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# On the Causal Completeness of Physics

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*According to an increasing number of authors, the best, if not the only, argument in favour of physicalism is the so-called 'overdetermination argument'. This argument, if sound, establishes that all the entities that enter into causal interactions with the physical world are physical. One key premise in the overdetermination argument is the principle of the causal closure of the physical world, said to be supported by contemporary physics. In this paper, I examine various ways in which physics may support the principle, either as a methodological guide or as depending on some other laws and principles of physics.*

## 1. Introduction: The Overdetermination Argument and the Causal Closure Principle

According to an increasing number of authors, the best, if not the only, argument in favour of physicalism is the so-called *exclusion* or *overdetermination* argument'.[1] The basic reason for the claim of exclusivity is that the other main thread one may pull in order to argue for physicalism, namely, the one related to unificatory ideals, has been shown to be under threat. It used to be argued that physicalism was true because we had inductive reasons to think that all the sciences were becoming one, or, even better, because for something to be explainable, it had to be capable of being integrated inside a basic framework; if the world was to be intelligible, then its different descriptions had to be unifiable.[2] However, according to some of the aforementioned authors and to what in fact seems to be a widespread view that we will adopt here as a working hypothesis, the reflection started by Fodor (1974) about the special sciences has shown that there is no prospect of all the sciences becoming one, or for physics to provide reducing explanations of the entities that occupy other sciences, since each science proceeds at its own level of generalization and has its own taxonomic and explanatory interests. Thus, there seems to be no *epistemological* argument for physicalism. According to this view, if one wants to argue for physicalism, one has to construe a straight *ontological*

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argument which shows that, no matter how the different sciences individuate and generalize, they are always ultimately speaking about physical entities.[3]

The overdetermination argument is quite straightforward, though it becomes more sophisticated as one tries to find possible refutations of it. It is not supposed to establish physicalism[4] *tout court*, but physicalism of a restricted kind, namely, the thesis that all the entities that enter into causal interactions with the physical world are physical[5]. The argument, thus, is of special concern to the mind, since at least some mental events (i.e. the instantiation of a mental property by an individual) are, on the face of it, clearly involved in causal interactions with the physical world. In fact, the mind has classically been the focus of the present argument, but the argument can be 'exported' to any dubious domain, as long as the instantiation of dubious properties seems to bring about physical effects.[6]

The overdetermination argument consists basically of three premises, namely:

(i) the principle of the causal closure of the physical (CCP): every physical effect (i.e. caused event) has physical sufficient causes;
(ii) causal efficacy of the 'dubious': dubious events cause changes in the physical world;
(iii) no overdetermination: there is no dubious/physical causal overdetermination.

And the conclusion is that

(iv) dubious events are physical events.

The argument can even be simplified if one adopts a stronger version of the CCP, according to which physical effects have *only* physical causes. This version of the CCP, as can be seen, makes the 'no overdetermination' premise unnecessary and thus converts the argument into one of just two premises. However, this strong version of the principle appears *too* strong. If we are to believe in the CCP because it is supported by contemporary physics (see below), then it seems prima facie that physics by itself cannot rule out the possibility that the effects it explains are not in fact overdetermined. Of course, for the sake of simplicity, we do in fact reject this possibility, but if we do so, then this is more like holding the weak version and then denying overdetermination than going straight for the strong version of the principle. In any case, the weak version of the CCP will always be easier to prove, and it is also always easy to exclude overdetermination from a commitment to the simplicity of nature. Basically, nature would not double causes and laws unnecessarily.

Now, even though a great amount has been written on this argument, there is a point of special importance that has not been sufficiently addressed: why should we believe in the causal closure of the physical world? Some of the authors that think this is *the* argument for physicalism, as well as many others, hold that the principle is supported by contemporary physics. However, it is not a law that appears in physics textbooks. Where does it come from? Two answers come to mind. First, it can be said that it is not a physical law, but rather a methodological norm or principle that guides physicists in their research. Moreover, it can be defended that it is a norm well supported by inductive evidence: until now, physicists have confronted just two types of situation: either the events to be explained were uncaused, or they were (sufficiently, say) caused by physical events. That is, physicists have all the inductive evidence required to believe that they do not need anything other than physics to explain all the physical phenomena. Second, it may be said, although the CCP is not strictly a truth of physics, it is supported by, or depends on, actual laws of physics. In particular, it seems possible to link it to conservation laws.

What I propose to do in this paper is to centre on these two possible ways of supporting the principle of the causal closure of the physical. I will start by studying the view that the principle is a methodological or heuristic guide, and then move on to consider the connections between it and some physical laws. My conclusions will be, first, that while an a priori belief in the principle is unfounded, the CCP could perhaps be considered an inductively well-supported generalization. This approach, however, would have to face a problem with the historical record, for the belief in the CCP is intermittent in the development of physics. This intermittence by itself does not imply that our current belief does not stem from scientific induction, but the historical record also shows a coincidence between the belief in the CCP and the belief in some conservation laws. This lends extra plausibility to the idea that the principle may be linked to conservation laws. However, it is not easy to explain how this link works. What I will do is propose a general way to do it, which requires an explanation of causation of physical effects in terms of a specific kind of process.

## 2. Causal Closure of the Physical as a Guiding Principle

According to many authors, a very important part of scientific theories, paradigms or whatever are made up by some quite general laws that serve as guidelines for research. Thomas Kuhn, for instance, called these laws 'symbolic generalizations'[7] and held that they are two-sided: on the one hand, they look like any other laws, but on the other hand, they state definitions and are therefore tautological. Probably, though, their most peculiar feature is that they set the agenda for research within the paradigm, behaving like schemata that have to be filled in (Kuhn's own examples are the law $F = ma$ and the action–reaction principle). Now, perhaps the principle of the causal closure of the physical world may be properly seen as one of these 'guiding principles'. Usually, these heuristic principles work within (and define) a paradigm or theory, and in that regard the CCP would be a bit of an oddity, for it is arguably a principle that works across paradigms. That is, it seems to accompany very prima facie different kinds of physics. In effect, although the belief in the CCP has not been constant in the scientific word-view, it is not exclusive to contemporary physics. Two examples are Epicurean physics, according to which the atomic world of bodies was causally closed, and Leibnizian dynamics.[8] However, this inter-theoretic belief is clearly a minor point: there may be heuristic principles that define not a paradigm or a theory but a whole scientific discipline.

The CCP does look like a guiding principle in some respects: it says something very general or schematic that has to be filled in, and it tells physicists what they have to look for. The equation $F = ma$ is schematic because it obtains different expressions, depending on whether it applies to free fall, simple pendulum, etc. Equally, the CCP obtains different expressions depending on the kinds of physical causes and effects that may be present. Both the law $F = ma$ and the CCP, on the other hand, implicitly contain instructions for the physicists: the former tells the Newtonian scientist how to confront new experiences by trying to apply it; the latter tells contemporary physicists that they should look for physical causes first. However, at one point, the CCP departs from the usual characterization of guiding principles (and specifically, from what Kuhn says about generalizations), which has to do with their quasi-tautological nature. Whereas $F = ma$ may be said to define the concept of force, it is doubtful that 'every physical effect has physical sufficient causes' defines anything. The statement is not analytic (if there are analytic statements): the causal influence of non-physical events on the physical world ('downward causation', as it is sometimes less neutrally called)[9] is entirely conceivable and perhaps even possible.

