Cartwright on wholism

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Abstract

This paper proposes a critical examination of the wholism that Cartwright contemplates. The first part spells out the consequences of this position – notably our principled ignorance of nature as a whole. The second part considers that physical theory which is widely claimed to exhibit some sort of wholism, namely quantum physics. I sketch a wholistic model of quantum physics and compare this model to the wholism that Cartwright considers. The result is that – contrary to what Cartwright suggests – we do not have to see ourselves as being ignorant of nature as such and our scientific view of nature can be quite systematic instead of being a patchwork. Finally, Cartwright's wholism is confronted with confirmation wholism and semantic wholism. The result is again that these sorts of wholism speak against a patchwork view of our knowledge.

1. Wholism as a metaphysical background for anti-fundamentalism

Nancy Cartwright is famous for rejecting fundamentalism in the sense of the view that the laws of nature reduce in principle to the laws of one fundamental physical theory or supervene on a set of fundamental laws. Instead, there is a patchwork of laws, that is, several groups of laws that are not related to each other in a systematic or uniform way.[1] By a law of nature, Cartwright means a necessary regular association between properties.[2] Consequently, she claims that our description of nature cannot even in principle be reduced to one fundamental theory. There is an irreducible plurality of different theories each of which has its own limited area of application. There is no systematic relation between these theories.

Note that what Cartwright calls fundamentalism is a more general position than what is known as fundamentalism in the epistemological debate about fundamentalism versus wholism. A fundamentalist in Cartwright's sense need not subscribe to the claim that there is one foundation of knowledge – such as the sense data of the classical empiricists, the Cartesian *cogito* or the Kantian transcendental unity of apperception – which is unshakeable in the sense that it is the point where justification comes to an end, justifying itself. A fundamentalist in Cartwright's sense is anyone who holds that there is a basic description of the world to which all other true descriptions can in principle be reduced. What is more, according to Cartwright, to be a fundamentalist, it is sufficient to endorse global

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1 See in particular Cartwright (1999).

2 For instance Cartwright (1999), pp. 4, 49.

supervenience – the view that there is a basic level of the world on which everything else supervenes.[3]

Cartwright does not regard her anti-fundamentalism as a version of anti-realism *tout court*. She takes herself to be a local realist, that is, a realist about a wide variety of phenomenological laws that have a limited domain of application each.[4] To avoid being classified as an anti-realist, however, Cartwright has to do more. On the one hand, she has to say something about the relationship between these domains. On the other hand, in order to steer clear of fundamentalism, what holds these domains together cannot be anything like universal laws. As an antidote to both anti-realism and fundamentalism, she contemplates a metaphysics of wholism in the following sense: Nature is one interacting whole. Different theories carve out different aspects of this underlying whole. The whole cannot be adequately described by any one of these theories or any combination of these theories.[5] This metaphysics of wholism is attractive in the context of Cartwright's position, because it seems to explain both why there is a patchwork of laws and how the different domains that these laws describe hang together.

The aim of this paper is to inquire whether Cartwright's anti-fundamentalism might be supported by a metaphysics of wholism, independently of whether or not Cartwright is in fact prepared to endorse such a metaphysics. In this section, I consider Cartwright's wholism and its relationship to her anti-fundamentalism as well as her metaphysics of capacities. The following two sections compare the wholism that Cartwright contemplates with those areas in contemporary philosophy in which some sort of wholism is widespread: the interpretation of quantum physics on the one hand and semantics on the other hand. The aim is to establish whether or not a metaphysics of wholism can lend support to anti-fundamentalism.

In her paper "Can wholism reconcile the inaccuracy of theory with the accuracy of prediction?", Cartwright (1991) sets out her aim as follows:

> I begin with the observation that the laws of physics are true only of what we make. … We do not measure the success of modern physics by its ability to explain the material world around us as it naturally comes but, rather, by its ability to create very particular environments in which nature behaves in highly regular and precisely predictable ways, as in a laboratory, where we put our theories to the test, or in new pieces of technology, where we put them to use, as with the hydrogen bomb or the laser.
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> This observation bears on recent debates about scientific realism. A kind of anti-realism is an easy next step. If the laws of physics are true just of what we make, then there is a sense in which we make the laws of physics true. In this paper I want to give a model about how this might be the case. The model begins with the assumption that nature is far more wholistic than we imagine; using the model I then try to explain why our atomistic descriptions can be deployed to produce such precisely accurate results. (Cartwright (1991), p. 3)

