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ORIGINAL PAPER

A Defense of Emergence

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Abstract I defend a physicalistic version of ontological emergence; qualia emerge from the brain, but are physical properties nevertheless. First, I address the following questions: what are the central tenets of physicalistic ontological emergentism; what are the relationships between these tenets; what is the relationship between physicalistic ontological emergentism and non-reductive physicalism; and can there even be a physicalistic version of ontological emergentism? This discussion is merely an attempt to clarify exactly what a physicalistic version of ontological emergentism must claim, and to show that the view is at least coherent. I then defend the view from objections, for example, Kim's (Philos Stud 95:3–36, 1999) attempt to apply a version of his exclusion argument to ontological emergentism. I conclude by offering a positive argument for the view: given certain empirical evidence concerning the organization of the brain, physicalism might have to endorse ontological emergentism to avoid epiphenomenalism.

Keywords Emergence · Mind–body problem · Consciousness · Downward causation · Exclusion argument

1 Physicalistic Ontological Emergentism

It is commonplace to distinguish between epistemological emergentism and ontological emergentism.[1] Epistemological emergentism thinks of emergence

[1] Throughout, I am primarily concerned with the claim that *qualia* emerge from the physical; there might be emergent properties aside from qualia, but I will not discuss this possibility much. Below, I briefly discuss the possibility that quantum mechanics provides evidence for the existence of ontologically emergent properties, but again, my main focus will be on qualia.

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"strictly in terms of [the] limits on human knowledge of complex systems…for such theorists [emergence] is fundamentally an epistemological, not metaphysical, category" (O'Conner and Wong 2005: section 2). For example, some epistemological emergentists claim that the appearance of an emergent property is "unpredictable." That is,

> Emergent properties are systemic features of complex systems which could not be predicted (practically speaking; or for any finite knower; or for even an ideal knower) from the standpoint of a pre-emergent stage, despite a thorough knowledge of the features of, and laws governing, their parts (O'Conner and Wong 2005: section 2).

An epistemologically emergent property might not be a genuinely novel property of a system. It is simply that we could not have predicted the existence of the property given knowledge of the parts of the system and their relations to one another. In contrast, ontological emergentism holds that,

> the physical world [is] entirely constituted by physical structures, simple or composite. But composites are not (always) mere aggregates of the simples. There are layered strata, or levels, of objects, based on increasing complexity. Each new layer is a consequence of the appearance of an interacting range of 'novel qualities' (O'Conner and Wong 2005: section 2).

That is, an ontologically emergent property is "'nonstructural,' in that the occurrence of the property is not in any sense constituted by the occurrence of more fundamental properties and relations of the object's parts" (*ibid*). An emergent property "is a novel, fundamental type of property altogether" (*ibid*). Epistemological emergentism is generally seen as more benign and less controversial than ontological emergentism, presumably at least in part because it only makes claims about the limits of human knowledge and not about the metaphysical nature of the world.[2] Throughout, I am concerned with ontological emergence, and when I use the term "emergentism," I am referring to ontological emergentism.[3]

There are many different versions of ontological emergentism, but it seems many versions share a few core claims. *First*, if property *E* emerges from physical system *S* in a given world, then *E* emerges from *S* with law-like regularity; that is, whatever else might be said about the emergence relation, it is lawful. O'Connor and Wong (2005: section 3.1), for instance, remark that,

[2] Adherents of epistemological emergentism include Bedau (1997), who holds that chaotic systems have epistemologically emergent properties, and Clark (1997), who applies the concept of epistemological emergentism to issues in cognitive science. Sometimes epistemological emergentism is called "weak emergentism" while ontological emergentism is called "strong emergentism."

[3] Of course, epistemological emergentism and ontological emergentism might not be mutually exclusive. *Prima facie*, it appears that ontological emergentism might entail epistemological emergentism, but not vice versa. But I will not discuss this issue in depth. I should also note that some have recently called the once sharp distinction between epistemological and ontological emergentism into question. It might be that some kinds of ontologically emergent properties can be captured in epistemological definitions or descriptions; see, e.g., Wimsatt (1997), Boogerd et al. (2005), and Bedau (2008). So, assuming that consciousness is ontologically emergent, perhaps it can ultimately be captured in epistemological descriptions?

> Earlier emergentists did not give very clear accounts of the relationship between the necessary physical conditions and the emergents, apart from the general, lawful character of emergence. Given the requisite structural conditions, the new layer invariably appears.

This aspect of emergentism is endorsed by contemporary emergentists as well. So, e.g., if a pain quale emerges from a brain state in which C-fibers fire, any time C-fibers fire, a pain quale will emerge.[4] *Second*, it is often claimed that emergent properties have novel causal powers. Kim (1992a: 135), for example, remarks, "So the following summarizes the heart of the emergentist doctrine on mental causation: *mentality must contribute genuinely new causal powers to the world*…." *Third*, obviously, an emergent property will not be reducible to its emergence base. Kim (1992a: 124) states:

> This claim of course is central to the whole emergentist program:
> [The Irreducibility of Emergents] Emergent properties are "novel" in that they are not reductively explainable in terms of the conditions out of which they emerge (also see Stephan (1992)).

Indeed, the very notion of a reductive ontological emergentism is incoherent.

So, an ontologically emergent property (i) stands in a lawful relation to its emergence base, (ii) has novel causal powers not had by its base, and (iii) is irreducible to its base. These last two tenets are closely related. Recall that an ontologically emergent property is "nonstructural," i.e., "the occurrence of the property is not in any sense constituted by the occurrence of more fundamental properties and relations of the object's parts" (O'Connor and Wong 2005: section 2); this is what is meant by the claim that an ontologically emergent property is "irreducibile." An emergent property is not identical to the conditions which give rise to it; it is something over and above those conditions. An emergent property is irreducible because it is a *new* property from those which give rise to it; "further, newness of property, in this sense, entails new primitive causal powers, reflected in laws which connect complex physical structures to the emergent features" (O'Conner and Wong 2005: section 3.1). That is, the claim that an emergent property is irreducible is sometimes thought to entail that it is has novel causal powers. These novel causal powers will be causal powers not had by the emergent property's base; they will only appear at a higher level of organization, even though they might be able to causally influence lower levels of organization (this would be a case of "downward causation"). Conversely, if one claims that emergent properties have novel causal powers, one must claim that emergent properties are irreducible. Clearly, if an emergent property is identical to—or is nothing over and above—its base, it cannot have causal powers not had by its base.

