

Zeno Objects and Supervenience

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1. Introduction

Many philosophers accept a 'layered' world-view according to which the facts about the higher ontological levels supervene on the facts about the lower levels. Advocates of such views often have in mind a version of atomism, according to which there is a fundamental level of indivisible objects known as *simples* or *atoms* upon whose spatiotemporal locations and intrinsic properties everything at the higher levels supervenes.¹ Some, however, accept the possibility of 'gunk' worlds in which there are parts 'all the way down' such that there are no simples and insofar as composite objects exist these are composed of smaller objects which in turn are composed of smaller objects, and so on. It may nonetheless still be claimed that the facts about each ontological level supervene on the facts about the lower levels.

But do the lower-level facts *necessitate* all of the higher-level facts, such that any two worlds identical with respect to the lower-level facts are identical with respect to the higher-level facts? At a more local level, is it a necessary truth that the properties of a composite object supervene on the properties of its parts?² I shall argue that the answer to both questions is 'no' because there are possible objects whose properties do not supervene on the properties of their parts (or on any other low-level facts). I shall

¹ Normally the laws of nature are also included in the supervenience base, though the supervenience is only of an interesting form if the laws do not explicitly relate lower and higher levels.

² For simplicity, throughout this paper when I speak of parts I mean proper parts and when I speak of properties I mean intrinsic properties plus spatiotemporal locations unless stated otherwise. I shall assume that colours are intrinsic properties, though I argue below that it makes only minor differences to my overall claims if they are extrinsic properties. I take it however that any interesting supervenience claim must exclude properties such as 'being a part of a composite object that has such-and-such properties' from the supervenience base.

demonstrate this by describing a composite object that consists of nothing but a spatial arrangement of atoms each of which is blue all over, yet the object is red all over and could have been any colour whatsoever. The facts about the atoms thus fail to determine the facts about the composite object they compose. There may well be other counterexamples to supervenience involving more contentious phenomena such as quantum entanglement.³ But none that I have heard strike me as so straightforwardly demonstrable as the phenomenon that I shall describe.

I start by describing the object. Then in section 3 I explain why the object has the properties that I claim it has. Finally in section 4 I make some brief remarks about the significance of such objects.

2. *The object*

The object is what I shall call a *Zeno object*, for reasons that I hope will be apparent from its description. It is spherical and has an onion-like structure. More precisely, it consists of a solid central sphere surrounded by an infinite number of concentric spherical layers with no outermost layer. There are gaps between the layers, though this is probably inessential. The lack of an outermost layer results from the fact that the layers are arranged in a Zeno series; that is to say, the successive thicknesses of the layers starting from the centre form an infinite decreasing series whose sum tends to a finite limit. The gaps between the successive layers also decrease in thickness in the same way, each gap being exactly as thick as the layer it surrounds. Suppose the parts are numbered, starting from 1 at the centre. Then for any n , part number n has a thickness of 2^{-n} and is followed by a gap of the same thickness. Thus in the centre, part number 1 is a solid sphere of radius one-half unit. Outside this is a gap of thickness one-half unit. There then follow alternating concentric spherical layers and gaps of thicknesses $\frac{1}{4}$, $\frac{1}{4}$, $\frac{1}{8}$, $\frac{1}{8}$... and so on to infinity. The composite sphere has a radius of two units.

³ This paper was partly inspired by hearing talks by Jonathan Schaffer and Elizabeth Barnes concerning such putative 'emergent' phenomena.

I shall mainly discuss an object whose layers are atoms. Strictly speaking, however, this is inessential; the layers could themselves have been composite without thereby changing anything important in the argument that follows. This would remain true even if the layers were made of gunk; such objects would still present counterexamples to necessary supervenience between layers. I take it, however, that the breakdown of supervenience is most striking when it concerns an object that is nothing more than a spatial arrangement of atoms, and I shall concentrate on the atomic case for that reason.