Cartwright thus starts from her patchwork view: what we take to be laws of nature has only a very limited application, that is, an application confined to situations that are like those ones which we create in a laboratory. Nevertheless, she has to explain the success of science, which constitutes the main argument for a fully-fledged scientific realism. According to what

3 For instance Cartwright (1999), pp. 32–33.

4 For instance Cartwright (1999), p. 23.

5 See in particular Cartwright (1991) and compare Cartwright (1999), pp. 29–31.

is known as the no miracles argument for scientific realism, the success of our scientific theories in the prediction of novel phenomena would be a miracle if our theories were not approximately true, that is, if they were not accepted as giving an approximately true description of what the world is really like.[6]

According to Cartwright, modern science proceeds by induction: on the basis of descriptions that prove to be applicable to the situations that we ourselves create, we make an induction to general laws of nature. Cartwright maintains that this induction leads to a wrong result. She offers wholism as a model of how it can be possible that, although our theories are wrong from a perspective larger than the one of the situations we ourselves create, they have worked so far with amazing success. She says:

> The most immediate way to parley a wholistic intuition into a model for anti-realism is to imagine cases in which the variations that we find salient are determined within a far larger context; yet, like the chicken [Russell's example of a chicken whose induction works for a time, but is fatally wrong], we encounter them only during an epoch in which the relevant background remains relatively stable. (Cartwright (1991), p. 7)

To elaborate on this wholistic model, Cartwright takes an example from economics:

> Haavelmo … imagined the economy to be governed by a set of linear, simultaneous equations, containing random shock terms. … They do describe separate and stable mechanisms which can be manipulated and deployed to produce predictable economic consequences. (That's the hope at least.) But the existence and stability of these mechanisms is an epiphenomenon of the entire economic and social context. They can, so to speak, be 'carved out' of this whole; but what we carve out need not be there to begin with. … The punchline is of course that the fundamental laws of physics may not be so fundamental either. Just as Haavelmo hoped conceptually to carve out separate mechanisms from an underlying interacting whole, physics carves them out physically. By choice and arrangement of materials and either by intensive shielding or heavy over-determination, we create special environments which hold fixed the principle effective parts. We may in this way arrive at very precise and reliable regularities without in any way grasping the true form of what is going on. (Cartwright (1991), pp. 8–9)

The idea hence is that nature as a whole is far more complex than we might imagine. Our theories carve out certain aspects of nature and we create the environments that are necessary for our predictions to work, that is, environments which keep certain factors stable and which eliminate other disturbing factors. However, we cannot develop a true fundamental theory of nature as a whole. This wholistic metaphysics has a Kantian ring: We know only the way in which nature appears to us – that is, the various aspects which our theories describe and which we create in our scientific and technological activities; but we cannot know what nature is like in itself – that is, we are ignorant of nature as a whole. This is a principled ignorance, since Cartwright's point is that there can be no true or approximately true fundamental theory that applies to nature as a whole.

How does this wholistic metaphysics relate to Cartwright's theory of capacities? According to Cartwright, capacities are more basic than laws. A capacity is more general than a disposition: it is not tied to any single kind of manifestation. In other words, capacities are determinable, whereas dispositions are determinate.[7] She says:

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6 See, for instance, Putnam (1975), p. 73.

7 See Cartwright (1999), p. 64.

> It is capacities that are basic, and laws of nature obtain – to the extent that they do obtain – on account of the capacities; or more explicitly, on account of the repeated operation of a system with stable capacities in particularly fortunate circumstances. Sometimes the arrangement of the components and the setting are appropriate for a law to occur naturally, as in the planetary system; more often they are engineered by us, as in a laboratory experiment. But in any case, it takes what I call a *nomological machine* to get a law of nature.(Cartwright (1999), p. 49)

Capacities "can be assembled and reassembled in different nomological machines, unending in their variety, to give rise to different laws".[8]

