains* that supervenient property (we allow that the base or supervenient properties are conjunctive, so that instantiation of a range of base properties—i.e. a single conjunctive base property—is what explains the having of the supervenient property). Let us call this explanatory dependence. *A*-properties explanatorily depend on *B*-properties iff:

(DEP') $\forall x \forall X \in \mathbf{A} \ (Xx \to \exists Y \in \mathbf{B} \ (Yx) \text{ and } x \text{'s having } Y \text{ explains } x \text{'s having } X$)

In the haunted physical world, (DEP) holds but (DEP') does not, since the ghosts inhabit the objects by brute stipulation—there is no explanatory relation between the physical structure of a given rock and the phenomenological structure of the ghost which inhabits it. Note that I shall bracket the issue of explanation, and simply assume that some account of its metaphysical structure can be given²⁶—in fact one's account of explanation can be thought of as a parameter of this relation.²⁷

Another objection to this form of dependence is that it is focused on individuals in a way that makes it impossible to capture the kinds of dependency global supervenience was introduced to capture, namely, cases where a high-level property depends on a widely dispersed collection of objects and properties. For example, being a genuine dollar bill requires more than the right paper and distribution of paint, it requires having been produced in a particular way. It is not hard to modify dependence so that it can capture this kind of dependence. We can describe a variety of dependence whereby if an object in a world has a supervenient property then there exists a collection of objects in that world which have base properties which explain the exemplification of the supervenient property. If an object is a dollar bill then it and certain other objects with certain properties must exist which collectively explain its being a dollar bill. This captures the core notion that high level property instances require some grounding in base level properties and objects.

A final objection to this definition of dependence (DEP) is that it renders mentalphysical dependence–one of its core applications–false, because the things that have mental properties (e.g., whole persons) lack the physical properties posited by physics (spin, charge, charm, etc.), insofar as those properties only apply to elementary particles.²⁸ One immediate response is to invoke the modified form of dependence just introduced, which does not require that *A* and *B* properties be instantiated in the same objects, but allows, in this case, that properties of persons depend on a distribution of fundamental physical properties over the physical particles which that person is made out of. However, let us respond to the objection using our basic dependence (DEP) clause.

Prior to addressing the objection directly, it is worth noting how pervasive its impact would be, if it were taken seriously. It would immediately invalidate supervenience theses of form (S2) above, which obviously involves a dependence claim. It would also render the vast majority of remaining supervenience claims either false or trivially true. For example, most claims of form (S1) above say that all physically indiscernible things are non physically (e.g. mentally or aesthetically or ethically) indiscernible. If the domain comprises fundamental particles, these claims will be trivially true insofar as physically indiscernible fundamental particles lack mental, aesthetic, and ethical properties altogether, and hence are trivially indiscernible. If we allow high level objects into our domain of discourse, then the objects will have a variety of mental, ethical, and aesthetic properties. But the relevant objects (e.g., persons and paintings) will be physically indiscernible insofar as they lack fundamental physical properties. Such supervenience claims will thereby be rendered false.

I think the right response–and the response tacit in most uses of supervenience– is to insist that complex properties constructed from fundamental physical properties are themselves physical properties.²⁹ For example, brain states are complex physical properties which are founded, ultimately, on fundamental physical properties of a brain's elementary particles. A compelling statement of this view is in Hellman and Thomson, who claim, roughly, that properties are "ideologically" physical if they are denoted by predicates all of whose non-logical elements are taken from the class of fundamental physical projectives.³⁰ Given the vocabulary of physics, any property expressed by a predicate all of whose non-logical elements are taken from that vocabulary will itself be physical. For example, a predicate which describes the attributes and relative locations of all the elementary particles comprising a high level object denotes a complex physical properties from aggregates of the same, one can, following Jessica Wilson, distinguish physical from "physically acceptable" properties, where the latter (which include the former) are akin to

the complex physical properties just described.³¹ The base set of relevant dependence relations will then contain physically acceptable properties.

4. Conditional determination and the problem of vacuous indiscernibility

We have seen that determination fails to capture ontological dependence. One way to remedy the problem is to conjoin determination and dependence, which results in something equivalent to (S2) above, as we shall see. But, having dissociated determination and dependence, we will sometimes want to use determination on its own– that is, in contexts where dependence does not hold. This raises its own problems, and motivates the introduction of a new variety of determination, what I call "conditional determination."