An open question concerning emergentism is: "assuming that emergentism is or can be a form of physicalism, what is the relationship between it and non-reductive

[4] This is potentially problematic; one might think that a "lawful" relation between two entities means that one can predict the presence of one entity given the presence of the other, which can be seen to contradict the definition of "epistemological emergentism." Here, "lawful" simply means that "if one entity is present, the other will invariably appear."

physicalism?" It is often assumed that a physicalistic version of emergentism would simply be a form of non-reductive physicalism (presumably in part because a core tenet of emergentism is irreducibility). Kim (1999: 5) goes so far as to remark: "the fading away of reductionism and the enthronement of non-reductive materialism as the new orthodoxy simply *amount to* the resurgence of emergentism;" that is, non-reductive physicalism just is emergentism more or less. I think this is a mistake, at least when the form of emergentism in question is ontological emergentism: there are some important differences between physicalistic emergentism and traditional non-reductive physicalism, and a failure to appreciate this confuses matters (this is not to suggest, of course, that a physicalistic emergentism will resemble traditional forms of reductive physicalism, but only that it must be radically different from the standard versions of non-reductive physicalism that came into vogue after the rejection of type identity). To explain, type identity theory claimed that mental state types (e.g., pain qualia) were identical to brain state types (e.g., C-fibers firing) [some early type identity theorists were Place (1956) and Feigl (1958)]. Of course, non-reductive physicalism arose as a rejection of this view; it was argued, for instance, that type identity is "chauvinistic" insofar as it does not allow for creatures with radically different physical constitutions (from us) to have certain types of qualia (e.g., pain) that they appear to have [see Putnam (1967), for example]. That is, because mental states can apparently be multiply realized, many rejected type identity theory in favor of another view. To be specific, many chose to endorse some form or other of token physicalism: each mental state token (e.g., a given pain quale) is nothing but a physical state token (e.g., a specific instance of C-fibers firing), but it is possible for a mental state type to be realized in different physical state types, and contemporary non-reductive physicalism was born. In short, a key concept of traditional non-reductive physicalism is *realization*: in a sense, because mental state tokens are realized in physical structures in the brain, they are nothing over and above the brain, but they are irreducible to those structures because they can be realized in different types of physical structures.

Emergentism, however, must reject the claim that qualia are realized in the brain. To see this, consider the very plausible "causal inheritance principle:"

> If mental property M is realized in a system at t in virtue of physical realization base P, the causal powers of *this instance* of M are identical with the causal powers of P (Kim 1992a: 18).

Given this principle, if qualia are realized in specific physical structures in brains (e.g., C-fibers firing, or whatever it is that happens in a Martian's brain when it has pain), they have the same causal powers as those structures; i.e., if qualia are realized in physical structures in brains, they cannot have causal powers not had by those structures. But emergentism claims that qualia have causal powers not had by their basal conditions (and it is safe to assume that if qualia emerge, their basal conditions are various physical structures in brains, so if emergentism is true, qualia have different causal powers than these structures). But then if emergentism is true, qualia cannot be realized in these structures (for if they were, they would not have distinct causal powers from these structures); emergentism must reject the claim that qualia are realized in the brain. Since the notion of realization was

central to traditional forms of non-reductive physicalism, emergentism will be very different from these views. Another way to put the point is: traditional non-reductive physicalism held that qualia are irreducible because they are multiply realizable, but emergentism must hold that qualia are irreducible because they are something over and above the physical structures in the brain from which they emerge (if they have causal powers not had by these structures, they must be). Of course, this does not mean that emergentism is chauvinistic. Emergentism can simply claim that while qualia emerge from physical brains, the same qualia type might be able to emerge from different types of physical brains; so just as pain emerges from some physical states of the human brain, perhaps it can emerge from some physical states of Martian brains (strictly speaking, it would, though, be incorrect to say that emergentism can account for multiple realization, because it must reject realization).[5]

There is at least one more significant difference between any putative physicalistic emergentism and traditional versions of non-reductive physicalism. Of course, another core concept of traditional non-reductive physicalism is property dualism: mental properties are not identical to physical properties (but since mental properties are always realized in or by physical properties, this is not a form of ontological dualism).[6] It seems, however, that physicalistic emergentism cannot endorse property dualism: if physicalistic emergentism is true, mental properties must be physical properties, even though these physical properties will not be lower-level neural properties (we saw above that emergentism must claim that mental properties are not reducible to their basal conditions, namely, brain states). To see this, consider the concept of "causal closure," the claim that any physical effect has a physical cause. Any version of physicalism must endorse causal closure because if causal closure fails, there is a physical effect that has a non-physical cause, in which case there are non-physical entities and so physicalism is false. Therefore, if qualia are not physical properties, i.e., if property dualism is true, then given that they have causal powers, causal closure will be violated. It follows that any version of physicalistic emergentism must deny property dualism. In effect, if physicalistic emergentism is true, then even though qualia will not be reducible to lower-level neural properties, they are physical properties nevertheless, and property dualism is false. To clarify, traditional non-reductive physicalists could endorse property dualism without endorsing ontological dualism because of their adherence to realization. If mental properties are always realized in or by physical properties, then even though mental properties are not identical to physical properties, everything is still physical in a strong enough sense to avoid ontological dualism (or at least this is what traditional non-reductive physicalists thought and still think). But since emergentism must reject realization, if it claims that mental properties are not identical to physical properties then it is committed to ontological dualism (after all, such a view would posit mental properties that are *wholly* distinct

[5] I'm not sure why some philosophers have failed to see that physicalistic emergentism must reject realization: perhaps the reason is that it is difficult to imagine a form of physicalism that does not endorse at least realization? Many make the assumption, questioned below, that if qualia are not identical to or realized in the brain, they must be non-physical.

[6] See, e.g., Kim (2005: 34).

from physical properties). In short, realization made it possible to endorse property dualism without endorsing ontological dualism, but emergentism cannot appeal to realization, therefore, if it is a form of physicalism, it must reject property dualism. (I have more to say about causal closure below.)

Finally, some wonder if emergentism can even be a form of physicalism. Above, we assumed that emergentism was consistent with physicalism, but is it? Recall that emergentism consists of at least three claims: qualia emerge from their basal conditions with law-like regularity, they have novel causal powers not had by their basal conditions, and they are irreducible to those basal conditions. It does not appear that any of these tenets (or any combination of them, for that matter) entail that qualia *must* be non-physical. For example, there is nothing about the claim that qualia stand in a law-like relation to the brain that suggests the falsity of physicalism. It is difficult to see how the claim that qualia have novel causal powers not had by brains entails that they must be non-physical; many physical properties have causal powers not had by brains, for instance. Likewise, it seems one can coherently claim both that qualia are irreducible to the brain (in the strong, emergentist) sense and that qualia are physical properties (many physical properties are not neural properties). In short, none of the core tenets of emergentism appear to contradict physicalism. Many do think that if qualia are not identical to or realized in neural states they must be non-physical; if one believes this, emergentism will necessarily be a form of dualism (since again, emergentism must reject identity and realization). But this claim is often simply assumed without argument, probably because it is difficult to see how qualia could be physical if they are not identical to or realized in neural states. I question this assumption below. Physicalistic emergentism might very well be false, and many think that it is, but it appears that at least broadly speaking, it is not false because it is incoherent or logically inconsistent.