As has been said, Kuhn pointed out that symbolic generalizations offer a double perspective: as laws among others, and as definitions. The CCP is not a definition, but it seems to have a dual character, too, in this case as an a priori truth and as an a posteriori general law. On the one hand, the principle summarizes the aspiration of physics to be explanatorily comprehensive, which is, more than anything, an epistemic a priori demand (on this demand, see Fair 1979). This means that the principle can be seen not so much as a statement about the world but as an assumption that reflects and obeys explanatory needs or wants.

On the other hand, it is also possible to see it as a truth about the world among others, contingent and a posteriori. According to this second perspective, the CCP just says something very general about the world. It could have not been true (at least assuming that necessity is not exhausted by physical necessity) and its truth is a discovery not about the science of physics, but about what the world is like. Its evidence, as we said above, would be inductive. In what follows, I will briefly explore these two views and their respective justifications. The conclusion will be that, if the CCP is going to work in an argument for physicalism—and not to follow from it—then, if it is a methodological guide, it must be a posteriori. The a priori perspective that it offers does not have an acceptable justification, and so its similarity to typical guiding principles would be restricted to the features of generality and setting the agenda for research. However, there are some reasons for suspecting that the CCP is not *just* a heuristic principle anyway (i.e. one that it is independent of other laws of physics).

### *2.1. Causal Closure of the Physical as a Guiding Principle with A Priori Justification*

Let me take these two views on the CCP in turn, and the criticisms that may be raised against such possible justifications of the principle. The first view is that the principle is not really a factual statement and that it has an a priori justification. Two roads lead to this view. The first, the more ambitious one, stems from a commitment to the idea that everything is and must be ultimately explainable in terms of physics, e.g. that there are 'what is F?' questions and that their responses make use of terms of physics alone.

From this, it follows that there are only physical properties, therefore that there are only physical causes, therefore that all physical effects have physical causes. That is, there must be an ultimate level of more or less mechanistic explanations. However, this sounds like classical reductionism, which, as we said in the introduction, is questionable. This point may be disputed, but if this is the way we take to justify the principle, then the CCP would not be needed (and it could not be used either, on pain of circularity) in order to argue for physicalism.

The second justification for the principle following this a priori thread mentions only the physical domain. The principle would reflect the status of physics as a basic science: given that physics is basic, or describes a bottom-level on which all the rest of entities supervene, it must be explanatorily comprehensive, and the principle must be true. However, it can be questioned (a) whether being basic entails being explanatorily comprehensive, and (b) whether physics is indeed basic. Emergentists would agree that physics is the science of the bottom level; nonetheless, they would claim that it cannot explain everything that happens in its domain, for some causal powers 'emerge' and bring about changes in the physical world that physics cannot explain. As for (b), some authors, such as Cartwright (1994, 1999) and Dupré (1993, 2001), deny that physics is basic in the sense used here, that is, that it explains and describes the bottom level that somehow fixes or determines the rest of the facts of the world.

The usual view of the sciences and the metaphysical structure of the world is that the world is layered, and that each science studies one of the layers. According to the doctrine inspired in logical positivism, such as Paul Oppenheim and Hilary Putnam's view (cf. Oppenheim and Putnam 1958), layers are just descriptive, not ontological, for there is just one layer, the physical. Eventually, these descriptive layers will disappear when all the sciences are reduced to the science concerned with the only ontological layer. Maybe the most usual view today (see Kim 2002, 2005) is that positivists were right in saying that layers are just descriptive, but wrong both in their reductive promises and in drawing a pyramid of layers, formed by physics as its basis, and chemistry, biology, psychology, and sociology consecutively on top of it. The argument for this last claim is that there is no reason why, for example, a psychological property should supervene only on biological properties: silicon-based properties are just as good supervenient bases.

In both views (the pyramidal picture and the multiple realization model), physics deals with the bottom level of description of reality. In both views, it is also defended that no matter what other sciences do, how they taxonomize or generalize, physics can proceed blind to them. One could think that this is so simply because it is basic in relation to all the others. However, the emergentist can adopt either of these general pictures and yet claim that physics cannot explain everything in its domain. The emergentist typically holds that, even if physics is basic—i.e. it is the lowest-level science—there are configurations of basic physical entities out of which emerge entities that are not physical, whose study belongs to another science. An emergentist, thus, reads either of the two models ontologically: there are entities belonging to the different layers, and sciences are not just different descriptions of the same thing. But the point is that the emergentist also holds that the entities that emerge from the physical have downward powers of causation, that is, that they produce changes in the physical world, and so there are physical effects that physics cannot explain. Now, the fact that emergentism is not obviously false shows that from physics being basic, it does not follow that it is explanatorily comprehensive.

All three views (pyramidal, multiple realization, and emergentism) considered have it that physics occupies the basic layer and that the rest of the sciences study phenomena that depend, in one way or another, on what physics studies. Cartwright and Dupré, however, deny this. On their alternative picture, physics, or better, the different disciplines of physics, are just sciences among others. There is a 'reality', a world out there, that is the object of study of every science, but each one takes a different perspective on it. According to Dupré (1993, 2001), just as a gardener takes a perspective on plants that differs from the one taken by a cook (they attend to different properties of plants, and so they build different taxonomies), so the different sciences take different perspectives on the world on account of their different interests. Cartwright (1994, 1999), in her defence of the 'patchwork model' against the pyramidal picture, makes much the same point. According to her, there is no empirical reason to consider that theories of physics speak about the whole of reality. Rather, laws of physics describe more or less accurately highly constrained domains ('nomological machines'), outside which the laws of physics simply do not apply. For instance, Newtonian physics cannot predict where a dollar bill falling from a window in open air will finally land. Since it fails in this and similar predictions, there is no reason to hold that Newtonian laws apply to pieces of paper falling in the open air. Thinking otherwise, i.e. thinking that Newtonian physics applies to the falling dollar bill, is just dogmatic.

Now, this view, when considering the different sciences and their relationships, turns into an unconstrained pluralism. As what (the different disciplines of) physics truly says is restricted to narrow domains, there is no reason to think that physics describes a complete level of reality. Other perspectives on phenomena other than those studied by physics can prove successful: for instance, some biological theories can be judged to be well supported when applied to domains where physics is unable to provide a good prediction. If this is so, then we have reason to believe in the laws of biology for that domain, and we do not have reason to believe in the laws of physics when dealing with such domains. If Cartwright's empiricism is conceded, then the metaphysics we end up with points to a picture where there is a ground level, so to speak, but it is the world, or reality, and not the world-as-described-by-physics.