According to a position that is widespread in philosophy of science, capacities, powers or dispositions require something that has the capacities, powers or dispositions in question. That something cannot consist solely of capacities and the like; over and above that, it has to have some intrinsic properties or other that are in some sense a basis for its capacities (although it is not necessary that the capacities supervene on the intrinsic properties). This reasoning also leads to a sort of Kantian metaphysics of nature: Scientific inquiry can only reveal the capacities of the things in nature, but not their intrinsic properties. We can thus only know the way in which things appear to other things including ourselves by manifesting certain capacities, but not what they are like in themselves. We have no access to their intrinsic properties.[9]

This is also a metaphysics that one might contemplate employing as a basis for anti-fundamentalism (although none of the authors referred to in the last footnote intends to receive this metaphysics in that way): we know only the manifestations of capacities, but not what it is in the things themselves in virtue of which they have various capacities. Cartwright, however, rejects such a metaphysics. According to her, it makes no sense to draw a distinction between – intrinsic – properties and powers:

> As we represent the world, objects have properties, and by virtue of having properties they are empowered to do things, in particular to change facts about properties in other objects, including facts about what we perceive and what we experience. … Thus the question of whether every dispositional property is grounded in an occurent property makes no sense. There just are properties and all properties bring powers with them.[10]

Cartwright is prepared to endorse the view of Shoemaker (1984), chapter 10, according to which properties consist in their causal powers.[11] Consequently, she is not committed to intrinsic properties: all properties may in the last resort turn out to be relational.

The position that dispositions or capacities are grounded on intrinsic properties gives rise to an atomistic metaphysics: the essence of things is their intrinsic properties. Intrinsic are all and only those qualitative properties that a thing has irrespective of whether or not there are other contingent things. That is to say, having or lacking an intrinsic property is independent of accompaniment by other things or loneliness.[12] Consequently, things are held together not in virtue of what they are in themselves, but in virtue of the relations they enter into.

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8 Cartwright (1999), p. 52. As to capacities, see the whole chapter 3 in Cartwright (1999) and Cartwright (1989), in particular chapter 5.

9 See in particular Foster (1982), chapter 4 including the appendix, Jackson (1998), pp. 23–24, and Langton (1998).

10 Cartwright (1997), p. 74. See also Cartwright (1999), p. 73.

11 Cartwright (1999), p. 70.

12 See Langton & Lewis (1998) and for a refinement Lewis (2001).

Cartwright's reservations about such a position link up with her wholism: if there is no distinction between properties and powers, then things are connected by their very nature; manifesting their capacities in causal interaction is their essence. Cartwright's metaphysics of capacities can thus be combined with a view of nature as being one interacting whole instead of there being unknowable intrinsic properties of individual things on which their dispositions are grounded. In other words, a metaphysics of wholism can be employed in order to counter the argument that capacities presuppose intrinsic properties. Our ignorance concerns the fact that we cannot know nature as a whole, but only various aspects of this whole.

2. *A wholistic model from quantum physics*

One would like to know more about this wholism than just learning that nature is one interacting whole and that our theories carve out different aspects of this whole, thereby simplifying its real complexity. When it comes to wholism with respect to the domain of physics, there is one physical theory that is often received as revealing some sort of a wholistic feature of nature, namely quantum theory. The purpose of this section therefore is to sketch a model for a wholistic metaphysics of nature based on quantum theory. The aim is to spell out wholism as precisely as possible on the basis of our current knowledge in order to see whether a wholistic metaphysics really supports Cartwright's anti-fundamentalism.

Quantum systems often have to be described as being in what is known as entangled states: there is no description available that attributes to the quantum systems in question a well-defined state each. Instead, only the whole of these quantum systems taken together is represented as being in a well-defined state (that is, a pure state). That state of the whole includes correlations between the conditional probability distributions of properties of its parts. These correlations are known as EPR-correlations following a famous paper by Einstein, Podolsky & Rosen (1935). These correlations are independent of any spatio-temporal distance between the parts of the whole in question. They are well confirmed by experiments, notably experiments that carry out measurements on two quantum systems with entangled states at a space-like distance: the setting of the parameter to be measured and the measurement on the one side of the arrangement are separated by a space-like distance from the setting of the parameter to be measured and the measurement on the other side.[13]