Supervenience qua determination, in all its traditional forms, requires individuals (or worlds) lacking in base properties to be indiscernible at the supervenient level. Consider the case of physical-mental determination: things physically indiscernible are mentally indiscernible. Now suppose we have two things lacking in physical properties altogether, which are therefore base indiscernible. By (DET) they will be mentally indiscernible as well. For weak physical-mental determination, this implies that free-floating Cartesian spirits—e.g., angels or ghosts—within such worlds all have the same thoughts. For strong physical-mental determination, this implies that angels between worlds all have the same thoughts. For global physical-mental determination as traditionally defined, this implies that all worlds lacking in physical properties are mentally the same. For example, if the heavens are numerically many, they are qualitatively one—they all have the same number of angels doing the same things in the same ways. Let us call this the problem of vacuous indiscernibility.

We needn't countenance such extravagant possibilities to find this a pressing problem. For example, suppose you believe that brain states determine emotional states, but you also believe that sentient extraterrestrials can have emotions. Then you are forced by (DET) into the position that all sentient extraterrestrials have the very same emotions (assuming they lack brain states). You are clearly better off with the claim that brain states determine emotional states *when the relevant system* has brain states at all.

The case of global determination has already shown us how to handle this: by restricting attention to objects with base properties. *B*-properties conditionally determine *A*-properties iff: $\forall x \forall y$ (($\exists Z_1, Z_2 \in \mathbf{B} (Z_1 x \& Z_2 y)$) $\rightarrow (x =_B y \to x =_A y)$). We can think of conditional determination as saying that *B*-properties determine *A*-properties on the condition that the *B*-properties are instantiated. We can also think of this as determination with a domain (or in the case of weak determination, domains—one for each world) restricted to those individuals which instantiate base properties.

Conditional determination solves the problem of vacuous indiscernibility in all its forms. If brain states conditionally determine mental states then non-neural intelligence can be as varied as the extraterrestrials and machines which support it. If physical states conditionally determine mental states then angels are free to express their boundless variety, both within and between worlds.

No special additions are required for global determination, in light of the modification already introduced above (a kind of conditional determination for worlds), whereby worlds are only taken to be base-indiscernible if there exist a restricted base isomorphism between their objects, that is, an isomorphism restricted to objects with base properties. Since no such isomorphism connects worlds lacking in base property instances altogether, their supervenient property distributions are free to vary. Heavenly diversity is thereby permitted.

5. Determination and dependence, separately and conjoined

We have seen that determination and dependence, though they are often conflated, are distinct. To see this, let us consider cases where determination and dependence separately hold, and the case where both hold.

Tones depend on but are not determined by amplitude. Tones always co-occur with amplitudes (DEP), but a given amplitude does not determine a unique tone (DET). Similarly with color and extension. Colors always co-occur with extensions, but a given extension does not determine a unique color. Many tones can sound at the same amplitude; many colors can fill the same extension. In each of these cases one property must be exemplified if the other is, but the nature of the connection is not deterministic.

Determination can also obtain absent dependence. Amie Thomasson (personal communication) provides another interesting case. On certain theological views, sins are determined by deeds but don't depend on them (owing to original sin, one can have sinned without having done anything). That is, even if it is true that individuals indiscernible with respect to deeds done must be indiscernible with respect to sins committed, it is not the case that anyone who has committed a sin has done some deed. For we are all sinners from the start, or so the story goes. Thus, (DET) without (DEP). If we are use nonconditional determination, this assumes that original sin is the same for all. If we assume instead that deeds conditionally determine sins, then original sin can vary from one deedless agent to the next.