Cartwright's and Dupré's reflections, then, show that the claim that physics is basic in the sense considered here may be at least disputed.

In conclusion, it is difficult to show that the CCP has an a priori justification. At least, (i) it cannot be justified (in this context) by assuming reductivism, (ii) it does not follow from the fact that physics is a basic science (emergentists assume this, but they deny that it is explanatorily comprehensive), and (iii) it is possible to argue that physics is not basic.

### *2.2. Causal Closure of the Physical as a Guiding Principle with A Posteriori Justification*

As mentioned above, it is also possible to hold that the CCP, while being methodological, has an a posteriori justification. This view would turn the principle into a factual statement. As said above, such a justification would be inductive: in past cases, physical events have been shown to be either uncaused or caused by physical causes alone. Moreover, in former cases where there seemed to be non-physical causes that bring about physical effects, one of these two things happened: either it was shown that such causes were in fact physical, or it was revealed that such causes were spurious and that the real causes were physical.

This way of justification is more promising than the a priori way. There is a first problem, however, with considering that the contemporary belief in the CCP may be grounded on it. Such a problem has to do with the historical evidence. As we explained above and as we will repeat again later, the belief in the CCP has not been permanent throughout the history of science. Rather, it appears for the first time in some more than primary stages in the development of physics (Epicurean physics) and reappears much later, coinciding with some particular versions of physics, namely, some versions that postulate the existence of universally conserved quantities. This is not by any means a knock-down problem for this approach. However, it may motivate that we look at some other place and explore the connections between our belief in the CCP and some conservation laws.

It cannot be ruled out, however, that the *contemporary* belief in the CCP is not well founded on inductive evidence. Epicureans or Leibnizian physicists, it can be said, did not have enough evidence to believe in the causal closure of the physical. So, it is not induction that supports the principle in all cases. However, it can be argued, we do have such inductive support for the principle. Since Leibnizian dynamics, physics has been extraordinarily successful in finding physical causes for all physical effects, even for those that perhaps appeared harder to explain: those concerned with living stuff. That is, it cannot be ruled out that today (but not before), there is enough inductive evidence to believe in the CCP regardless of any other particular physical law.

This approach to the question would use a dual explanation for the belief in the CCP: in past stages of physics, the most reasonable explanation for such a belief is the belief in laws such as conservation laws—for this reason, the CCP rules only when such laws do—whereas at the present stage, besides by the belief in conservation or other actual laws, the CCP is justified by the inductive record, so that if such laws were forsaken, the belief in the CCP would still survive. As I say, it cannot be ruled out that this may be the right approach to the question, even though reasons of simplicity may make us prefer a non-dual explanation, an explanation that would rest in every case on some connection of the principle with conservation laws. However, it is true that there is a difference between our belief in the CCP and Leibniz's, which is that ours is considerably better supported by inductive evidence. It is this difference that makes the dual explanation prima facie appealing.

There is a second question, however, that is worth mentioning and may pose some problems to what has just been said, or, at least, may give the account a harder ride than expected. It seems that the inductive record points towards physicalism. Nonetheless, there are authors who, despite appearances, are reluctant to interpret the history of science in a physicalist-friendly way, and who would surely deny that there is inductive support for the CCP. For instance, some philosophers of biology and of other 'special sciences' hold that, even if it is true that the basis of any process whatsoever is physical, there are 'emergent causal powers', flowing from particular organizations of the physical. That is, even though we know almost everything that happens at the physical level in certain processes (for instance, cellular metabolism), the right interpretation of what goes on must talk about new causal powers that leave their trace in the physical world.

The work of Kauffman (1995) and some followers in theoretical biology, for example, points in this general direction. According to Kauffman, physico-chemical sciences cannot explain by themselves simple processes of living matter, since molecules behave very differently when they form part of a living whole and when they do not. In general, wholes must receive direct attention (by the sciences of complexity) because bottom-up explanations are not illuminating. It is not the parts and their behaviour that explain the whole but the other way around: knowledge of the whole will explain the behaviour of the parts. Niño El-Hani and Emmeche (2000) develop this intuition into an explicit defence of downward causation.[10] In line with Kauffman, they hold that the study of the living has shown that the behaviour of molecular components in a cell is constrained by their being elements of it. Van Gulick (1993) has taken a similar approach to mental causation.

These authors defend downward causation according to could be called 'the basketball team model'. In a basketball team, the players are effective causes of what the team is able to do. However, the behaviour of the players cannot be understood if we forget that they are playing for and in the team. Teams 'selectively activate' the causal powers of the players, and it can even be said that teams 'recruit' players, i.e. that the players are there because they have the powers that the team requires from them. Teams, then, are self-preserving self-organized entities which constrain and partly explain the behaviour of their players.[11]

This model of downward causation may be flawed, of course, as may be the interpretation of how living wholes and their parts relate. The point, however, is that according to these authors, recent developments in science (the newborn sciences of complexity) have revealed that not all physical effects have physical causes. This claim can be denied, but not just by saying that the development of science gives inductive evidence for the CCP. That is, it seems possible to interpret that the inductive record counts against the CCP instead of in its favour ('we are finding more and more parts of the physical world affected by the emergence of complexity'). And if this is to be denied by means of an argument, then we cannot take the CCP as one of its premises saying simply that we have inductive reasons to hold onto it.

So, the persistence of emergentism poses a problem also for this way to support the CCP. But the same goes for Dupré's and Cartwright's views explained above: both authors would deny that there is the inductive evidence required for our belief in the principle. Simply, this principle is unsupported by evidence (see Dupré 2001). That is, by the way, the reason why both Dupré and Cartwright, as committed empiricists, oppose belief in the CCP: since the CCP does not have sufficient evidence in its favour, there cannot be any sound reason to believe in it. Thus, the idea that the CCP is a statement about the world whose truth is founded in empirical evidence must be taken with some care. At least, it is not immediately evident that the case is as claimed. However, it is an idea that I think can be plausibly defended by paying attention to what really goes on in complex systems and, especially, by digging in the history of science, much in the way Papineau (2001) does (see below).[12] However, Papineau's work puts us in the track of another way to ground the principle, and it is to this which I want to turn.

## 3. Causal Closure of the Physical and Physical Laws

As stated above, there is a second way that can be explored in order to justify the CCP, which is by grounding the principle, or making it supervene, on physical laws. As far as I can see, there is no direct entailment from any physical law, or set of physical laws, to the CCP. However, it seems possible to develop this approach in two steps: first, it may be shown that causation, or at least causation of physical events, is a kind of specific process; second, it may be defended with some plausibility that some physical magnitudes, or physical properties in general, can claim responsibility for that specific kind of process. However, this is by no means easy to achieve, as will become clear.