One possible strategy the physicalistic ontological emergentist might pursue in the effort to show that emergentism is consistent with physicalism is to equate physicalism with strong supervenience (as some contemporary philosophers of mind do), and then simply note that emergentism is consistent with strong supervenience. There is nothing incoherent about the idea that the same types of qualia emerge from the same types of brain states in all metaphysically possible worlds (e.g., in all metaphysically possible worlds, pain emerges from C-fibers firing). One could object that physicalistic ontological emergentism might claim that qualia are novel physical properties that are distinct from all other physical properties, but if so, then why think qualia are physical properties? But it is perfectly coherent to hold that qualia are physical properties that happen to be unique from all other physical properties. The property of being a prime number is a unique numerical property insofar as it is not identical to any other numerical property, yet it is a numerical property all the same.

So, it appears that physicalistic ontological emergentism is not logically contradictory; logically speaking, it might be that consciousness is both physical and emergent. But one might object that this is not enough: we also need to be given some positive reason (aside from the claim that physicalistic emergentism will endorse causal closure) to think that these emergent properties are physical. Since

Descartes, numerous reasons to doubt dualism have been offered, even aside from the issue of causal closure. For example, some have charged that (i) dualism violates Occam's razor (since, in bifurcating reality into two types of entities, it makes matters needlessly complex) (Churchland 1984), (ii) it is mysterious how non-physical entities (be they substances or properties) can influence physical entities (a difficulty first raised by Princess Elisabeth), (iii) dualism contradicts specific laws of physics (the conservation of energy) (see, e.g., Lycan 1996: 188), (iv) dualism lacks explanatory power (e.g., saying that the mind is non-physical does not make matters less mysterious), (v) dualism cannot account for the unity of consciousness (see, e.g., Robinson 2009: section 5), (vi) dualism cannot solve the "pairing problem" (see Kim 2005) and so on.[7] So there are various extant reasons to think that qualia are physical; some of these reasons apply only to specific forms of dualism while some of them apply to any form of dualism. But if these reasons are forceful, one might ask, then why not simply endorse a traditional form of physicalism (e.g., the identity theory or traditional non-reductive physicalism)? But there are numerous reasons for doubting these traditional forms of physicalism as well. For example, some have charged that (i) the identity theory is chauvinistic (Putnam 1967), (ii) phenomenal experience is wholly unlike the operations of neurons, so the claim that the former is identical to or realized in the latter seems implausible (see, e.g., Lockwood 2003 for a discussion of this so-called "grain problem"), (iii) non-reductive physicalism entails epiphenomenalism (Kim 2000, 2005) and so on. So there are reasons to think that qualia, while physical, are not successfully explained by traditional forms of physicalism. Physicalistic ontological emergentism, if it appeals to anyone at all, will likely appeal to those who, like myself, are moved by *both* the traditional objections to dualism (or at least some of them) *and* the objections to traditional forms of physicalism. It offers one possible way of keeping the mind separate from mere neural states while simultaneously keeping it firmly entrenched in the physical world.[8]

In sum, ontological emergentism claims that emergent properties emerge with law-like regularity from their emergence base, have novel causal powers not had by the emergence base, and are irreducible to that base. Emergentism is at least *prima facie* consistent with physicalism, though a physicalistic emergentism will be very different from standard forms of non-reductive physicalism (e.g., traditional token physicalism). Most notably, physicalistic emergentism cannot claim that qualia are realized in lower-level neural properties and so must deny property dualism (while qualia will not be reducible to lower-level neural properties, they must be physical

[7] Clearly, physicalistic ontological emergentism would not face some of these problems that dualism has traditionally faced. For example, if qualia are (emergent) physical properties, then there is no mystery as to how they could interact with the physical; physical properties interact with other physical properties all of the time. Also, the view would not violate the conservation of energy either. Above, we saw ways that the view would differ from traditional non-reductive physicalism; here, we see a couple of ways that the view would differ from at least some forms of dualism.

[8] Below, I discuss the Electromagnetic Theory of Consciousness, which claims that consciousness is identical to an electromagnetic field that emerges from neural states. If we have any reason to think that this theory is true, we have a further reason to think that emergent qualia are physical.

properties nevertheless). Perhaps such a view can avoid some of the traditional objections to dualism and physicalism?

2 Objections to Emergentism

There is no shortage of objections to physicalistic ontological emergentism; in this section, I defend emergentism from what I take to be the most serious of these. Note that often, this section has a modest goal: I am not attempting to establish the truth of emergentism, but am merely trying to show that various arguments that purport to falsify it do not succeed.[9]

2.1 The Exclusion Argument

Kim (1999) offers the following argument to show that qualia do not emerge from the physical. Posit two physical neural states that occur in temporal succession, *P* and *P**. Also, suppose that qualia emerge from the brain. So, e.g., *M* is a qualitative mental state that emerges from *P* and *M** is a qualitative mental state that emerges from *P**. Kim then argues that *M* is epiphenomenal. The argument is roughly the following: if *M* causes anything, it causes either *P** or *M**. But *M* cannot cause *P** for the following reason:

> if causation is understood as nomological (law-based) sufficiency, *P*, as *M*'s emergence base, is nomologically sufficient for it [i.e. *M*], and *M*, as *P**'s cause, is nomologically sufficient for *P**. Hence, *P* is nomologically sufficient for *P** and hence qualifies as its cause (Kim 1999: 32).[10]

Likewise, *M* cannot cause *M** because *P**, as *M**'s emergence base, is nomologically sufficient for *M**. In other words, if *M* does not cause *P**, then *M* does not cause *M** either because the existence of *P** is sufficient to guarantee the presence of *M**. But if *M* does not cause either *P** or *M**, then it causes nothing, i.e., it is epiphenomenal. Further, if *M* is epiphenomenal, it does not emerge: recall that a core tenet of emergentism is the claim that emergent properties have novel causal powers. Kim concludes that qualia do not emerge.