Such dissociations can also be applied to our standard picture of the relation between mental and physical states, allowing us to articulate unusual but logically coherent possibilities. The standard picture is that physical states determine but do not depend on mental states, while mental states depend on but do not determine physical states. That is, physical states are correlated with specific mental states, if they are correlated with any mental state, but can occur without any mental state at all (physicalmental determination but no physical-mental dependence), while mental states always cooccur with some physical state, but which one is not specified (mental-physical dependence but no mental-physical determination). The conjunction of these claims turns out to be equivalent to the supervenience of mental states on physical states. However, each claim can be held independently of the other. One could hold physical-mental determination while denying mental-physical dependence (a kind of partial idealism which allows free-floating Cartesian spirits but requires embodied spirits to obey their physical base), or hold mental-physical dependence while denying physical-mental determination (a kind of indeterminist physicalism in which mental states always come with physical substrates but in which those substrates don't always give rise to the same mental state).

What about determination and dependence together? This is equivalent to the second formulation of supervenience, (S2) above, which can be more precisely defined as follows:

(S2)
$$\forall x \forall X \in \mathbf{A} (Xx \to \exists Y \in \mathbf{B} (Yx \& \forall y (Yy \to Xy)))$$

That is, any individual which instantiates a supervenient property also instantiates a baseproperty such that any individual which has that base property will have that supervenient property. For example, assuming mind brain supervenience, anyone who has some mental state has some brain state, such that anyone in that brain state will be in that mental state. Kim initially took (DET) and (S2) to be equivalent,³² but Van Cleve showed them to be logically independent.³³ Van Cleve did not, however, show how they relate to each other.

Assuming maximal properties (see note 13), (S2) is equivalent to (DET) and (DEP). PROOF. ((DET) and (DEP)) \rightarrow (S2): Consider an arbitrary individual *c* and property A₁ \in **A** such that A₁*c*. By (DEP) there exists a B₁ \in **B** such that B₁*c*. If *c* instantiates B₁, it also instantiates a maximal property in **B**, call it B^M. Now consider an arbitrary *d* such that B^M *d*. Since B^M is a maximal property, *c* and *d* are *B*-indiscernible. Then by (DET) *c* and *d* are *A*-indiscernible. So A₁*d*. (S2) \rightarrow ((DET) and (DEP)): Consider an arbitrary individual *c* and property A₁ \in **A** such that A₁*c*. Then by (S) there exists a *B* such that *Bc*. So we have (DEP). To see that (DET) is entailed, deny it, so that *B*-properties don't determine *A*-properties. Consider two individuals *c* and *d* that are *B*indiscernible but not *A*-indiscernible, so that, for example, A₁*c* and ~A₁*d*. Focusing on A₁*c*, by (S2) there is a B₁ such that B₁*c* and all *y* which are B₁ are A₁. Since *c* and *d* are *B*indiscernible, we have B₁*d*. And since all *y* which are B₁ are A₁, we have A₁*d*. Contradiction.

Insofar as (S1) and (S2) are the main forms of definition in the supervenience literature, we have shown how all major forms of supervenience can be characterized relative to determination and dependence. (S1) just is (DET), while (S2) is the conjunction of (DET) and (DEP). In many cases the conjunctive form of (S2)—(DET) and (DEP)—is preferable to (S2) itself. The conjunctive form makes the constituent structure of this form of supervenience explicit, which in turn facilitates more finely tuned applications. For example, rather than trying to tune the modal parameters of (S2) directly—thereby influencing both the determination and dependence components simultaneously—we can separately vary the modal (and other) parameters of each relation

6. The problem of extras

Let us now apply these distinctions to a problem in the physicalism literature—the "problem of extras." The problem is as follows. Physicalism requires that worlds (in some suitable class of worlds, e.g. physically possible worlds) physically indiscernible from the actual world be non-physically the same, but for the addition of "extra" non-physical beings, e.g. ghosts and angels. As Frank Jackson says: "physicalists are typically happy to grant that there is a possible world physically exactly like ours but which contains as an addition a lot of mental life sustained in nonmaterial stuff."³⁴ But global supervenience kills the ghosts and angels, since it requires that worlds physically indiscernible from the actual world (where, we assume, there are no such beings) be nonphysically indiscernible as well. Thus global determination is too strong to capture physicalism.