There are two influential reductive views as to what causation is. The first of these views holds that causation is nothing but the action of forces (this is the account defended by Bigelow and Pargetter 1990, but it seems it is also implicitly adopted by many authors, most conspicuously for our purposes, by Papineau 2001). The second has it that causation is the transference, transmission, or exchange of conserved quantities.[13] Both of these accounts, then, explain causation in terms of a particular kind of process: the action of forces in the first, the transference, etc. of some quantities, in the other. However, this reduction of causation to something else is just the first step that has to be taken in order to ground the CCP on physical laws. The second step consists in showing that only physical processes, by which I mean processes involving just physical magnitudes, can play the role of being reductive bases of causation.

In this section, I will try to explain how this account would work for the action-of-forces account, and what problems can be encountered therein. The next section will be devoted to what have been labelled 'conserved quantity theories'.

### *3.1. Forces*

In a very illuminating and, it can be said, seminal paper (which bears witness to the long time the CCP has just been taken for granted), Papineau (2001) has traced the genealogy of the contemporary belief in the CCP to Helmholtz's proposal that energy is universally conserved and the first scientific studies in neurophysiology and biochemistry.

As Papineau tells it, before Helmholtz it was possible to believe that there were vital and mental forces that created energy in the form of movements, and indeed many scientists thought that vital and mental forces were among the fundamental forces of nature, and that they were not conservative. Joule's experiments, which showed that heat was a form of energy, started to change the view of most physicists about whether energy could be lost and/or created, but it was Helmholtz who defended that all forces were energy-conservative. At some point, Helmholtz's views became predominant in science, with the result that dualists' and emergentists' favourite response to reductionism became increasingly unpopular. However, some philosophers and scientists still thought that there were non-physical forces acting on the physical world, thus violating the CCP. Their position then was that such forces conserved the energy.

According to Papineau, there were, and still are, two ways that the defender of the CCP could approach this new issue. On the one hand, there is what he calls 'the argument from fundamental forces'. This argument makes use of the idea that there is a limited set of fundamental forces—three on the present account (i.e. electroweak, strong, and gravitational), just one in the expected future—which can account for all variations in the distribution of energy. This approach, incidentally, is the one taken by Carl Sagan in his famous *Cosmos* series, when he wonders, as against astrological beliefs, how it could be that the planets interfere with our behaviour given that none of the physical forces could be responsible for such interference.

The problem with this argument is that it enables the anti-physicalist to dig in their heels, and claim that it is still open whether the repertoire of forces should include more, non-physical forces. To take Sagan's concern, the defender of astrological beliefs could say that there is at present moment no evidence against the existence of some other (non-physical) ways to mediate between positions of the planets and human behaviours. Of course, physical forces could not fulfil this mediation role, but perhaps other kind of conservative forces could. In the same way, it is open for the defender of vital or mental causation to say that bodily movements are brought about by the action of forces outside the repertoire of physics.

This kind of response is possible, for it is up to the defender of the CCP to prove that the only conservative forces in the world are physical forces. Now can this be done? Papineau defends that we can always try to prove it on inductive grounds: physics is explaining more and more phenomena by means of this limited set of forces and seems to require no extra aid in any case.

This looks like a convincing, though perhaps not a knock-down, argument. Note that, though also inductive, it differs in significant ways from the argument dealt with in the last section. For there, the issue was whether there are any inductive grounds to claim that every physical effect has a physical cause. As 'cause' and 'effect' are somewhat elusive notions, it is not easy to isolate the relevant inductive evidence. Hence, as we saw, when physicalists and emergentists are confronted with the historical record, their diagnoses as to what has been happening in science openly differ.

However, when talk about causes is replaced by talk about forces, and talk about effects is similarly replaced by talk about variations in energy-values, things change, for here the emergentist cannot adduce evidence in their favour. Although, of course, they can quarrel with the reduction of causation to the action of forces and of effects to variations in energy-values (see below).

However, in order to see how the evidence counts in favour of the physicalist, and so how the argument from fundamental forces can be supported, we have to turn to Papineau's second argument: the argument from physiology.

As has been said, although convinced that energy was conserved, a number of philosophers and scientists in Helmholtz's time held that there were non-physical conservative forces leaving their print in the physical world. This was the view defended by physiologists such as von Liebig and Müller, and philosophers like Mill and Bain. However, the first experiments in neurophysiology started to make this move unpopular, as they found no trace of these non-physical forces in the inner boundaries of bodies. And much the same thing can be said about 'vital forces': as biochemistry began its successful career, it became clear that it could provide good and sufficient explanations of biological phenomena. Again, no trace was found of vital forces.

Papineau holds that it was the development of biochemistry and neurophysiology that explains the contemporary 'rise of physicalism'. It was the development of these two scientific programmes that provided the inductive evidence required to make the 'argument from fundamental forces' strong. But more than providing direct inductive support for physicalism (after all, biochemistry and neurophysiology are not physics), what they did was provide negative evidence against mentalism and vitalism.

So, as a way of summing up Papineau's account, we can say that, on his view, the CCP is supported by an argument from fundamental forces which in turn finds its evidence in discoveries in at least biology and neurophysiology.

This would make the truth of the CCP depend on the truth of the following claims:

(i) physical effects are, or involve, variations in the quantity of (the universally conserved) energy possessed by an object (body or whatever);
(ii) the causation of physical effects consists in the action of forces;
(iii) there is inductive evidence, partly negative, for the view that such forces are physical forces.

Let us start by commenting on the significance of the third claim. The CCP is a very general principle which, as has been explained, is typically used in exclusion arguments for physicalism. One form these arguments can take is (see Section 1):

(a) every physical effect (i.e. caused event) has physical sufficient causes;
(b) dubious events cause changes in the physical world;
(c) there is no dubious/physical causal overdetermination.

Now, Papineau has shown that this argument can be very plausibly used against mental dualism. However, it can be objected that it is not exactly this argument that is the strongest against this kind of dualism. As has been explained, in Papineau's hands, the CCP is an inductively supported generalization, supported by other better-supported generalizations such as:

(a′) bodily movements have sufficient neurophysiological causes;[14]

Now if this is so, then the really strong argument against mental dualism would be:

(a′) bodily movements have sufficient neurophysiological causes;
(b) bodily movements have mental causes;
(c) bodily movements are not causally overdetermined.

This argument, incidentally, can be traced back to the problem that Norman Malcolm (1968) stated long ago, namely, '[I]f we bear in mind the comprehensive aspects of the neurophysiological theory—that is, the fact that it provides sufficient causal conditions for all movements—we shall see that desires and intentions could not be causes of movements'. Although I do not have the space to discuss it here, Malcolm's problem (a′–c) is not exactly the initial overdetermination problem (a–c), and admits different solutions.[15]

What I want to bring to our attention here is the following: if we want to use the CCP in order to argue for physicalism, then, given Papineau's claim (iii), what we really have deep down, so to speak, is not an overarching argument for physicalism, but a family of stronger domain-dependent exclusion arguments.