However, note that the emergentist can give an alternative account of the situation described above. Emergentism will agree with Kim that *P* is nomologically sufficient to produce *M*; recall that emergentism claims that an emergent property arises from its emergence base with law-like regularity. But emergentism need not claim that if *M* plays a causal role in producing *P**, *M* is nomologically sufficient for *P**. It might very well be that *M* plays a causal role in bringing about *P** even though it could not have brought about *P** all by itself. To clarify, posit *P*, and suppose that *M* emerges from *P*. *P* is nomologically sufficient for *M* (again,

[9] One exception is my discussion of the Electromagnetic Theory of Consciousness (see below); there, I claim that there is some empirical evidence for physicalistic ontological emergentism. This is a positive reason to think it is true, and so is not merely a defensive maneuver.

[10] As Kim (1999) notes, his argument also succeeds, if it succeeds at all, if one thinks of causation as counterfactual dependence.

emergentism posits a law-like connection between emergent properties and their emergence bases). Thus far, emergentism has no issue with Kim's account of the situation. *M* will have novel causal powers not had by *P*; again, the claim that emergent properties have novel causal powers is a core tenet of emergentism. But these novel causal powers had by *M* might not be sufficient, by themselves, to bring *P** about *ex nihilo*. Rather, *M* might causally interact with *P*, its own emergence base, to somehow alter *P* so that it "turns into" *P**.[11] That is, *M* causally affects *P* in such a manner that brings *P** about. On this account, *P* has causal powers since it brings about *M*, and *M* has causal powers since it causally affects *P*, and both are needed to ensure the presence of *P**. *P** will then, in turn, bring *M** about since *M** emerges from *P*. On this account, *M* is not epiphenomenal.

But one might object that this alternative account solves nothing. Kim claims that if causation is understood as nomological sufficiency, then given that nomological sufficiency is transitive, *M* will have no causal work to do. That is, if *P* is nomologically sufficient for *M*, and *M* is nomologically sufficient for *P**, then *P* will be nomologically sufficient for *P** (by the transitivity of nomological sufficiency), and so will count as its cause, thereby making *M* epiphenomenal. But one might claim that denying that *M* is nomologically sufficient for *P**, as I did above, is of no help. Given that *P* and *M* are sufficient to produce *P**, and that *P* is sufficient to produce *M*, *P* will still be sufficient to produce *P**, and so *M* still has no causal work to do. But it appears that the emergentist can overcome this worry, even if she grants that causation is nomological sufficiency and that nomological sufficiency is transitive. Specifically, the emergentist can claim that there are some cases in which an entity might be nomologically sufficient to produce another entity, even though the former is not the *sole* cause of the latter; this can occur if all of the other entities that are needed to produce the latter are also produced by (or emerge from) the former. To clarify, the emergentist might hold that nomological sufficiency does not entail causal exclusivity. So, the emergentist can claim that there are cases in which an entity *a* can be nomologically sufficient for a different entity *c*, yet *a* is not the *only* cause of *c*; i.e., even though *a* is nomological sufficient for *c*, there is some other entity *b* that is *also* needed to produce *c*. How can this be? Isn't it the case that if something is sufficient for another entity, it is or can be the sole cause of it? Often that is the case, but in instances in which *a also* produces that other entity *b* that is needed to produce *c*, *a* might be sufficient for *c* insofar as *a* will lead to a *c*, yet *a* is not the sole cause of *c* because *b* is also needed. So, the emergentist can claim that while *P* is nomologically sufficient to produce *P** in the sense that if *P*, then we will have *P**, this does not imply that *M* has no causal work to do, because if not for the causal powers of *M*—causal powers that *P does not have*—we would not have *P**. *P* is nomologically sufficient for *P**, but only because it also produces an entity, *M*, that has its own causal powers, causal powers that are needed to bring *P** about. The causal powers of *M* are needed to bring *P** about, and the fact that *P* causes *M* does not change that. This response might not be open to the traditional non-reductive physicalist: given the causal inheritance principle, *M* will have the *same* causal

[11] There might be other ways for an emergent property *M* to bring about *P**. I am merely sketching one possible account.

powers as *P*, and so *M* either contributes nothing in terms of causing *P**, and so is epiphenomenal, or else *M* and *P* make identical causal contributions in the production of *P**, in which case we would have causal overdetermination. In sum, *P* might be nomologically sufficient for *P**, but might not be the *sole* cause of *P**; it is sufficient only because it also causes the *other* entity needed to cause *P**, but it is not the sole cause because that other entity—with its novel causal powers—is also needed.

One might wonder what emergentism would say about the more sophisticated version of the exclusion argument offered in Kim's (2000) and (2005); perhaps emergentism is defeated by a more developed version of the exclusion argument? Kim's argument is well known, so my exegesis will be brief. Basically, Kim (2005) argues that the conjunction of four claims, each of which non-reductive physicalism is committed to, entails epiphenomenalism; as a result, non-reductive physicalism entails epiphenomenalism. These four claims are: mind–body supervenience, causal closure, the denial of causal overdetermination and property dualism. Traditional non-reductive physicalism might be committed to these claims or it might not be; I leave this issue aside. I do discuss, however, what physicalistic ontological emergentism will or must say about these four claims. First, if Kim (2000) is correct, and it appears that he is, that mind–body supervenience is minimal physicalism or is necessary for physicalism, then physicalistic emergentism is committed to mind–body supervenience. Also, as discussed above, any version of physicalism must obviously endorse causal closure; so, physicalistic emergence is committed to causal closure. Physicalistic emergentism need not worry about overdetermination; since qualia have causal powers not had by their emergence base, the issue of overdetermination cannot arise. That is, emergentism is consistent with the denial of causal overdetermination. Of course, traditional forms of non-reductive physicalism might violate the ban on causal overdetermination (e.g., given the view's commitment to realization and the causal inheritance principle, mental and physical properties will have the same causal powers), but again, emergentism must deny realization. Finally, as we saw above, physicalistic versions of emergentism must deny property dualism; emergentism will claim that mental properties are not reducible to lower-level neural properties, but they must be physical properties. Newer, more developed versions of Kim's exclusion argument hold that the conjunction of four claims entails epiphenomenalism; but given that physicalistic emergentism is only committed to three of these claims (and indeed, must deny the fourth), these versions of the argument do not apply to emergentism.[12]

[12] This is another instance in which everything seems to turn on the fact that emergentism denies realization while traditional non-reductive physicalism does not. If realization and the causal inheritance principle are true, then the mental and the physical will have the same causal powers, so overdetermination threatens; but since emergentism denies realization, it can claim that qualia have new causal powers and so can avoid overdetermination. Again, one might be tempted to ask why we should think these ontologically emergent properties are physical, but again, there are numerous extant reasons to reject dualism (see above).