We can capture this version of physicalism by separately specifying determination and dependence clauses. In particular, we conjoin a "minimal" form of determination across possible worlds with explanatory dependence in the actual world. We begin by characterizing the problem of extras more precisely. Witmer, in the most detailed statement of the problem to date, parses it into two: the problem of extra individuals and the problem of extra properties.³⁵

The problem of extra individuals arises as follows. Take a world physically indiscernible from our own and add an extra individual, say, a happy ghost. This world is physically indiscernible from our own, but it is not mentally indiscernible (there is more happiness in the extras world). Global supervenience as traditionally defined–worlds physically the same are non-physically the same–seems to rule this possibility out and thereby fail as a formulation of physicalism. Witmer solves the problem on a technicality. Thanks to the extra happy ghost, there is no onto function from our world to the extras world, so there is no base isomorphism from the actual world to the extras world. It is not, therefore, considered to be "physically indiscernible" from the actual world, and the problem is solved: the extra ghost is permitted.

Clearly this is not an optimal solution, for it violates our metaphysical intuitions. It works by treating our world and the extras world as physically distinct, though they are, by hypothesis, physically the same. Moreover, as we have seen, unrestricted property isomorphisms allow worlds that are indiscernible but for objects without base properties (that is, "extra individuals") to be discernible at the supervenient level. So, in this case, a single extra ghost shows up on a world just like ours and the rest of the mentality in that world detaches from its physical grounding and can freely vary.

A better solution to the problem of extra individals is to take advantage of our revised, conditional form of global determination, which uses restricted base isomorphisms. That we draw on a conditional form of determination should not be surprising, for this form was introduced precisely to deal with cases where determination needs to be specified independently of dependence. Recall: *B*-properties globally determine *A*-properties, on the conditional definition, if and only if for any pair of worlds, any *B*-isomorphism between their *B*-objects is a supervenient isomorphism. Thus, the extras world *is* considered to be physically indiscernible from our own. The extra ghost is ignored, since it does not fall within the purview of the isomorphism, which is restricted to objects with base properties. Moreover, non-physical properties are distributed over the rest of the objects in the extras world in the same way as they are in the actual world, as any physicalist would expect.

The problem of extra-properties is as follows. We again imagine a world just like ours. This time, rather than adding an extra object with non-physical properties, we add extra non-physical properties to a physical object already in our world. We allow that spirits have haunted, e.g., my big toe, or a cactus in my garden. Again, we have a world physically indiscernible from our own but non-physically discernible from it. So what is taken to be a physicalistically acceptable situation is again ruled out by global supervenience. Witmer solves the problem by a variation on a theme introduced by Jackson: he says that physicalism restricts attention to worlds which are "minimal physical duplicates of our own," which on Witmer's recasting means that worlds physically indiscernible from the actual world have "at least" the same non-physical property distribution as the actual world does, but are free to also have extra non-physical properties.³⁶

Although I like the appeal to an "at least" clause, this solution has two problems. First, the "at least" clause is left intuitive. Second, and more seriously, the solution (both in Witmer and in his predecessors) is tied to the actual world and its minimal duplicates. In the vast space of possible worlds only a tiny subset are addressed. Thus, the actualworld based formulation of physicalism allows that non-actual worlds can be physically the same but arbitrarily different non-physically. This in turn violates determination (DET), a core physicalist intuition, and an essential component of supervenience, as we have seen. We can do better by formulating physicalism using specific varieties of determination and dependence.

We begin by noting that indiscernibility is an equivalence relation on possible worlds. We can partition possible worlds into equivalence classes consisting of worlds that are base indiscernible, in this case physically indiscernible. I shall call collections of base-indiscernible worlds "base classes." We use restricted base isomorphisms to define indiscernibility (e.g., two words are physically indiscernible if there is a property isomorphism between the *physical objects* of those worlds). Thus all the worlds in a physical base class will be physically the same, but may have "extra" non-physical individuals.

For each base class we assert that there is at least one world in which nonphysical–physical explanatory dependence (DEP') holds. In these worlds everything nonphysical has some physical explanation, some grounding in physical objects. Emergentism is ruled out, as are "extra-properties." It is a general claim of the physicalism literature that the actual world is one of these worlds. This is the dependence component of physicalism. Everything non-physical is grounded in something physical, in the actual world, and, we add, in at least one world of every class of physically indiscernible worlds. We now specify a determination clause. This clause should say, roughly, that any distribution of physical properties over the objects of a world determines a minimum distribution of non-physical properties over those objects (namely, we shall see, those required at an explanatory minimum), though there may be additional, extra properties as well. To capture this idea, we define a new a variant of determination, "minimal determination." Minimal determination says that for any base class of worlds there is at least one "minimal world" and that the supervenient properties of these minimal worlds can be "overlaid" on all the worlds of their base class. Let us make this precise.