The dynamics of quantum systems is described by the Schrödinger equation (or a relativistic generalization of this equation). According to the Schrödinger dynamics, interaction leads to ever more entanglement. Consequently, in the end, if we assume that there is direct or indirect interaction between any two quantum systems, we get to a view of ubiquitous entanglement. Even if we do not take interaction into account, starting from the formalism of quantum theory, it is to be expected that whenever we consider a whole that has two or more quantum systems as its parts, the states of these systems are entangled.[14] Hence, if we imagine the state of all quantum systems taken together, this will be an entangled state. On the basis of considerations such as the mentioned ones, a number of philosophers of

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13 For an introduction to the philosophy of quantum theory including entanglement and the relevant experiments see for instance Albert (1992).

14 See for instance Scheibe (1991), p. 228.

science interpret quantum theory in terms of wholism.[15] One can thus build a model of nature being one wholistic system on quantum theory.

How does this wholism relate to experience? If we employ the Schrödinger dynamics to describe a situation of measurement, we have to conclude that the state of the quantum system becomes entangled with the state of the measuring apparatus (instead of system and apparatus being in separate states). This is the source of the notorious measurement problem in the interpretation of quantum theory. Fortunately, ubiquitous entanglement is not the end of the story. Decoherence shows how the appearance of classical properties and states can arise within a world of quantum entanglement.[16] Note that as long as only decoherence is in the play, there is no question of non-locality in the sense of one event being causally relevant to another event at a space-like distance, since no reduction of entanglement to separate states occurs.

However, decoherence can at most account for why there appear to be classical properties and states, since decoherence does not include the notion of a state reduction, that is, a dissolution of entanglement. Decoherence does not enable us to understand the existence of classical properties and states (if they exist). To put the matter in more technical terms, decoherence refers to an improper mixture (entangled states) that cannot operationally be distinguished from a proper mixture (systems with separate states each).[17] It is therefore in dispute whether the reference to decoherence is sufficient to cope with the measurement problem or whether, in addition to admitting decoherence, a change to the Schrödinger dynamics – such as the one proposed by Ghirardi, Rimini & Weber (1986) – is called for. Furthermore, it is in dispute whether, if one commits oneself to a metaphysics of quantum entanglement without countenancing a change to the Schrödinger dynamics, decoherence is sufficient to account for our impression that there is a classical world or whether controversial additional ontological commitments have to be endorsed (such as, e.g., the commitment to many superposed experiences as in the many minds interpretation).[18] These issues are not relevant here. The point is that, owing to decoherence, there is a basis for understanding how the appearance of a classical world to observers can in principle be integrated into a model of a quantum domain of ubiquitous entanglement.

There are a number of differences between this model of a wholistic quantum world and Cartwright's wholism in connection with a metaphysics of capacities:

1) The reason why the quantum whole is a wholistic system is not that it is an interacting whole. Although interaction leads to entanglement, entanglement is not a sort of interaction; it is not a causal relation. Insofar as there is a causal relation between two or more systems, it is presupposed that these systems have a well-defined state each. If this were not the case, a causal dependence between changes in state-dependent properties of each of the systems in question could not be formulated. Insofar as quantum systems are subject to entanglement, by contrast, they do not have well-defined states each.

2) It can be argued that causal relations, powers and dispositions or capacities in general require intrinsic properties on which they are in some sense grounded, although Cartwright,

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15 As to a conceptual analysis of what this wholism amounts to, see Teller (1986); Howard (1989); Healey (1991); Esfeld (2001), chapter 8.

16 As to decoherence, see the papers in Giulini et al. (1996) and in Blanchard et al. (2000).

17 See d'Espagnat (1971), chapter 6.3, as to the differentiation between proper and improper mixtures.

18 See Albert & Loewer (1988) and Lockwood (1989), chapters 12 to 13.

for one, does not accept such an argument (see section 1 above). In any case, it seems that this type of argument cannot be applied to the quantum relations of entanglement, since they are not causal relations. Referring to the non-separability of quantum systems and the issue of whether or not quantum systems are individuals in particular, one can maintain that all there is to quantum systems insofar as they are subject to entanglement are the relations in which they stand, intrinsic properties that could in some sense be a basis for these relations being excluded.[19]

3) The sketched position of quantum wholism is committed to the concept of a quantum state of the world (or of nature as a whole). Of course, no one will ever be able to write down that state. Nonetheless, there is nothing here whose nature is in principle unknowable. This metaphysics of quantum wholism does not admit of the Kantian distinction between the world as it appears to us and as it is in itself, insofar as the latter is in principle inaccessible. We know what the world is in itself, namely an unimaginably complex network of quantum relations of entanglement. And it seems that we can know in principle how this way the world is in itself is connected with the way in which the world appears to us, decoherence being the clue.