By stipulation, each of the layers is blue all over. There are, of course, worlds in which objects change colour when placed in close proximity to one another, but I stipulate that this is not the case here – the parts remain blue when composing the object. I shall argue, however, that the whole sphere need not be blue; it could be any colour whatsoever, say red. More generally, for any two colours C_1 and C_2 there is a world containing an object with parts that have colour C_1 all over and are otherwise exactly as described above yet the object they compose has colour C_2 all over. In fact the object need not even be a uniform colour; it could be striped, polka dot, tartan or anything else, regardless of the colours of the parts. There are also individual worlds containing two objects qualitatively identical with respect to their parts, as described above, yet the objects differ from one another in colour.⁴

⁴ I do not claim that supervenience breaks down with respect to *every* set of proper parts. Given a fairly unrestricted mereology the proper parts of the Zeno object include some composite objects that are themselves Zeno objects and which necessarily share their colours with the whole object (the entire object minus the central part, for example). It is the *atoms* upon which the properties of the Zeno object fail to supervene, or the composite structural equivalents of the atoms in non-atomic (e.g. gunk) cases. All talk of parts should be read accordingly in what follows. Where the relevant parts are composite they could, however, be Zeno objects; in which case there could for example be a red Zeno object made of blue Zeno objects which are made of yellow Zeno objects, and so on, perhaps indefinitely.

3. *The argument*

One way to put the argument, in brief, is that because the object has no outer part its outer surface is not identical with the surface of any of its parts. Consequently not all of the surface properties of the object are determined by the surface properties of its parts.

An analogy will help make this clearer. Consider the well-known case of Thomson's (1954) lamp. This lamp has a toggle button such that if the lamp is *on* pressing the button will switch it *off* and if the lamp is *off* pressing the button will switch it *on*. Until one second before time t the lamp is off; one second before time t the button is pressed. It is pressed again half a second before t , again one quarter of a second before t , and so on. At time t the button has been pressed infinitely many times. But is the lamp on or off at t ?

Thomson argued that the scenario showed that there was something contradictory about the idea of performing a supertask (i.e. completing an infinite number of tasks). But Paul Benacerraf (1962) showed to most philosophers' satisfaction that Thomson's argument is unsound. The correct thing to say about the Thomson lamp is that nothing about the specified state of the world prior to time t is sufficient to determine what the world is like at time t . Consequently in some worlds at t the lamp would be on, in others it would be off; indeed some pairs of worlds differ from each other in no other respect than this. Moreover, as far as *metaphysics alone* is concerned any consistently specifiable state of the world can follow any other; consequently as far as metaphysics is concerned any state of affairs whatsoever could obtain at t . Now, within a given world there may be laws of nature that constrain possible sequences of events and perhaps in some cases the constraints are such that the only possible states of affairs at t are that the lamp is on or the lamp is off. But there are other worlds differing in their laws of nature but otherwise identical prior to t where at t the lamp ceases to exist, or turns into a frog, or whatever else one can dream of happens.

The argument for non-supervening Zeno objects takes the moral of Thomson's lamp from the temporal case and applies it in modified form to an analogous spatial case. Consider another Zeno object just like one described above except that although the innermost part is blue the next layer is red and thereafter the layers alternate between

blue and red. Think of these as corresponding to the on/off states of Thomson's lamp. What colour is the object? With Thomson's lamp because there is no last press of the button the states of the lamp prior to t fail to determine the state of the lamp at t . In a roughly similar way because the Zeno object has no outermost layer the surface properties of the inner layers fail to determine all the surface properties of the object.

One might nonetheless be tempted to think that the Zeno object just described must at least be either blue or red, not some other colour, or one might at least claim that this is true in the closest possible worlds. Even if this were true the failure of the colours of the parts to determine the colour of the whole would still constitute a counterexample to necessary supervenience. But it is not true; the Zeno object can be any colour whatsoever, even in the closest worlds in which such objects exist.