2.2 Emergentism is "Magical"

Some, e.g., Kim (1992b), have claimed that there is something grossly implausible or "magical" about emergent properties. However, at least one possible source of this feeling can be alleviated. Kim (1992b) argues that the causal properties of a high-level property (such as an emergent property) must be the same as the causal properties of lower-level properties; if so, then high-level properties cannot have novel causal properties as emergentism claims. To elaborate, Kim adheres to the causal inheritance principle mentioned above, i.e.,

> If mental property *M* is realized in a system at *t* in virtue of physical realization base *P*, the causal powers of *this instance* of *M* are identical with the causal powers of *P* (Kim 1992a: 18).

Further, Kim holds that if one denies causal inheritance, one is basically positing "causal powers that magically emerge at a higher-level and of which there is no accounting in terms of lower-level causal powers and nomic connections" (as quoted in Pereboom 2002). So, emergentism is implausible. However, while Kim's argument might call traditional forms of non-reductive physicalism into question, it loses its force when applied to physicalistic emergentism. To explain, if high-level properties are realized in lower-level properties, as traditional non-reductive physicalism claims, then it appears these high-level properties must have the same causal powers as the low-level properties. Given realization, it would be magical if high-level properties somehow had causal powers not had by low-level properties. But again, emergentism must deny realization, so Kim's argument is inapplicable to emergentism. In other words, emergentism, since it denies realization, will not run afoul of the causal inheritance principle, which only applies in cases in which high-level properties are realized in low-level properties. There might be other reasons that lead one to think that emergence is somehow magical or at least suspicious; but Kim's worry—at least—can be assuaged.

2.3 The Lack of Scientific Evidence

Some have claimed that ontological emergentism should be rejected because there is little or no scientific evidence that ontologically emergent properties exist. McLaughlin (1992) remarks, for instance, that there is no evidence whatsoever for the existence of any ontologically emergent properties.[13] As others have pointed out, though, there are actually good reasons for thinking that quantum mechanics provides evidence for the existence of ontologically emergent properties: see e.g., Teller (1986), Penrose (1994), Healy (Healey 1991), Humphreys (1997), and Silberstein and McGeever (1999). So, we cannot deny that qualia are ontologically

[13] The history of emergentism probably contributes to the perception that there is no scientific evidence for the existence of emergent properties. British emergentism withered away because of scientific advances; science demonstrated that the properties that were thought to be emergent were not (e.g., some British emergentists thought that "life" was an emergent property, but advances in biology overturned that view). In short, since British emergentism faded away because of scientific advances, there is a lingering perception that emergentism is somehow "unscientific" or not supported by scientific evidence.

emergent properties simply because there is no scientific evidence that ontologically emergent properties exist; there might very well be such evidence. To give an example, Silberstein and McGeever (1999: 187) discuss the famous EPR-Bohm systems:

> if two spin-half particles (an electron and a positron) are produced by the decay of a single spin-zero particle at some central point and move directly outwards in opposite directions…the spins of the electron and positron must add up to zero…[so] the particle spins will always have opposite values.

This will be true even if the particles eventually end up on opposite end of the universe. According to Silberstein and McGeever (1999: 187), there are three possible explanations for this phenomenon: (i) the particles "agreed in advance" what their respective measurements would be, (ii) the particles influence one another at a distance, or (iii) the system has an emergent "correlation property" not had by the system's parts, i.e., the system has an ontologically emergent property. Silberstein and McGeever argue that (i) is unlikely since this would contradict quantum mechanics (see 1999: 187), and that (ii) would threaten special relativity (when the particles are too far apart, special relativity cannot make sense of one particle influencing another because there will be no temporal order between events involving the two particles), so it seems (iii) is true. That is, (iii) gives us a way to explain the EPR-Bohm systems without having to contradict an important scientific theory. But if (iii), there is at least one ontologically emergent property. Likewise, Humphreys (1997) argues that quantum entanglement is best understood as a case of emergence. None of this provides any direct evidence for the claim that consciousness is an ontologically emergent physical property. But some think that emergentism in general, be it a claim about the mind or not, lacks any support from science. If one holds this opinion, one will be predisposed to reject the form of emergentism offered here; however, the examples above suggest that this opinion is mistaken.

Finally, even assuming that there is no scientific evidence for the existence of ontologically emergent properties, it might be that consciousness is the only ontologically emergent property; consciousness is not yet explained, so it is possible that it ontologically emerges even if nothing else does.[14]

2.4 If Not Identity or Realization, then Dualism?

Above, I mentioned the assumption that if qualia are not identical to or realized in neural states, then dualism is true. Recall that this assumption will entail that emergentism, which must deny identity and realization, is necessarily a form of dualism. The assumption is plausible because it is extremely difficult to see how qualia could be physical if identity or even realization do not hold.

[14] Some philosophers, e.g., Kim (1999), have claimed that if anything at all ontologically emerges, it is consciousness and qualia; so some have suggested that perhaps qualia are the only ontologically emergent properties.

However, this worry is not insurmountable. Consider, for example, the Electromagnetic Field Theory of Consciousness (see, e.g., McFadden 2002). The theory, or at least the version of the theory I discuss here, consists of three core claims. First, the brain produces an electromagnetic field. Second, this electromagnetic field can in turn influence the firing of neurons. Third, this electromagnetic field is consciousness. The first claim is uncontroversial: we have "known for more than a century that the brain generates its own electromagnetic field" (McFadden 2002: 24); the field is produced from the firing of neurons and the various "fields generated by the movement of ions into and out of cells and within extracellular spaces" (McFadden 2002: 25). As McFadden (2002: 25–26) notes, electroencephalography (EEG) only works because this field exists; "EEG has been used…to measure electrical activity in the brain from changes in the field potential recorded at the scalp." Moreover, we know several properties of this field. We know that the strength of the field fluctuates, sometimes very dramatically (e.g., in the case of epileptics). We know that "sensory stimuli and motor activity are associated with temporally organized perturbations to these" fields (McFadden 2002: 27); so not only does the field fluctuate, but it fluctuates when a brain receives sensory information or generates bodily movement. Also, we know that this field has a detailed spatial and temporal structure.