4) Quantum wholism is in no sense a basis on which a claim to the effect that the world is dappled can be built, since quantum wholism encompasses the world as a whole at the quantum level. Furthermore, if there is a path from the quantum domain to the classical domain via decoherence, then it is shown that the metaphysical position of quantum wholism leads to the epistemological position that there is a systematic relation between the various theories of the natural sciences and a fundamental physical theory of the quantum realm. It seems that one can say at least that the phenomena described by other mature scientific theories supervene on the quantum domain taken as a whole. It can therefore be claimed that quantum theory, interpreted in terms of wholism, is a fundamental theory and perhaps even a universal physical theory. It may not be possible to reduce other theories of the natural sciences to quantum theory; but reduction is not necessary in order to show that there is a systematic connection between the theories of the natural sciences. This is not to say that quantum theory, interpreted along the lines of the sketched model of quantum wholism, is the final truth of the matter. There is no question of metaphysical realism here. Quantum theory may tomorrow be superseded by another physical theory and the entire case for wholism break down. On the other hand, there is as yet no experimental evidence that disconfirms quantum theory.

Cartwright is, of course, aware of the discussion on quantum wholism. Given her position, she warns us not to succumb to what she calls the quantum takeover. In her view, quantum theory is no universal theory. There are both quantum and classical states; one and the same system can be in both at the same time without contradiction. There is no general formula how quantum properties relate to classical properties.[20] For Cartwright, thus, quantum theory is a theory like all the other theories of the natural sciences: It has a limited domain of application, and there is no systematic relation to other theories; the laws of quantum physics are nothing but one piece in the patchwork of natural laws. As regards the EPR-correlations,

19 See Ladyman (1998) on what he calls ontic structural realism and furthermore French & Ladyman (2003) as well as Esfeld (2004).

20 See in particular Cartwright (1999), chapter 9.

Cartwright favours a particular causal account of the correlations that are measured in the experiments. She conceives that causal account as an alternative to quantum wholism.[21]

This is not the place to dwell on the interpretation of quantum theory and to consider the merits and demerits of quantum wholism versus a causal account of the EPR-experiments that avoids a commitment to quantum wholism. The conclusion of this section can be summed up as follows: (1) If one contemplates a metaphysics of nature in terms of wholism, one should be able to spell out that metaphysics. (2) The only physical basis for a wide-ranging and substantial wholism of nature stems from quantum physics. (3) If one works out quantum wholism, one realizes that a metaphysics of nature built on quantum wholism can in no way serve as a basis for an epistemology of a patchwork of laws of nature. One may envisage generalizing this point and tentatively claim the following: As soon as the idea of a wholistic metaphysics of nature is spelled out, that spelling out results in a fundamental theory that (a) describes nature as one wholistic system at a certain level and that (b) thereby seems to describe something which can serve at least as a supervenience basis for the claims made by other theories instead of lending support to a patchwork view of scientific theories. To establish such a claim, more case studies would be necessary. Nonetheless, wholism does not seem to be the appropriate candidate for a metaphysics of nature on which a patchwork view of science can be grounded. To put in a nutshell, if the world is wholistic, it is unitary rather than dappled.

3. Confirmation wholism and semantic wholism

Apart from quantum physics and the metaphysics of nature, there is another area where a sort of wholism is widespread: the theory of the meaning, confirmation and justification of our beliefs. Perhaps the most prominent source of this wholism is Quine's seminal paper "Two Dogmas of Empiricism" (Quine (1953)). Quine claims that only a whole theory and in the last resort only the whole of our knowledge can be confirmed or disconfirmed by experience. This is confirmation wholism. Furthermore, single statements have meaning only insofar as they are integrated into a whole theory and in the last resort into the whole of our knowledge. This is semantic wholism.