Let me explain: neurophysiology showed that bodily movements had sufficient physical causes by claiming responsibility for the change in the value of kinetic energy that a bodily movement involves. Biochemistry did the same with respect to biological phenomena. But this shows that the CCP is true just in the case that the only 'dubious' domains are the mental and the biological. However, there may be more dubious domains, including the domains that, for the sake of simplifying our exposition, we have accepted belongs or are reducible to the physical, namely, neurophysiology and biochemistry. As has been said, some authors hold that even at the cellular level, there are emergent properties, instantiating the phenomenon of 'downward causation'. It could then be said (with some difficulty, I acknowledge) that these emergent properties cause variations in energy. The physicalist, in turn, should respond to these claims by providing the physical causes of the variations of energy that the emergentists want to ascribe to their preferred candidates.

Besides, the CCP may well be used against all kinds of superstitious beliefs. In such cases, it has to be shown that, e.g. astrological explanations cannot work because their *explananda* involve variations in energy values, and these changes are accounted for by physical forces.

In a nutshell, as the inductive support for the CCP comes from discoveries such as those in biochemistry and neurophysiology, we will have a stronger argument for physicalism if, instead of the CCP, we make use of what such discoveries have taught us (roughly, that vital and mental forces have biochemical and neurophysiological competitors, respectively).[16] That is, domain-specific exclusion arguments are necessarily stronger than arguments that make use of the CCP. After all, on this view, the CCP inherits its plausibility from the discovery of the putative physical causes that compete with putative non-physical forces in domain-specific exclusion arguments.

This should not be taken as a criticism of Papineau's views. Rather, it is intended as a comment on the strength of the CCP when used as a premise in exclusion arguments. The point is: if Papineau is right about the CCP, it is always possible to find a stronger argument against a domain-specific dualism or emergentism.

The use of the CCP can in principle be met by the response, ‘there are non-physical conservative forces implicated here’ (‘here’ pointing to a specific domain). The physicalist would then be obliged to explain how physical forces are really doing the causal work in such a domain. The use of a domain-specific exclusion argument, however, does not admit this kind of response by the anti-physicalist.

Now, as I have reconstructed Papineau’s defence of the CCP, besides claim (iii), there are two other claims on which its truth depends. These are:

(i) physical effects are, or involve, variations in the quantity of (the universally conserved) energy possessed by an object (body or whatever);
(ii) the causation of such physical effects consists in the action of forces.

Can we take these two claims as well established? Or is it possible for the anti-physicalist to deny either of them?

Starting with (i): why should the dualist or emergentist concede that physical effects involve variations of energy? It seems that they could hold, for instance, that non-physical events bring about variations in charge or momentum. To take a silly example, they could claim that non-physical forces are at work even in a classical elastic collision of two bodies carrying equal quantities of linear momentum travelling in the same direction. In such a case, the energy of either body before and after the collision is the same: the only thing that varies is its momentum (not in magnitude but in its vector).[17] So, the anti-physicalist could say that such a variation is due to non-physical forces: claim (i) does not forbid them to say so.

But aside from this admittedly odd and easily answerable position,[18] the dualist or emergentist may hope that there are physical events that do not consist in, or involve, increases or decreases in energy or any other conserved quantity. It is not easy to conceive what these physical events could be like, but the point is that, lacking a principled characterization of what a physical event is, the anti-physicalist may hope to be able to deny (i).

As for the reduction of causation to the action of forces, I think there is room for disagreement. As has been said, the thesis that causation is to be explained by the action of forces was put forward by Bigelow and Pargetter (1990). It is a very controversial thesis. While its main source of controversy comes from its reductive spirit, I take it that it may be controversial even if its intended application is restricted to physical causation, in particular, even if physical effects are understood as claim (i) proposes. Aside from others, a plausible source of worry has to do with the notion of force being too attached to classical mechanics (there may be quantum correlates of forces, but talk of forces as such is not as widespread in quantum theories). It can also be said that forces have a secondary role in physics, at least when compared to conserved properties (although, I have to say, this may be a matter of subjective perceptions, which seem to differ among physicists). The relatively greater attention that conserved quantity theories (see below) have received in contemporary discussions may bear witness to these or similar worries.

To conclude, Papineau presents a defence of the CCP which has the structure mentioned in the opening of this section: he tries to show that causation of physical events consists in a specific kind of process—the action of forces, in his case—and then tries to establish that some physical properties—physical forces—account for this kind of process. In order to do this, he defends that physical events involve variations in energy, and that there is inductive evidence against the existence of non-physical energy-conservative forces. Against this, the dualist or emergentist can question whether (a) this latter claim is as well supported as it is said, (b) all physical events involve variations of energy, and (c) the causation of physical events consists in the action of forces.

### *3.2. Conserved Quantity Accounts*

Conserved quantity (CQ) accounts are one of the alternatives to the action-of-forces accounts discussed in contemporary literature. Variants of these accounts have been developed during the last two decades by Wesley Salmon and Phil Dowe. In what follows, I will briefly explain what they comprise and what they can tell us about the CCP, but I will start with this latter concern. CQ theories, as we will see, explain causation as the transference, transmission, or exchange of conserved quantities. Though this point is not obvious to all,[19] it seems it is an account that is supposed to apply to all types of causation: any causal interaction of any type should in principle be explainable as the transmission, etc. of some conserved quantity. Now, if we were to restrict its application to physical causation, we may hope to be able to establish that physical causation is the exchange of physical conserved quantities (mass-energy, linear and angular momentum and charge, if these are the physical properties that are universally conserved). What this hopefully means is that physical effects must consist in variations of physically conserved quantities. As a result, we would have found a way to remove the worries expressed before about the characterization of a physical effect and the justification of the claim that physical effects involve variations in energy. For if the CQ theory were correct, we would have both a widening of physical effects to variations of any conserved quantity (not just energy), and a justification for considering only such variations as physical effects.

So, CQ accounts have the virtue of defining physical effects as variations in conserved quantities, and thus block some anti-physicalist reactions to the CCP. However, the virtuosity of CQ accounts would not finish here. We have seen that the main quarrel with the dualist or emergentist, once conservation laws are taken as established, revolves around the existence of non-physical conservative forces. CQ accounts, however, dispenses with forces: forces are not causes, and causes are not forces. To repeat, both causes and effects are defined as variations in conserved quantities. Hence, if physics says that some physical magnitudes are conserved both locally and universally, and physical effects are variations in the values of physical magnitudes, then it seems that we must have physical causes for all physical effects. To simplify, any increase or decrease in a conserved quantity possessed by an object (a physical effect) would be accompanied by its correspondent decrease or increase in another (its physical cause). In a nutshell, the issue of non-physical forces does not seem to arise within the CQ framework. Let us see whether this is really so.

Although traceable to David Fair's transference theory, contemporary CQ theories develop from Salmon's (1984) mark-transmission account. Salmon's primary goal was to distinguish physical causal processes from pseudoprocesses. His theory was articulated by means of the following definitions: (i) a process is something that shows a consistency of characteristics; (ii) a mark is the alteration of a characteristic that occurs in a single local intersection; (iii) a causal process is a process capable of transmitting marks; (iv) a causal interaction is an intersection of two processes whereby both are permanently marked.