The second claim, that this electromagnetic field can in turn influence the firing of neurons, is more controversial than the first, though it is by no means implausible. There are numerous ways the field might influence the behavior of neurons. For example, the field might alter the distribution of ions in the brain and "thereby directly modulate neuronal physiology" (McFadden 2002: 27). Also, some brain structures "are sensitive to electromagnetic fields" (*ibid*). But in McFadden's (2002: 28) opinion, "the best-characterized sensor of the brain's electromagnetic field are the voltage-gated ion channels in neuronal membranes, which have a well-defined role in information processing…." The amount of voltage needed to activate a resting neuron is greater than that of the field, but the field can affect a neural membrane, which might in turn cause a neuron that is close to firing to fire. Furthermore, there is empirical evidence for the second claim as well. McFadden argues that there is "considerable" empirical evidence that neurons "communicate through the [electromagnetic] field…," e.g., "*Ephaptic* nerve transmission describes the phenomenon whereby neuron firing is modulated by the firing of adjacent neurons and has been demonstrated in vitro…" (McFadden 2002: 29). Additional evidence comes from the use of transcranial magnetic stimulation (TMS). In TMS, a magnetic field is generated through the use of a coil placed on a subject's scalp; these fields are similar in strength to the ones naturally produced by the brain. These artificial fields can causally influence cognition, so it seems that naturally occurring fields can as well.[15] In sum, there are mechanisms in place through which the field

[15] To elaborate, McFadden (2002: 30) claims,

> In humans, the strongest evidence for the sensitivity of the brain to relatively weak em fields comes from the therapeutic use of transcranial magnetic stimulation (TMS). In TMS, a current passing through a coil placed on the scalp of subjects is used to generate a time-varying magnetic field that penetrates the skull and induces an electrical field in neuronal tissue.

could influence the behavior of neurons, and there is empirical evidence that suggests that the field does exert such an influence. The third and final claim, i.e., these electromagnetic fields simply are consciousness, is of course more controversial than the first two claims. Nevertheless, there is some empirical evidence for this claim as well. McFadden (2002: 31–32) outlines eight testable predictions that the theory makes, e.g., "Stimuli that reach conscious awareness will be associated with em field modulations that are strong enough to directly influence the firing of motor neurons" and "Stimuli that do not reach conscious awareness will not be associated with em field modulations that affect motor neurone firing," and discusses empirical evidence that suggests each prediction is true (see McFadden 2002).[16]

I discuss this relatively new theory of consciousness for several reasons. *First*, here is a form of physicalism, one that is not obviously or a priori false, in which qualia are not identical to or realized in neural states; the theory is clearly a form of physicalism…electromagnetic fields have been a theoretical entity of physics for nearly two centuries. That is, while it is tempting to assume that if identity and realization do not hold, physicalism is false, this is far from clear, as the existence of the Electromagnetic Field Theory of Consciousness—which has not yet been conclusively falsified—shows.

Second, the Electromagnetic Field Theory of Consciousness can plausibly be considered a physicalistic version of ontological emergentism. More precisely, the theory suggests that consciousness is an emergent property of neural states.[17] Above, I discussed three core claims of emergentism: (1) there is a lawful relation

Footnote 15 continued
Furthermore, "TMS has been shown to generate a range of cognitive disturbances in subjects including: modification of reaction time, induction of phosphenes, suppression of visual perception, speech arrest, disturbances of eye movements and mood changes (Hallett 2000)" (McFadden 2002: 30). The strength of these fields generated by TMS have been estimated at around 50–130 V/m (Epstein et al. 1990) and 20–150 V/m (Ruohonen et al. 2000) (McFadden 2002). These voltages are right around the "values that are typical for the endogenous fields generated during normal and pathological brain activity" (McFadden 2002: 30). So, "since TMS induced modulations of the brain's em field affect brain function and behaviour, it follows that the brain's endogenous field must similarly influence neuronal computation" (McFadden 2002: 30). The argument is essentially this: we know that artificially generated fields can influence neurons (and so cognition) often in dramatic ways, and it appears that these artificial fields are roughly the same strength as the naturally occurring fields produced by the brain, so it appears that these natural fields can causally effect neurons (and so cognition) as well.

[16] McFadden (2002) also points out that the theory can resolve the binding problem as well (a problem that is roughly analogous to the "unity of consciousness" problem long discussed by philosophers). Indeed, the theory might also be able to overcome the "grain objection" to physicalism (i.e., the worry that given the "smooth," continuous nature of qualia, they could not possibly be identical to or realized in discontinuous brain processes).

[17] Admittedly, this situation is complex. There is a sense in which the theory is an identity theory: consciousness will be identical to electromagnetic fields, which are physical entities. Consciousness is still identical to a physical entity (the fields), just not the one many people thought (neural states). But any version of *physicalistic* ontological emergentism must claim something similar; if consciousness emerges from the physical but is not a physical property, it seems dualism is true; recall the discussion above about how physicalistic ontological emergentism must deny property dualism. But as I now argue, there is also a sense in which the theory is a form of emergentism since these electromagnetic fields emerge from neural states.

between an emergent property and its base, (2) an emergent property has causal powers not had by its base, and (3) an emergent property is irreducible to its base. The Electromagnetic Field Theory of Consciousness meets each criterion (if one thinks of the field as a property of the brain). First, there is a lawful relation between the brain and the electromagnetic fields that the brain produces. For example, recall that the fields fluctuate when a brain receives sensory information or generates bodily movement; when the brain fluctuates, the fields fluctuate. This suggests that there is a lawful connection between the brain and the fields. Second, recall that it is not implausible that these fields can causally influence the brain; if they can, then they have causal powers. Further, it seems unlikely that the causal powers of a magnetic field would be exactly the same as the causal powers of the neurons that produce the field; so, these fields would have novel causal powers not had by their emergence base. Finally, these magnetic fields are clearly not reducible to their base; one cannot reduce a magnetic field created by neurons to the neurons themselves. Therefore, the Electromagnetic Theory of Consciousness is a form of physicalistic ontological emergentism.[18]

Third, as discussed above, there is a certain amount of empirical evidence for the Electromagnetic Field Theory of Consciousness; granted, this evidence is far from overwhelming, but there is some evidence nevertheless. If the theory is indeed a form of physicalistic ontological emergentism, then the evidence for the former is also evidence for the latter. *Fourth*, the following worry was raised in Sect. 1: even if it is logically possible that emergent qualia can be physical, we still need positive reasons for believing that they are physical. But the Electromagnetic Field Theory of Consciousness gives us such a reason: if emergent consciousness is identical to electromagnetic fields, then given that electromagnetic fields are physical, emergent consciousness is physical.