In later papers, Quine qualifies the claims made in "Two Dogmas": it is not the whole of our knowledge at once that is confronted with experience, but only a cluster of statements. A cluster of statements is also sufficient for meaning. Nevertheless, Quine maintains that such a cluster finally encompasses the whole of our knowledge: there is no strict partition within our knowledge. For any two parts of our knowledge, there are circumstances imaginable in which these parts may become relevant to each other as regards confirmation and / or meaning.[22] One of Quine's central examples is that it may turn out to be reasonable to abrogate the logical law of the excluded middle consequent upon the results of experiments in quantum physics (so that this law is in effect not a logical but an empirical one).[23]

Quine's confirmation wholism is widely accepted in contemporary epistemology and philosophy of science. Some sort of semantic wholism also is widespread in the theory of meaning. Today's most popular version of semantic wholism is inferential role semantics: the

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21 See Cartwright (1989), chapter 6, Chang & Cartwright (1993) and Cartwright & Suárez (forthcoming). For a criticism, see Cachro & Placek (2002).

22 See in particular Quine (1975), pp. 313–315; Quine (1986), p. 619; Quine (1991), pp. 268–269.

23 See for instance Quine (1953), p. 43; Quine (1986), p. 620; Quine (1991), pp. 268–269.

meaning of a predicate consists in the inferences that a statement in which the predicate in question is employed licenses. Nonetheless, semantic wholism and conformation wholism are two distinct positions. In particular, one can be a confirmation wholist without being a semantic wholist.[24]

Semantic wholism and confirmation wholism are both opposed to a patchwork view of the natural sciences. As regards confirmation wholism, the relations between the different domains may not always be evident in normal science, but they become manifest in a situation that calls for changes, as Quine's example of quantum logics shows. As regards semantic wholism, when confronted with the objection that science is split up in many compartments, Quine replies by referring to the logical and mathematical components that are common to all scientific theories.[25] Quine sees logic and mathematics as being able to guarantee a minimal unity of science, because he does not regard logical and mathematical statements as having a meaning in separation from empirical statements.[26] Whatever the exact status of logical and mathematical statements may be, if the idea of a strict separation between analytic and synthetic statements is rejected and an inferential semantics accepted, there seems to be no principled limit to the inferential relations that contribute to the meaning of a given statement. In other words, there are no isolated patches of knowledge.

The widespread acceptance of some sort of wholism in confirmation theory as well as in semantics illustrates that a theory of confirmation and a theory of meaning is indispensable in order to make the claim of a patchwork of natural laws even intelligible. We need a theory of confirmation that shows how confirmation can be limited to a particular theory (or a particular patch for that matter). And we need a theory of meaning that is an alternative to an inferential role semantics for scientific concepts. If this theory is to be atomistic, it has to tell a story as to how scientific concepts can get their meaning one by one. If this theory is to be a localism in the sense that the concepts of each theory are interdependent, but there are various and many theories, then we need a principle that is capable to keep the inferences that are constitutive of the meaning of a concept within the boundaries of one theory. In any case, given that logical and mathematical principles are pervasive in scientific theories, it seems that we need a strict distinction between analytic and synthetic predicates or statements in order to keep the meaning of logical and mathematical predicates apart from the meaning of empirical predicates. Cartwright would have to provide us with such a theory of meaning and confirmation in order to support her anti-fundamentalism.

Furthermore, Cartwright's metaphor of different theories carving out different aspects of an underlying whole needs clarification: How are the different theories related to one another? Can they be translated into one another? If so, why does the translatability of the concepts not contribute to their meaning? If not, there seems to be no communication across different theories possible; we are then on the well known route from meaning wholism to social wholism and from there to social relativism and social constructivism. However, Cartwright would then face all the well known objections to social relativism. In particular, Davidson (1974) argues in his famous essay "On the very idea of a conceptual scheme" on the basis of meaning wholism and social wholism that the transition from this wholism to social

24 See for instance Fodor & Lepore (1992), chapter 2.

25 For instance Quine (1975), p. 314; Quine (1986), p. 620.

26 See for instance Quine (1991), p. 269.

relativism is incoherent: the idea of different conceptual schemes by means of which we approach the world is unintelligible. Hence, Cartwright either has to rebut the argument against different conceptual schemes (or different incommensurable perspectives on the world, etc.) or to elaborate on the metaphor of different theories carving out different aspects of an underlying whole in such a way that she is not committed to conceptual schemes or the like. If, however, there are no conceptual schemes in the sense of Davidson's attack on this notion, then, again, a unity of science and our knowledge as a whole seems to be in principle possible.