With this apparatus, Salmon drew the demarcation line between causal processes and processes such as the movement of a shadow. His most widely discussed example is that of a beacon rotating in the centre of a circular building. A brief pulse of light going from the beacon to the wall is a causal process. If a red filter is placed in its path, the pulse turns red, and remains red from the point of intersection to the wall without further intervention. In contrast, the spot of light that travels around the wall is a pseudoprocess. It can turn red for a moment if, for instance, one places a filter on a point of impact on the wall, but from that point onwards, the spot will not be red without further intervention.

Salmon's theory was later improved on by Phil Dowe's conserved quantity theory. This CQ theory can be stated by two premises:

> CQ1: A *causal interaction* is an intersection of world lines which involves exchange of a conserved quantity.
> CQ2: A *causal process* is a world line of an object which possesses a conserved quantity.

According to this theory, the spot of light, in its movement around the wall, has velocity and luminosity but does not have energy, momentum, or charge. Any of these would belong to the light pulse and to the wall over which it impacts (see Dowe 1992, Salmon 1997). The vague concept of mark thus acquires a definite meaning: marks are changes in the values of conserved quantities. In this sense, the conserved quantity theory improves on the initial mark theory: it coincides with the mark theory's diagnoses but is deeper and more precise. As a matter of fact, the conserved quantity theory can explain why the movement of a shadow or of the rotating spotlight in the circular building is not a causal process. Properties such as velocity cannot be transmitted, transferred, or exchanged, because they are not conserved. In classical mechanical interactions, the incident momentum equals the salient, and thus it can be said that one of the objects transmits its momentum to the other, or that they exchange their momenta. Nothing of this sort can be said about velocity: the incoming velocity may vanish in great part. It is thus explained that a process that has velocity but not mass cannot be a causal process. In order to be a causal process, it is necessary to have some property that can be transmitted or exchanged, and this means a conserved property.

Now, while Fair was explicit in presenting his transference theory as a physicalist account of causation, Salmon and Dowe are not committed to a physicalist reading of their theory. Fair held that all causal *relata* had to be reducible to physical events, since only physical events could be involved in the transference of energy. It is not easy to find a similar statement in Dowe's writings. When presenting his account, he usually adds that the conserved quantities in question are universally conserved quantities, and lists mass-energy, charge, and momentum. Moreover, his and Salmon's examples deal with physics. However, it is controversial whether the theory demands a physicalist reading: for all that it says in CQ1 and CQ2, it could be applied to any sphere of reality, or even to any exchange where some property is locally conserved.

If there were good reasons to go along with Fair, and hold that all causation in the world is transference (or transmission, or exchange) of energy (or some other physical conserved quantity), then the CCP would be verified straight away. If all instances of causation are exchanges of conserved quantities, then not only do all physical effects have physical causes but also all effects whatsoever have physical causes (and only physical causes). But if this is conceded, the widest species of physicalism would be established (not just the restricted kind—of events causing physical events—that we are considering here). If the only events (or processes) that can enter into causal interactions are physical events, then there is reasonably nothing but physics, at least if a causal criterion of reality is adopted ('to be is to have causal powers'). However, as I say, there is no convincing reason why we should buy into this physicalist reading of CQ theories.

So, what do CQ theories tell us about the CCP? As stated above, it seems that CQ theories offer a definite characterization as to what a physical effect is. CQ theories say that an (unqualified) effect is to be considered as the variation in the value of a conserved quantity. On the other hand, physics says that there are various physical quantities that are universally and locally conserved. It seems to follow, then, that all physical causal interactions must involve the exchange, etc. of one or other of these quantities. And from this, it appears safe to extract the idea that to be a physical effect is to be a variation in the value of one of these conserved quantities.

Now, if this idea of how we could define physical effects were valid, we would be in a position to claim that physical effects require physical causes. There could not be an increase or decrease in the value of a conserved quantity at $t$ (a physical effect) without its corresponding decrease or increase in the value of that same quantity at $t'$ (a physical cause).

So, it seems that the CQ account would allow us to make some significant improvements in our search for a justification of the CCP. On the one hand, CQ theories support the claim that physical effects are variations not just in energy but in any other physical conserved quantity: there must be a change in the value of a conserved quantity instantiated by an object when what is brought about is a physical effect. On the other hand, and more importantly, it assures us that such changes, or physical effects, have other changes in physical conserved quantities as their causes. These changes, in turn, could be characterized as physical causes. In a nutshell, CQ theories allow us to think of physical effects and causes as variations in conserved quantities, while conservation laws allow us to claim, besides, that any physical effect has a physical cause.

However, perhaps this is all too easy. In the last section, we saw that it was open for the anti-physicalist to show some scepticism about—apart from the reduction of physical effects to variations in energy values—(a) the reduction of causation to a specific kind of process—action of forces, in that case—and (b) the claim that only physical forces are conservative. Could the dualist or emergentist not resist the application of CQ theories on grounds similar to these?

First of all, CQ theories are at least as controversial as action-of-forces accounts. For instance, they do not do justice to the directionality of causation, making it dependent just on the parameter of time, which, given the possibility of backwards causation, is a risky choice. Also, they have the prima facie undesirable consequence of regarding worlds where no property is conserved as lacking causal relations.[20]

Second, it may be defended that there is still room for the anti-physicalist concerns with non-physical entities doing some causal work. In the last section, these concerns were put in terms of forces, under the assumption that causal interactions in physics are mediated by the action of forces: dualists or emergentists, it was said, may claim that there are conservative forces that are not physical, say, mental or vital forces. The answer to this problem was to go case by case showing that there was no trace of these forces, and that every change in the value of a conserved quantity instantiated by an object was due to the action of a physical force (if there is more than one). However, it might be said, this (finally, inductive) method may not be a completely satisfying way to ground the CCP, since it leaves room for some scepticism about its generality.

If we adopt Dowe's view on causality in physics, the problem would seem to be that the anti-physicalist can say that some variations in the values of certain conserved physical properties are accompanied by inverse variations in the values of certain non-physical properties. That is, an increase in, for example, the kinetic energy possessed by an object could be accompanied by a proportional decrease in the vital or mental (or astrological, etc.) energy of another. After all, it is not uncommon to hear the defender of pseudo-sciences speak of odd forms of energy.[21]

Prima facie, this may look like a difficult way to go. CQ theories in effect leave it open whether only physical properties are conserved. For all they say, there may be non-physical conserved quantities which are used as marks of causation. For instance, odd-energy may be conserved, and there may be causal interactions that exchange odd-energy. However, that there are non-physical causes which bring about physical effects requires, on this account, that there be exchanges between odd-energy and energy. This, it may be said, is forbidden by the principle of the conservation of energy. In any local interaction, energy must be conserved.