To see why this stronger claim is true consider a disanalogy between Zeno objects and Thomson's lamp. Given the conservation and other laws obtaining in close worlds Thomson's lamp typically has a time-slice *at* t , not just at times *prior* to t .⁵ This is why we find it natural to think that at t the lamp must be on or off; in closer worlds it still exists at t and in the closest worlds in which it still exists it is sufficiently unchanged in its form that it must be either on or off. So in such worlds the two possible states of the lamp prior to t carry over into the same two possible states of the lamp *at* t . Most laws of nature, however, are temporal – they say something about the state of the world at t_1 given the state it was in at t_0 . But in worlds close to actuality there are no equivalent laws that hold across space (at a single time); the fact that a given state of affairs obtains at points to one side of a line L does not in itself tell us *anything* about the state of affairs *at* line L , or on the other side of it.

Consequently even in the closest Zeno object worlds there is no implication, parallel to that in the Thomson Lamp case, from the fact that the internal parts of the Zeno object alternate blue-red to the conclusion that the object is either blue or red. Similarly, the fact that the first Zeno object's parts are all blue does not imply that the object is blue. The colour of the object is entirely undetermined by the colours of its parts even in the closest worlds in which such objects exist.

⁵ I intend the expression 'time-slice' as neutral between the various theories of persistence (endurantism, perdurantism, stage theory etc.)

José Benardete, whose book (1964) inspired much of the recent resurgence of interest in Zeno-related phenomena, discussed objects similar to the Zeno objects described above but was mistaken in what he wrote about their appearances. Benardete claimed (1964: 257) that such objects would be, in a certain sense, invisible, although detectable through vision as a sort of ‘gap’ in what is seen. He appears to have held this view for the reason that since such objects have no outermost part, with each part being hidden from view by the part in front of it, there is simply nothing to see. But this is clearly false; although no proper part of the object can be seen, *the object itself* (the fusion of the parts) might well be visible.⁶

Whether something is visible depends on whether and how it reflects light; and what colour it is depends on what colour of light it reflects. It may be that in the worlds in which Zeno objects exist matter must have a rather different nature than in the actual world; and similarly what one might call ‘light’ might not be the same light that exists in the actual world. This is unimportant; in many worlds there could be something-or-other whose nature is modified by reflection from an object in such a way as to affect the sensory organs of the inhabitants of that world in such a way as to produce corresponding sensations constituting what we might as well call colour vision. It doesn’t matter whether this is really *colour* or *light* (as in the actual world); all that is needed here is a property of an object that does not supervene on the properties of its parts. An object that reflects ‘light’ in one way differs in its causal powers from an object that reflects ‘light’ in a different way; and if it can be shown that these causal powers are not determined by the properties of the object’s parts then we have a counterexample to supervenience. Nevertheless, since it is harmless, I shall continue to talk of light and colour.

So what happens when light strikes a Zeno object? It does not strike any atomic part of the object because there is no outermost part. Consider a spherical region R of point-thickness precisely two units from the centre of the spherical Zeno object. Between R and every point closer to the centre there are an infinite number of spherical layers. But

⁶ In his article on Benardete’s puzzle cases John Hawthorne (2000) makes a broadly analogous point in arguing that a whole object (in this case the fusion of an infinite series of walls) can arrest the motion of a ball that strikes it even though the ball does not strike any of its atomic parts (i.e. the individual walls).

at R there is nothing. So the Zeno object does not occupy R, but occupies every point within R. It thus has a topologically *open* surface – a surface with no outermost layer of points. Light *reaches* R but cannot proceed to any point *beyond* R. Light thus strikes the open surface of the object but does not thereby strike the surface of any atomic part of the object. That is why the properties of the parts do not determine what happens when light strikes the object. It is not the fact that a Zeno object has a topologically open surface that makes it a counterexample to supervenience. There could be a finite composite whose atomic outermost part had a topologically open outer surface; yet the colour of the object would necessarily be identical to the colour of the outer surface of the outermost part because the surfaces of the two would be identical.