To make the concept of an "overlay" precise we use a variant of property isomorphism which is structure preserving in one direction but not the other. I call this an overlay. The concept of an overlay is easily illustrated by an example from graph theory:



Graph *A* can be "overlaid" on graph *B* in that there is a 1-1 and onto function between the vertices of *A* and *B* such that any relation which applies to the vertices of *A* applies to their images under that function.³⁷ This implies that *B* has "at least" as many edges as *A*, though it allows that it can have extra edges. Similarly with worlds. World *w*' has "at least" the same supervenient properties as *w* if there is an overlay from *w* to *w*', that is, a bijection ϕ from *w* to *w*' such that an *n*-ary base relation applies to an *n*-tuple (*x*₁,...,*x*_n) of objects in *w* only if it applies to ($\phi(x_1), \dots, \phi(x_n)$) in *w*'. In other words, *w*' must have all the properties and relations *w* has, but it can also have extra-properties and relations which *w* lacks.

Minimal global determination is then the claim that for all worlds w_i , w_j , if there exists a base isomorphism between w_i and w_j , then any isomorphism from the minimal world of their base class to w_i or w_j , is also supervenient overlay (there may be multiple minimal worlds but for rhetorical convenience we refer to "the" minimal world). That is, all the worlds in a base class are such that the minimal world of that class can be supervenient overlaid on them. Roughly, we have classes of worlds that are the same in terms of base properties, and which share a core set of minimal supervenient properties.

In the context of physicalism we stipulate that the minimal supervenient world of a base class is one in which explanatory dependence holds. If two worlds are physically the same then the world in their base class in which explanatory dependence holds can be supervenient overlaid on them.³⁸ This implies that worlds have those non-physical properties required, at an explanatory minimum, by their physical properties.

Physicalism, then, can be expressed as follows: (1) for at least one world in each base class—the minimal world of that class—explanatory dependence holds: everything non-physical has some physical grounding. We assume that the actual world is the minimal world of its base class. (2) physical properties minimally determine non-physical properties in all possible worlds, in that base indiscernible worlds are such that the minimal world of their base class can be supervenient overlaid on them. That is, for all physically indiscernible worlds w_i , w_j , any isomorphism from the minimal world of their base class to them is also a non-physical overlay.

This conjunction of specific forms of determination and dependence solves both problems of extras. The explanatory dependence clause rules out extra individuals or properties in the actual world: any object in the actual world which has a non-physical property has a physical property—thus no extra individuals. An object's instantiation of a non-physical property is always explained by its instantiation of a physical property—thus no extra properties. The minimal determination clause ensures that all worlds physically indiscernible from the actual world will have "at least" the same non-physical properties as the actual world, but allows both for extra individuals and properties. Since it assumes physical isomorphisms are restricted to physical objects, it does not rule out extra individuals in non-actual worlds. Since it only assumes supervenient overlays from the actual world to non-actual worlds, it does not rule out extra-properties in non-actual worlds.

This solution to the problem of extra-properties does the same work as Witmer's and Jackson's solution, but the "at least" clause is more precisely specified and the solution covers physical variations on the actual world. *All* physically possible worlds generate some explanatorily basic distribution of non-physical properties, though nonminimal worlds may have extra-properties and individuals as well. This solution has other benefits. First, rather than separately solving the problems of extras and individuals in an *ad hoc* way, we are solving both problems at once using independently motivated ontological tools. Second, the tools used here have been shown to be more metaphysically satisfying than the traditional alternatives. For example, we are not forced into the awkward position of a treating a world just like ours but for the addition of an extra ghost as being physically different from our world. Third, this solution is considerably more flexible than previous solutions. In particular, we can separately tune the parameters of the determination and dependence components. We could, for example, allow minimal worlds to simply be those worlds in a given base class with the fewest supervenient property instances, and dispense with explanatory dependence. Or, we could independently vary the modal scope of the two relations, allowing explanatory dependence a wider or narrower range than minimal determination. Finally, this solution highlights more of the metaphysical structure of physicalism than is otherwise apparent. We see that, on the conception of physicalism implied by recent discussions, physically possible worlds are partitioned into classes of worlds which are physically the same and non-physically overlapping, but capable of arbitrary variation otherwise.