Yet, the anti-physicalist may try to motivate some scepticism. Imagine that, in effect, energy is universally conserved. However, it is also a law that odd-energy-plus-energy is conserved in the world. That law, moreover, holds in a way such that every local conversion of energy into odd-energy is followed by a similar conversion of odd-energy back into energy. Then, the following alternative picture to what we think really happens would be possible: neurons fire and bring about an increase in the odd-energy possessed by my brain or whatever; after that, a 'firing' of my odd-properties and a loss of odd-energy cause my arm to move. This would mean that at least there are some exchanges between energy and odd-energy, or, if it is preferred, that some exchanges of energy are mediated by exchanges of odd-energy. From the point of view of physics, such weird exchanges would probably be described just as slow transferences of energy. Given the non-physical nature of odd-energy, it would just seem as if some losses or gains in energy had taken some time in being adjusted by similar gains or losses. In any case, it seems that the problem of non-physical conservative forces strikes back by means of an analogue.[22]

Again, the only answer the physicalist can come up with is that, on the one hand, there is no trace of such odd-energies and, on the other hand, there is evidence of exchanges of plain energy everywhere, so to speak. For instance, if what the presence of odd-energy would look like from the point of view of physics is as I have said, then it would be good if we found no trace of such slow energy transferences. In any event, what we require in the end is that there be enough inductive evidence supporting the view that conserved quantities are not locally and momentarily transformed in something else. We seem to have such inductive evidence, which supports the view that energy as a physical magnitude is universally locally conserved, in the same way that we seem to have inductive evidence for the claim that only physical forces bring about variations in conserved quantities. As explained before, we can consider such inductive evidence more robust than the inductive evidence we may have for a direct defence of the CCP (see section 2.2).

To sum up what has been discussed in this and the earlier section: the CCP would be on safer grounds if we could show, first, that causation of physical events is a specific kind of process and, second, that such a process is physical through and through. We have tried two ways to fulfil this programme: by reducing causation to the action of forces and by explaining it in terms of exchanges of conserved quantities. Although it may be said that the CQ approach has the advantage of providing a good characterization of physical effects, it has to be acknowledged that both kinds of reduction are questionable on their own. Yet, this is not the main problem we have found. The main problem has to do with the impossibility to rule out, by deductive argument, the existence of non-physical causes, be they conservative forces or conserved properties. The existence of such alien entities can only be questioned on inductive grounds. However, as was said before, the CCP is still on much safer grounds under this general approach. The inductive evidence may be controversial if what is discussed is whether all physical effects have physical causes. But if it can be shown that causation of physical events is something else, like action of forces, or exchanges of conserved quantities, the inductive evidence for the CCP is less disputable, to the extent that disputing its truth entails disputing a claim of physics.

The line taken here, however, has the drawback of making the CCP dependent on specific theories of causation in physics. What if CQ theories and the action-of-forces account turn out to be wrong? Would we lose confidence in the principle if the theories were forsaken? I am not convinced. For instance, I bet that our belief would remain undisturbed by the eventual failure of Dowe's account: to begin with, it both antecedes and is much more widespread than, the confidence in CQ theories. So, there seem to be reasons to believe in the principle which are independent of any theory of physical causality.

Finally, it may be claimed that this account has another shortcoming, namely, that it makes the truth of the CCP contingent on the truth of conservation laws plus perhaps some claim about physical forces.[23] That is, it gives no particular reason to think that the principle will continue to hold for new physical theories. It is not clear, in the light of the historical record, that this is a shortcoming. As has been said, it seems that science has advocated the CCP at only two moments in history: one is the aforementioned period started by Helmholtz; the other is Leibnizian mechanics, which held that both linear *momentum* and kinetic energy were conserved. To these, we should add, as has also been said, Epicurean physics, which may have implicitly believed that some property was conserved. So, from this point of view, it can be said that rather than being a shortcoming of the account, this is in fact one of its strengths, since it is able to explain the seeming co-variation between the belief in conservation laws and the belief in the CCP.[24]

However, it cannot be ruled out that, as has been mentioned before, today there are no more reasons to believe in the CCP than in the past, reasons that plausibly have to do with the storing of positive evidence in favour of the CCP. That is, it may be that the contemporary belief is today overdetermined by the 'methodological approach' and the 'supervenience on physical laws approach'. Perhaps, then, the belief in the CCP would survive the rejection of conservation laws, but, again, it seems that it would lose some of its strength.

## 4. Conclusions

Some authors hold that the overdetermination argument is the most powerful argument in favour of (a restricted kind of) physicalism. The overdetermination argument consists in three premises, one of which is the principle of the causal closure of the physical world, said to be a truth of contemporary physics. In this paper, we have examined two different basic ways of understanding this idea that the principle is a truth of physics, given that it is not found in textbooks. The first way is to see the principle as an heuristic principle. It has been ruled out, in this context, that the CCP may be a priori, but it has been said that it might be an inductively supported methodological guide.

The second way is to consider that the principle forms part of physics because it is supported by laws that figure in textbooks. Here, it has been defended, we have to proceed in two stages: first, we have to explain causation of physical effects in terms of a particular kind of process; then we have to show that only physical processes or events can be causes so understood. It is in this second stage where we will find the help of physics, be it via the statements that forces must be conservative and that they are reduced to three (one, or whatever), or via only conservation laws. One could question whether the attempt to explain what causation of physical effects is can be successful. More importantly, the anti-physicalist may try to make it doubtful that we have evidence against non-physical conservative forces and/or non-physical conserved quantities. However, it seems that we do have such inductive evidence to more than a reasonable degree, so that the CCP could be taken as the default truth, though it should be noted that if we are concerned with overdetermination arguments, we can have stronger domain-specific exclusion arguments. In such arguments, we would find pieces of the inductive evidence we have for the CCP acting as premises. Finally, as I say, it seems also plausible to hold that, even if this second kind of attempt were to fail, we would still have enough direct inductive evidence for our belief in the CCP.

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**Notes**

[1] Some examples: Peacocke (1979), Papineau (1990, 2001), Antony and Levine (1997), Sturgeon (1998), and Levine (2001).

[2] This positivist inspiration for physicalism can again be found in some contemporary authors, who defend new versions of identity theories, such as Block and Stanaker (1999) and Polger (2004). According to this view, an identity theory is supported by an inference to the best explanation argument. Furthermore, authors such as Devitt (1996), who insist on the importance of 'what is F?' questions, can be read as requiring physicalism from epistemic needs. All these authors, however, have to face the so-called 'problem of multiple realizability', which in its most neutral version holds that, as a matter of fact, scientific taxonomies do not fit the reduction schema, for the conceptual cuts of special sciences correspond to a disjunction of concepts of physics.

[3] I should stress that I do not want to be committed to a rejection of the unificatory programme. My intention here is to analyse the strength of the overdetermination argument (of one of its premises, in fact) under the assumption that it is at least more convincing than the classical arguments for reductionism.