Nevertheless, *something* must happen when light is shone on the Zeno object; and thus the object cannot just *lack* surface properties. If the light is not reflected the object will appear black and if the light is reflected then the object will appear a colour corresponding to the colour of the reflected light. All of these are possible, and there do not seem to be any other possibilities. So the whole object has reflectance properties that vary from one world to another; which, given our loose use of the word ‘colour’, means that the colour of the object varies from one world to another, and does so independently of the properties of its parts.⁷

I shall now consider some possible objections. Someone might object that the Zeno object has *no* colour, on the grounds that colour is a surface property yet the whole object has no outer surface.⁸ Hence there would be no failure of supervenience. Even if one were to put matters this way, however, it would still be the case that the object has causal powers (and thus, I take it, a property of some sort) that do not supervene on the properties of its parts, so it would still constitute a counterexample to supervenience between ontological levels. I think it far better, however, to say either that a Zeno object *does* have a surface (which is topologically open and not identical with the surface of any part), or else accept that such objects show that colour can be a

⁷ I am assuming that such an object can reflect light of a specific wavelength in a way that is not merely random; in some worlds for example there may be a law of nature according to which light reflects in one way rather than another from a Zeno object of a given specification. I see no reason to rule out such laws.

⁸ My thanks to Jonathan Schaffer for raising this issue.

property of objects rather than surfaces. I can see no motivation for rejecting both alternatives.

A further worry might be raised as to whether colour is an *intrinsic* property and, if not, whether this creates problems for my argument due to the fact that I have so far tended to state the supervenience claims that I am challenging in terms of intrinsic properties and local supervenience.⁹ My answer is that if colour is not an intrinsic property then my thesis regarding part-whole relations in objects must be restated slightly, but this will make no difference to the status of Zeno objects as counterexamples to the more general thesis of necessary inter-level supervenience. If higher-level facts necessarily supervene on the totality of lower-level facts (i.e. global supervenience) then on any view of the metaphysics of colour the colour of a composite object supervenes on the totality of lower-level facts. But Zeno objects show that this global supervenience fails; for there are at least some worlds in which the totality of lower-level facts fails to determine the colour of the object (consider for example a world containing a Zeno object and nothing else). Even if it could be shown that there are *some* worlds in which the totality of lower-level facts fixes the colour of a Zeno object this would only be a result of the contingencies of those worlds and would not show that the lower-level facts *necessitate* the higher-level facts.

Suppose, for example, that colours are dispositions to reflect specific wavelengths of light. Then it might be argued that colours are not intrinsic properties on the grounds that the laws of nature might make a difference to which wavelengths of light are reflected by an object with a given set of intrinsic properties. We could even suppose that in some worlds the reflective dispositions of a simple object are a function of its intrinsic properties and its spatiotemporal relations to other objects. Let us grant all this for the sake of argument. Then we should not expect the colour of a composite object to necessarily supervene on the intrinsic properties of its parts. Nonetheless we might still have expected that there would be no two worlds alike with respect to the totality of lower-level facts that were not alike with respect to higher-level facts. But this is shown to be false by any pair of worlds that are identical with respect to lower-level facts but which contain differently coloured Zeno objects.

⁹ My thanks to an anonymous referee for raising this issue.

Moreover, even those who think that colours are extrinsic properties would normally still have expected the colour of an object to supervene (locally) on the colours of its parts (and their spatiotemporal configuration). For the natural thought seems to be that no matter what extrinsic factors go into determining the colours of the parts, once the configuration and colours of the parts are fixed the colour of the whole is fixed. But Zeno objects show that this is false, for if the higher-level facts are not fixed by *all* of the lower-level facts then they cannot be fixed by only *some* of them. So some properties of a Zeno object fail to supervene on the properties of its parts in an unexpected way even if the colour properties in question turn out to be extrinsic.