More work remains to be done. For example, relations between physically discernible worlds have not been addressed at all. In particular, I have not specified how degree of physical similarity across worlds tracks degree of non-physical similarity. For example, it is consistent with the formulation above that a world just like ours but for the permutation of a few particles can be, non-physically, as radically *un*-like ours as one pleases (e.g. it could have no mentality at all). To capture the intuition that physically similar worlds (minimally) determine non-physically similar worlds, it is helpful to conceive of the set of possible worlds as a space, and to draw on a variant of similarity based determination³⁹ to show how degree of change non-physically is proportional to degree of change physically.⁴⁰

My point has not been to endorse this particular view of physicalism, but rather to show that we need finer grained tools than supervenience *simpliciter* to be able to articulate this view (and its variants) at all. I believe something similar will turn out to be the case in other contexts in which supervenience is deployed.⁴¹

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³ For convenience, I refer to the "base" and "supervenient" sets of properties for determination and dependence relations, even though both relations are distinct from supervenience. In other contexts it might be useful to name the relevant sets of properties differently, e.g. "determined" vs. "determining" properties, or "dependent" vs. "founding" properties.

⁴ Based on considerations similar to the ones I put forward in what follows, Grimes (1991) introduces two new concepts of supervenience, one each for determination and dependence. Grimes' formulations are different from my own, however, and whereas Grimes thinks of determination and dependence as types of supervenience, I think of existing concepts of supervenience as either being determination relations or determination relations conjoined with dependence relations.

⁵ I call these "forms" of supervenience because each comes in several varieties, in particular modal varieties ("strong" and "weak") which are distinguished by the number and placement of quantifiers over possible worlds or necessity operators.

⁶ McLaughlin (1995, p. 16).

⁷ Kim (1987, p. 316).

⁸ See Horgan (1993) for historical discussion and references.

⁹ See Davidson (1980, p. 214).

¹⁰ Compare Hellman and Thomson (1977).

¹¹ Proof of this entailment, and extensive discussion, is in my (in progress) "Mapping Supervenience."

¹² Actually, all that is required is that we focus on sets of properties which are mutually exclusive in that objects never exemplify more than one property in such a set at a time. Elsewhere I call sets of properties which meet this condition sets of "states." Maximal properties, discussed below, provide a way of converting arbitrary sets of properties into sets of states.

¹³ Cf. Kim (1984, p. 158). For example, if we have two atomic properties (properties not formed from other properties) B_1 and B_2 in a set **B** of properties, then the maximal properties in that set will be $B_1 \& \sim B_2$, $\sim B_1 \& B_2$, and $B_1 \& B_2$. $\sim B_1 \& \sim B_2$ not in the set because it is a negative property.

¹⁴ See Stalnaker (1996), Sider (1999), Bennett (2004), and McLaughlin and Bennett (2005). Strong, intermediate and weak varieties of global supervenience are sometimes distinguished. What is described here corresponds to "strong" global supervenience. Also note that I use phrases of the form "*X*-isomorphism" as shorthand for "*X*-preserving isomorphism."

¹⁵ Notice that I only apply the restriction to the base isomorphism. The reason is that we assume there can be many objects which possess base properties but not supervenient properties, e.g. unconscious rocks and rivers (for the case of physical-mental determination). In such a case restricted physical isomorphisms will *not* be restricted mental isomorphisms, for the bijections will apply to some objects *without* mental properties. However, mental indiscernibility still follows, assuming that every object with a mental property has a physical property (I call this "dependence" below). To show this, we further restrict the physical isomorphism to objects with mental properties, and

¹ See Horgan (1993).

² See Witmer (1999).

thereby secure a restricted supervenient isomorphism which satisfies our revised definition of indiscernibility.

¹⁶ Davidson (1980, p. 214).