2.5 Causal Closure

In Sect. 1, I mentioned that any form of physicalism must endorse causal closure. This includes physicalistic ontological emergentism: the view will hold that while mental properties are not lower-level neural properties, they are physical properties nevertheless (physical properties that causally influence lower-level neural properties). Admittedly, one might find this deeply unsatisfying as it stands. To explain, in much of the extant literature, physicalists distinguish between physical properties and mental properties, and then argue that the physical properties of a neural state are sufficient to cause another neural state. The idea is that we need not posit extra, non-neural, mental properties to explain mental causation; and indeed, we should not posit such properties because they would violate the causal closure of the

[18] One might object that electromagnetic fields are not novel in the sense that they can be found elsewhere in nature, so they cannot properly be called "emergent;" but why think that emergents are necessarily completely alien entities that are found no where else in nature? Denying this assumption allows physicalistic emergentism to avoid the awkward task of positing entirely new physical entities not currently found in, e.g., physics.

physical.[19] Now, even though physicalistic ontological emergentism will not violate causal closure, there still might be a related problem. Just as traditional physicalists argued against dualism by claiming that mental causation can be wholly explained by the causal powers of neurons, so we need not posit extra mental, i.e. non-physical, properties, they can object to physicalistic emergentism by claiming that since mental causation can be wholly explained by the causal powers of neurons, we need not posit extra non-neural physical properties. In short, even though physicalistic emergentism must claim that mental properties are physical properties and so cannot violate causal closure per se, one might still worry that non-neural physical properties are not needed to cause events in the brain, since apparently the causal properties of neurons can do all of the causal work.

But such considerations are not conclusive; there are some possible responses the physicalistic emergentist might make. One could argue that the "causal closure" concern overestimates the degree to which we understand the brain. After all, the brain is still fairly mysterious, and important discoveries are still being made (e.g., the recent discovery of the so called "mirror neurons"), so it is possible that we do not currently understand how emergent qualia might causally influence the brain, but they do so all the same. Again, we should not overestimate the degree to which we understand the brain and what is causing what in the brain; neuroscientists do see causal gaps when they look at the operations of the brain. Likewise, qualia might affect the physical, but we haven't noticed, because we incorrectly attribute the causal powers of qualia to other entities, namely, neural properties. In other words, there might be an intermediate link in the causal chain from *S* to *S*', emergent qualia, that traditional physicalists are simply ignoring. The point is this: it is not sufficient to reject physicalistic emergentism simply because it appears that the causal powers of neurons can do all of the causal work in the brain because this appearance might be misleading. To make this more concrete, consider again the Electromagnetic Field Theory of Consciousness. As we saw, the electromagnetic field produced by the brain might causally influence neural behavior, so assuming that qualia are identical to this electromagnetic field, we see a mechanism through which qualia might causally influence neural behavior even if they are not identical to or realized in neural states.

One might object that it is simpler to attribute the causal powers in question to lower-level neural properties, so that is what we should do. But the simplest explanation isn't always the correct one: it is possible that emergent qualia do in fact exist (again, note that here I am not trying to show that there definitely are emergent qualia; I am merely trying to show that some reasons we have to deny their existence are not conclusive). One might also object that one of the best reasons we have to endorse physicalism is the claim that lower-level neural properties can do all of the causal work, so we need not posit extra non-physical properties. So, in arguing for physicalistic ontological emergentism in the above manner I am actually undermining the view insofar as I am undermining physicalism itself. This point is

[19] See, e.g., Papineau (2002).

well taken; note, though, that there are other commonplace reasons to endorse physicalism aside from the one I reject.[20]

Finally, one might be tempted to object: all sciences ultimately reduce to physics, so unless emergentism can explain how emergent qualia can causally interact with the entities found in physics, it is likely false. Likewise, one might object that we have good theoretical reasons for claiming that neural states always cause other neural states (and emergent qualia never do) because neurons and neural states have chemical structures, and therefore the causation at issue can be explained in terms of chemistry (the idea is something like the following: biology can be reduced to chemistry, so causation at the neural level can be completely explained in the domain of chemistry, and so emergent qualia are superfluous). In short, one might appeal to some form of reductionism to defeat emergentism. The problem with such objections is that reductionism—be it the reduction of all sciences to physics or the reduction of biology to chemistry and so on—is now widely rejected by philosophers of science, and has been for quite some time. In effect, such objections rely upon a thoroughly discredited reductionism.[21]

3 An Argument for Emergentism

In this section, I offer a positive argument for emergentism: it seems that certain empirical evidence provides some, perhaps modest, evidence for emergentism.

It appears, at least given what we currently know about the organization of the brain, that the neural system associated with visual qualia, the ventral stream, is not connected to the neural system associated with behavior, the dorsal stream. Indeed, Gray (2004), a noted neuropsychologist, argued that this shows that visual qualia do not cause behavior (Gray also argues the same holds for other systems that produce different types of qualia, so he thinks that no qualia produce behavior). Clearly, the idea is that if visual qualia, for example, cause behavior, then the neural system associated with visual qualia must be connected to the neural system associated with behavior (so visual qualia can do their causal work), but since the two areas are distinct, visual qualia do not cause behavior. The problem, of course, is that our

[20] Another possible issue with physicalistic ontological emergentism concerns Hume's dictum, i.e., the claim that there cannot be necessary connections between distinct entities. Suppose, for example, that physicalism is committed to strong supervenience: if strong supervenience fails, physicalism is false. In the case of physicalistic ontological emergence, the strong supervenience claim amounts to this: facts about the mental—which are physical facts—strongly supervene on other physical facts, say, facts about brains. So, metaphysically possible worlds in which all brains are physical duplicates will be mental duplicates as well. But then there will be a necessary connection between qualia and other physical entities that are distinct from qualia, a violation of Hume's dictum. Given that Hume's dictum is endorsed by many philosophers, and admittedly seems intuitive, the incompatibility of Hume's dictum and physicalistic emergentism is a serious issue for physicalistic emergentism. However, as Wilson (2005) has argued, there are good reasons for thinking that physicalism is incompatible with Hume's dictum. That is, if one is going to reject a view because it contradicts Hume's dictum, one must reject physicalistic naturalism altogether.

[21] For criticism of the idea that biology can be reduced to chemistry, and for the idea that various sciences can be reduced to one another in general, see Horst (2007). Horst (2007) points out, for example, that such reductions rarely, if ever, succeed.

intuition that qualia cause behavior is extremely powerful. Also, if qualia do not cause behavior, then the worry that they cause nothing at all grows more pressing; in effect, epiphenomenalism threatens.[22] There is another possibility however, one that, so far as I know, has been overlooked. If ontological emergentism is true, then it will still be possible for visual qualia to causally affect behavior even though the relevant neural systems are not directly connected to one another. To explain, if (ontological) emergentism is true, then visual qualia are distinct from the ventral stream (or neural events or properties in the ventral stream); for example, qualia are not realized in or identical to activity in the ventral stream. But if so, then the fact that the ventral stream is not directly connected to the dorsal stream does not imply that qualia do not affect behavior. In other words, if the sort of macro-level causation or downward causation that emergentism posits actually occurs, then there is no reason why qualia cannot affect behavior despite the fact that qualia emerge from a system not directly connected to the system that produces behavior. In effect, given a version of the identity theory or traditional non-reductive physicalism, the organization of the brain suggests that qualia do not effect behavior. But since this appears very implausible, this calls those views into question. Emergentism, however, can avoid this problem, and this can be seen as evidence for it.[23] The strength of this argument depends upon just how implausible one thinks it is to deny that qualia cause behavior; if one thinks it is extremely implausible to deny that qualia cause behavior, and some do, one will be more inclined to see the argument as a strong one.