What if instead colours are categorical grounds of dispositions to reflect light? Colours would be intrinsic properties; but would the differing reflective dispositions of different Zeno objects show that they also differed with respect to their categorical properties?¹⁰ Even if not, there would still be higher-level facts concerning dispositions not determined by lower-level facts, so my more general claims would be unaffected. But if categorical properties are to *ground* dispositions then presumably, given the laws of nature, fixing the categorical property fixes the disposition. Consequently in nomologically identical worlds (or within a single world) difference of disposition should imply difference of categorical property. Hence, once the relevant laws are fixed, Zeno objects that reflect different wavelengths are indeed different colours. Perhaps worries about categorical grounds might go together with a worry that since the surface of the Zeno object is not the surface of any of its non-Zeno parts there is nothing there to ground any disposition that the Zeno object is claimed to have. But this begs the question; Zeno objects have properties such as size and shape so why could they not have other properties of the kind possessed by their non-Zeno parts, including whatever grounds reflective dispositions?

Finally, in case it should be wondered what makes it the case that the atoms are blue once comprising a Zeno object, given that each of them is shielded from view by the next one outwards, one could verify their colour by making a hole from the outer surface of the object through to the centre and looking inside (or by looking through arbitrarily thin fibre-optic cables fed between the layers). One would see blue light

¹⁰ My thanks to an anonymous referee for raising this issue.

reflected from each layer. In any case, it is not essential that the atoms be shielded from external light sources. A cubic Zeno object could, for example, be constructed from an infinite number of flat, square sheets with no last sheet on one face of the cube (cf. Benardete's (1964: 236–37) example of a book with no last page). The colour of each atomic sheet could be seen to be blue by looking at the cube from a suitable angle; but the face of the cube with no outer sheet could reflect light of any colour.

Although I have only discussed colour, examples of supervenience failure can be found along similar lines for various other surface properties. I leave it open, however, whether similar examples can be found for *all* surface properties. Moreover it is not clear that similar counterexamples can be constructed for properties other than surface properties (there seems to be no corresponding breakdown of supervenience for mass, for example).

4. Consequences

The properties of Zeno objects do not merely *differ* in surprising ways from the properties of their parts. What is important is the failure of supervenience.¹¹ What follows from this for broader metaphysical issues depends on what other assumptions are made. I shall not attempt a lengthy discussion here but I shall make a few very brief remarks.

Firstly consider atomism, the view that all of the facts about the world are, or supervene upon, the facts about the atoms. I have already argued that this kind of atomism is at most contingently true. More generally, the 'layered' conception of reality of which atomism is an example, according to which all higher-level facts supervene on lower-level facts, is similarly shown to be at most contingently true.

This is not to deny the possibility of ontological levels, however. On the contrary consider, secondly, *mereological nihilism*, the view that necessarily only the atoms exist. I offer no knock-down arguments against nihilism, but I do suggest that nihilism seems

¹¹ The phenomenon described here is thus quite different from the non-stick object composed of stick-able parts described in Prosser 2006.

less plausible once atomism is rejected. The possibility of irreducibly (i.e. non-supervening) higher-level facts seems to fit more naturally with the view that higher ontological levels need be no less fundamental than the atomic level. One might for example find it prima facie plausible that where there is an irreducible instantiation of a colour property there is an object that instantiates the colour (this is not to deny that some properties can be instantiated by pluralities, but only to deny that supervenience fails in such cases).

Finally, suppose that one were worried about the very possibility of gunk on the grounds that if there are parts all the way down there is nothing to 'anchor' the properties; there is no fundamental level from which the higher-level properties are derived. The buck is passed downwards indefinitely, so to speak, and it might thus seem puzzling how gunk could have certain kinds of properties, such as colour, at all. Zeno objects, however, can be made of gunk as described above. Consequently even in gunk worlds properties can be instantiated at higher levels independently of lower-level properties. The buck can stop at any level.¹²

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References

Benacerraf, P. 1962. Tasks, supertasks, and the modern Eleatics. *Journal of Philosophy* 59: 765-84.

Benardete, J. A. 1964. *Infinity: An Essay in Metaphysics*. Oxford: Clarendon Press.

Hawthorne, J. 2000. Before-effect and Zeno Causality. *Noûs* 34: 622-33.

Prosser, S. 2006. The Eleatic Non-Stick Frying Pan. *Analysis* 66: 187-94.

Thomson, J. 1954. Tasks and super-tasks. *Analysis* 15: 1-13.