[4] Physicalism is usually stated by means of a supervenience thesis, according to which any possible world that is a minimal physical duplicate of the actual world is indiscernible from it in all respects (see Jackson 1998).

[5] By 'physical entities', I mean 'entities postulated by a true theory of physics'. There is a problem with this understanding of physicalism, due to our ignorance of this true theory and therefore of what entities we are in fact speaking about (see Crane and Mellor 1990). I will just assume that there is a solution to this problem, and that the true theory of physics will not include mental (or, in general, dubious) concepts in its repertoire. Another thing worth mentioning is that physicalism as I will understand it here speaks about physics 'considered strictly', and not about a broad construction of 'the physical'. The same goes for the term 'physical world': such a world is the world as depicted by the true theory of physics.

[6] Besides other possible considerations, there is at least a reasonable doubt as to the status of uniqueness of the argument from overdetermination, which is that some deeply committed physicalists (or, rather, naturalists, but the overdetermination argument is also presented as *the* argument for naturalism; see Antony and Levine 1997) take it that mental states are not

causally efficacious. For instance, Millikan says that 'on the account of this essay, the semantic category of a thought is determined relative to its biological functions, which depend in turn upon its history, upon its place relative to certain prior events. But having a certain history is not, of course, an attribute that has "causal powers"' (Millikan 1993, 136).

[7] This label is not very fortunate, since there are what one would call 'symbolic generalizations' that do not look like methodological guides (equations, for instance), and also there are methodological guides that one would not call 'symbolic generalizations': Kuhn's own example of the action-reaction law is one of these. For this reason, I will switch to the label 'guiding principles', used in the structuralist literature with roughly the same intended meaning as Kuhnian generalizations. This terminological change, as well as the idea that the CCP could be considered one of these guiding principles, was suggested to me by Ulises Moulines.

[8] From the belief in the CCP (plus the belief in mental causation), Epicureans inferred the material nature of the soul. Leibniz, however, did not deduce the physical nature of the mental from the principle. As he believed in the non-physical nature of the mind, he opted for parallelism.

[9] The talk of 'downward causation' implies that physics is the bottom-level science and that all supervenes one way or another on the physical. However, this may be a controversial view, as will be explained.

[10] See also the essays contained in Andersen et al. (2000). There, Moreno and Unmerez, for instance, defend emergentism at the cellular level. El-Hani and Pereira (1999) make much the same point as El-Hani and Emmeche (2000).

[11] Van Gulick says that brains are 'self-sustaining or self-reproductive in the face of perturbing physical forces that might degrade or destroy them'. Also, 'it is because of the existence and persistence of the pattern that the particular constituents of its instances were recruited and organized as they are' (Van Gulick 1993, 252).

[12] At the present stage, I can only say that I have some doubts that the 'basketball team model' may be applicable to non-intentional entities and that I also doubt that there is a notion of causality that can be used to explain this kind of 'downward causation'. It is a topic, in any case, that must wait for another occasion. In the present context, I only mention it in order to show that there are authors who discuss the inductive record usually assumed to be favourable to the CCP. Incidentally, this does not mean that I think that it is not possible to found our belief in the CCP in scientific induction. As I have said, and will say again later, it appears to be a promising route, only that (a) the historical record suggests the approach of conservation laws and (b) this latter approach makes it possible to give a definite closed sense to the principle by which we can exclude the intervention of non-physical causes in the physical world.

[13] On transference, see Fair (1979), on transmission, Salmon (1984; 1997), and on exchange, Dowe (2000a). In what follows, I will use all these terms as if they were synonymous. They express clearly different notions, but I do not think these differences are relevant for our present purposes.

[14] Let us assume, for the time being, that neurophysiology and biochemistry are reducible to physics.

[15] A very brief hint: Fred Dretske (1988) holds that mental events are the structuring causes of behaviour, while neurophysiological events trigger it. That is, mental and neurophysiological events are different kinds of causes, and so they do not compete: mental events as structuring causes are responsible for the fact that neurophysiological events trigger behaviours. This is a possible non-reductivist solution to Malcolm's problem. Yet, it is unlikely that Dretske's account may provide a non-reductivist solution to the problem of mental causation if, instead of (a'), we have the original causal closure principle, for in that case it seems that the principle (arguably) establishes that structuring causes must be physical.

[16] Although we would still have to show that neurophysiology and biochemistry are reducible to physics.

[17] One can say that in such a case, the first body has the second's energy, and vice versa. This would be allowed by Fair's notion of transference, but not by more empiricist *at-at* accounts (see Salmon 1997).

[18] There is no reason why the physicalist could not complement energy with charge, momentum, or any other physically conserved quantity.

[19] Not at least to Fair—see below.

[20] Perhaps our world turns out to be one of them. On the modal implications of CQ theories, see Kistler (1997), Dowe (2000b), Vicente (2002). There are several other, apparently severe, problems with Dowe's individuation of objects.

[21] From now on, I will mainly deal with energy. It must be kept in mind, however, that physical effects are not restricted to variations in energy.

[22] As a referee has pointed out, this is as it should be, given that, at least in classical physics, forces and energies are interderivable (for instance, force is the negative spatial derivative of potential energy). Yet, it seems to me that the 'sound' of the anti-physicalist positions is not the same. It is one thing to say that there might be non-physical conservative forces and another to suggest that there are local interactions where, contrary to received wisdom, energy is not conserved. To my ears, the first claim, or, rather, the first way of putting things, sounds less committal. But this may be subjective, and in any case I want to stress that it is a question about 'sounds' (colouring, as some would say).

[23] Against this idea, it can be said that Cartesian mechanics held that there was a property that was universally conserved, quantity of movement, yet Cartesianism also held that the mental substance brought about physical changes. In the Cartesian framework, what the mind could do is change the direction of the moving particles (see Lowe 2000 and Papineau 2001 on this point). This fact could make us qualify our view: not just any physical theory that holds that some property is conserved holds thereby that the physical world is causally closed. But it is not clear that Cartesianism counts against the view presented here rather than confirms it, for in a theory such as Cartesian mechanics, physical causal interactions cannot be the exchange of conserved quantities either. The change in direction of a movement is a physical effect that does not result from such an exchange (one does not have to think of non-mechanical interactions or forces: it is enough to think of an elastic interaction of two bodies of equal mass and velocity colliding elastically with the same direction. There is a physical effect of this collision, namely, the change in the sense that each of the bodies follows, but it is not the result of the exchange of their quantities of motion).

[24] The link with conservation laws is made explicit under the CQ approach: simply, there cannot be any physical effects if there are no physical conserved quantities. But the co-variation between conservation laws and the belief in the CCP should be explained in a different, neutral, way. My hypothesis is that conservation laws block the 'easy response'—there are causes that create energy, momentum, or whatever. They force the anti-physicalist to defend the existence either of non-physical conservative forces or of odd forms of energy, etc., transformable into energy, etc., and this looks like a harder route.

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