References

Bedau M (1997) "Weak Emergence", Philosophical perspectives 11: mind, causation, and world. Blackwell, Oxford

Bedau M (2008) Is weak emergence just in the mind? Mind Mach 18:443–459

[22] To elaborate, in a discussion of Gray's argument, Biggs (2005: section one) remarks,

> The retina sends information to the brain along several distinct channels. Following Milner and Goodale (1995), Gray thinks of these channels as constituting distinct visual systems. Importantly for Gray, the system that leads to online behavior (the dorsal stream) is distinct from the system that leads to visual qualia (the ventral stream). Accordingly, visual qualia plausibly play no role in affecting online behavior, which is caused, instead, by the dorsal stream. Gray supposes that all senses resemble vision in this regard, and thus, concludes that no qualia affect online behavior.

Gray himself does not endorse epiphenomenalism, but it is clear that the empirical data he cites makes epiphenomenalism more plausible. Another issue is that, strictly speaking, epiphenomenalism might be false, but qualia do not cause anything that we care about (e.g., behavior); this would be almost as undesirable as epiphenomenalism.

[23] To be clear, the argument in this section only provides evidence for ontological emergentism and not for *physicalistic* ontological emergentism *per se*; i.e., dualistic ontological emergentism (say, interactionism without causal overdetermination) would be consistent with this argument as well. So perhaps all the argument shows is that *if* physicalism is true and qualia cause behavior, physicalistic ontological emergentism is true? One nice feature of the argument is that while some might claim that given what we know about the brain, emergent qualia are superfluous (see the discussion of causal closure above), the argument here suggests that given what we know about the brain, emergent qualia are needed.

Biggs S (2005) Review of Jeffry Gray's consciousness: creeping up on the hard problem. Psyche 11:2
Boogerd FC, Bruggeman FJ, Richardson RC, Stephan A, Westerhoff HV (2005) Emergence and its place in nature: a case study of biochemical networks. Synthese 145:131–164
Churchland PM (1984) Matter and consciousness. MIT Press, Cambridge
Clark A (1997) Being there. MIT Press, Cambridge
Epstein CM, Schwartzberg DG, Davey KR, Sudderth DB (1990) Localizing the site of magnetic brain stimulation in humans. Neurology 40:666–670
Feigl H (1958) The 'Mental' and the 'Physical'. In: Feigl H, Scriven M, Maxwell G (eds) Concepts, theories and the mind-body problem, vol 2. Minnesota Studies in the Philosophy of Science, Minneapolis
Gray J (2004) Consciousness: creeping up on the hard problem. Oxford University Press, Oxford
Hallett M (2000) 'Transcranial magnetic stimulation and the human brain". Nature 406:147–150
Healey RA (1991) Holism and nonseparability. Journal of Philosophy 88:393–421
Horst S (2007) Beyond reduction: philosophy of mind and post-reductionist philosophy of science. Oxford University Press, Oxford
Humphreys P (1997) How properties emerge. Philos Sci 64:1–17
Kim J (1992a) 'Downward Causation' in emergentism and nonreductive physicalism. In: Beckermann A, Flohr H, Kim J (eds) Emergence or reduction. Walter de Gruyter, Berlin, p 119–138
Kim J (1992b) Multiple realization and the metaphysics of reduction. Philos Phenomenol Res 52:1–26
Kim J (1999) Making sense of emergence. Philos Stud 95:3–36
Kim J (2000) Mind in a physical world: an essay on the mind-body problem and mental causation. MIT Press/Bradford Books, Cambridge, MASS
Kim J (2005) Physicalism, or something near enough. Princeton University Press, Princeton and Oxford
Lockwood M (2003) The grain problem. In: O'Connor T, Robb D (eds) Philosophy of mind: contemporary readings. Routledge, London
Lycan W (1996) Philosophy of mind. In: Bunnin N, Tsui-James EP (eds) The Blackwell companion to philosophy. Blackwell Publishers, Oxford
McFadden J (2002) Synchronous firing and its influence on the brain's electromagnetic field: evidence for an electromagnetic theory of consciousness. J Conscious Stud 9(4):23–50
McLaughlin B (1992) The rise and fall of British emergentism. In: Beckermann A, Flohr H, Kim J (eds) Emergence or reduction. Walter de Gruyter, Berlin, pp 49–93
Milner D, Goodale M (1995) The visual brain in action. Oxford University Press, Oxford
O'Connor T, Wong HY (2005) Emergent properties. In: Zalta EN (ed) The stanford encyclopedia of philosophy (Summer 2005 Edition). <http://plato.stanford.edu/archives/sum2005/entries/properties-emergent/>
Papineau D (2002) Thinking about consciousness. Clarendon Press, Oxford
Penrose R (1994) Shadows of the mind: a search for the missing science of consciousness. Oxford University Press, Oxford
Pereboom D (2002) Robust nonreductive materialism. J Philos 99:499–531
Place UT (1956) Is consciousness a brain process? Br J Psychol 47:44–50
Putnam H (1967) Psychological predicates. In: Capitan WH, Merrill DD (eds) Art, mind, and religion. University of Pittsburgh Press, Pittsburgh
Robinson H (2009) Dualism. In: Zalta EN (ed) The stanford encyclopedia of philosophy (Fall 2009 Edition). <http://plato.stanford.edu/archives/fall2009/entries/dualism/>
Ruohonen J, Ollikainen M, Nikouline V, Virtanen J, Ilmoniemi RJ (2000) Coil design for real and sham transcranial magnetic stimulation. IEEE Trans Biomed Eng 47:145–148
Silberstein M, McGeever J (1999) The search for ontological emergence. Philos Q 49:182–200
Stephan A (1992) Emergence—a systematic view on its historical aspects. In: Beckermann A, Flohr H, Kim J (eds) Emergence or reduction. Walter de Gruyter, Berlin, pp 25–48
Teller P (1986) Relational holism and quantum mechanics. Br J Philos Sci 37:71–81
Wilson J (2005) Supervenience-based formulations of physicalism. Nous XXXIX 3:426–459
Wimsatt WC (1997) Aggregativity: reductive heuristics for finding emergence. Philos Sci 64:S372–S384