The metaphysical wholism that Cartwright contemplates (nature as an underlying whole) does of course not imply a commitment to semantic wholism, which Cartwright has to reject (and vice versa). However, in any case – the semantic case as well as the metaphysical one – wholism does not lend support to the thesis of a patchwork of laws. Thus, as far as semantics is concerned, Cartwright needs a theory of meaning as well as a theory of confirmation that is a credible alternative to the mainstream wholism in order to make her thesis of a patchwork of laws intelligible; as far as metaphysics is concerned, she cannot simply rely on the wholistic conception of nature as an interacting whole in order to be able to give an account of the relationship between the different domains of scientific theories in a dappled world.

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REPLY ESFELD

One of the central aims of *The Dappled World* is to offer a metaphysical account of the patchwork way that successful science operates as opposed to an epistemological account that relies on our ignorance and cognitive limitations. The challenge then is to account for how there can be the kinds of regularity and precise predictability that we see in a world that is not ordered through and through by some fundamental and precise, regularity-type laws.

I originally thought that wholism and nomological machines offered alternative answers to this challenge. Michael Esfeld, I think correctly, points out that my nomological machines story is itself a wholistic story. Nomological machines are imbedded in and interact with the rest of the hugely diverse and less systematically interacting world. He also points out, again I think correctly, that it is hard to tell the pure wholistic story - the one without nomological machines - without advertising to a systematic theory underneath. Indeed my own examples of how we might have highly successful theories that are nevertheless totally “wrong” all seem to depend on there being a “right” theory underneath. Nor would I wish to find myself having to maintain that this underlying theory must somehow remain inaccessible to us. I still believe that there is a proper wholistic story to be told without universal laws at all. But my own best efforts I think have instead been with nomological machines, which do presuppose capacity laws, as opposed to regularity laws, that are in many cases very wide of scope if not universal, e.g. the capacity law that masses attract other masses)

There is, however, a central issue in the second section of Esfeld’s paper with which I continue to disagree: The power of quantum theory to serve as a model for an underlying theory. In *The Dappled World* I argue that quantum theory is extremely limited in its domain. Clearly Esfeld has not had the space here to take on these arguments, so the debate on this issue will have to take place elsewhere.

With regard to the third section of Esfeld's paper, I think I am not wedded to either semantic wholism or the wholism of confirmation, so I would like to challenge his suggestion that my views are inconsistent with them.

Confirmation wholism: I reckon that if it is true that almost any true claim bears evidentially on almost any other that is precisely because of the interconnected net of interactions in the world that my story of nomological machines, and the need for shielding, presupposes.

Semantic wholism: Semantic wholism as Esfeld describes it and as, I believe it is most plausibly constructed, depends on the very facts that support the wholism of confirmation: The meaning of a term depends on all the inferences it participates in and these are more or less the same inferences that connect with distant facts that bear evidentially on claims involving it. But these connections include the same connections that generate the need for shielding in the nomological machine story and hereby the account of how pockets of predictability and precision can do without a total cover of underlying universal regularity.

I wonder if Esfeld supposes the opposite because of the use of the term "aspect" - which I try to avoid. My story is not one of different perspectives, perhaps complementary in Bohr's sense. I present instead a story of one very complicated "God's eye" perspective in which there are a huge number of interacting qualities and quantities, many of which have fairly stable capacities that can be regimented to produce systematic and precisely predictable order if only properly shielded. So, on the nomological machines story, different theories do not carve out different aspects, where "aspects" are false, but perhaps useful representations of the world. Instead different theories study different sets of features all of which are supposed to be genuine, often interacting, features of one and the same reality.