¹⁷ Kim (1993, p. 139).

¹⁸ There have been various explicit discussions of dependence in the supervenience literature. Recently, Karen Bennett and Brian McLaughlin (2005) have read dependence as being a kind of "in virtue of" relation which is irreflexive and assymetrical. Kim (1993) defines dependence to be assymetrical supervenience. I do not think dependence should be thought of in these ways: colors and extensions, for example, are co-dependent, and neither is "prior to" or "in virtue of" the other.

¹⁹ See Husserl (1978), especially Investigation III, section 4 and following.

²⁰ Simons (1987, p. 254).

²¹ Simons (1987, p. 294).

²² Van Cleve (1990) is one of the few who describe this relation explicitly. He puts it in terms of the "slogan," "No *A*-properties without *B*-properties" (or, "Every *A*-property, some *B*-property" (p. 226).

²³ If one insists on being a pan-psychist then (DEP) provides a convenient way to express the view: namely, by the claim that physical properties depend on mental properties.
²⁴ The point is recognized in the literature. See, e.g., Grimes (1991, pp. 83-84), and McLaughlin (1995, pp. 27-28).

²⁵ See McLaughlin (1995, p. 18).

²⁶ For example, in terms of identity of underlying causal powers. See Wilson (1999).

²⁷ Some accounts of explanation may be such that *anything* which instantiates the base property will instantiate the explained supervenient property. This in turn generates (S2) above, which we shall see is equivalent to the conjunction of (DET) and (DEP). One might in such cases prefer to dispense with (DEP') in favor of the conjunction of (DET) and (DEP), especially if (S2) is *all* explanation is taken to amount to. However, it still may be useful to separately tune the parameters of (DET) and (DEP).

²⁸ Thanks to an anonymous referee for posing this objection.

²⁹ On property composition and issues related to it see, e.g., Bigelow and Robert Pargetter (1989) and Armstrong (1989).

 30 I say this is "roughly" what Hellman and Thompson claim because I have made some slight alterations to their definition. What they say is this: "given a certain vocabulary ϕ , we can regard any attribute expressed by a predicate with essential occurrences of members of ϕ as a ϕ -attribute" (1977, p. 316). However, as an anonymous referee pointed out, this allows such predicates as "being happy or having negative charge" to be physical.

³¹ Wilson (2005).

³² More specifically, weak supervenience of the first kind was taken to be equivalent to weak supervenience of the second kind, and strong supervenience of the first kind was taken to be equivalent to strong supervenience of the second kind. See Kim (1987). ³³ Kim (1987).

³⁴ Jackson (1993, p. 28).

³⁵ Witmer (1999).

³⁶ Witmer also introduces conditions which ensure that extra-properties don't conflict with properties already exemplified in a world (e.g., adding the property "is the happiest

being" to one object in a world could make some other object cease to have that property.) This highlights the fact that one cannot arbitrarily add extras, but must do so in a manner which preserves the basic property distribution of a given world. I shall assume that such conditions hold in what follows.

³⁷ More formally: let there be sets *X* and *Y*, let *X* have an *n*-ary relation *R*, and *Y* have an *n*-ary relation *S*, and $\phi: X \to Y$ be a bijection. We further require that ϕ satisfies the following condition: for any $(x_1,...,x_n) \in R$, it is the case that $(\phi(x_1), ..., \phi(x_n)) \in S$. This makes ϕ an "overlay," and *X* can be overlaid on *Y* via ϕ . In the example above there is a bijection from the vertices of *A* to the vertices of *B*, such that if vertices *v*, *v'* of *A* are connected by an edge then vertices $\phi(v), \phi(v')$ of *B* are as well. Thus, graph *A* can be overlaid on *B*.

³⁸ An alternative strategy would be to define the minimal worlds as those with the fewest supervenient property instances in a base class. This could then be used to define explanatory dependence.

³⁹ On similarly-based supervenience, see McLaughlin (1995, p. 34).

⁴⁰ Steps in this direction are taken in my "Mapping Supervenience."

⁴¹ I am grateful to Jonathan Cohen, Christopher Hom, Scott Hotton, Amie Thomasson, Jessica Wilson, and two anonymous referees for helpful comments and critique.

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