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Cartesian Primary Qualities in Light of Some Contemporary Physical Explanations*

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ABSTRACT: Descartes' derivation of the primary qualities of matter and their role in explaining observed physical phenomena are briefly reviewed. The lesson drawn from Descartes' methodology of explanation is that we ought to aim to reduce complex phenomena to simple unifying principles and conceptual primitives. Three proposed solutions to the apparent paradoxes in contemporary quantum physics (primarily associated with the notion of entanglement) are briefly compared with lessons taken from Descartes. It is argued that further research in this field should provide criteria for selecting modifications to the standard (largely Cartesian) conceptual scheme, along the lines of either visualisable causality or the physical spatial separability of all material objects.

KEYWORDS: Descartes, explanation, primary qualities, quantum theory, separability.

Introduction: Explaining the Material World

The unanalysed starting tenet of this paper is that determination of and explanatory reliance on primary qualities was one of the tools that helped Descartes escape radical philosophical doubt, most notably in the *Meditations*, and that it showed not only that we can know the world, but also how such knowledge should structurally relate to the world. However, this paper will not be a systematic historical analysis of the philosophical thought of Descartes and his contemporaries. Rather, its aim is to try and derive some lessons from the general characteristics of their explanatory method for use in a contemporary context. This should illustrate how contemporary philosophical aspects of theoretical physics are in conflict

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with the “received wisdom” of early modern philosophy, such as that of Descartes. The early modern origins of some of the obstacles that contemporary philosophy is encountering today will also be indicated. In this regard, the paper demonstrates possible connections between contemporary problems with providing explanations and the historical foundations of the physical explanatory conceptual scheme, but does not argue for a specific solution.

The current context is generally characterised by post-modern criticism of the physical explanatory framework and, more specifically, by a denial of the central tenet of modern (for our purposes: Cartesian) mechanistic explanation within contemporary physics itself (i.e. its sub-domain of quantum theory). Post-modern criticism suggests that ridding the accumulation of knowledge of all inessential disturbances in order to “speak the language of the world” is an aim which should be abandoned, because there is no straightforward recipe for obtaining knowledge, and no decision can be made between the competing explanatory conceptual schemes proposed by contemporary physics (see Luntley, 1995).

The standard proposed solution, calling for universal agreement on a very basic and limited conceptual scheme derived from everyday observable phenomena (an ontology of individuated material bodies in space and time), cannot be embedded into contemporary physics in a straightforward manner. An important task for the philosophy of physics today is to try to repeat Descartes’ achievement, while of course avoiding the pitfalls identified later (see e.g. Williams, 1978), and show *how* we can know the world. There are several ways this may be done, some of which will be outlined (as competing proposals) at the end of the paper.

Historical Sketch

In an admittedly rough historical overview, it can be taken as agreed that, in terms of the philosophy of nature, Descartes’ thinking formed part of a systemic revolution in the conceptualisation and understanding of the physical world. Of course, in its details Descartes’ approach was a failure, and no one does Cartesian physics today. Yet although it was theoretically disputed from the outset (see e.g. Newton’s criticism of Descartes’ analysis of momentum), it had a strong explanatory/visualisation value, as the example of Cartesian vortices illustrates:

> [Whewell was of the] opinion that one of the reasons that Cartesian vortex theory held on as long as it did [for almost 200 years], even after the great empirical and formal explanatory success of Newton’s program, was its ability to provide a directly understandable scenario for planetary motion in terms of contact action of the vortices upon planets. (Cushing, 1991: 352)

Newton's own analysis included mysterious action at a distance, a gravitational interaction across empty space undetectable by any means other than the effect it had on other masses, i.e. the phenomenon it was supposed to explain.[1] "[N]o one actually ever *understood* Newton's action at a distance (least of all Newton, by his own admission) and the riddle had to be 'forgotten' about until a different (causal) explanation was provided by Einstein's general relativity" (Cushing, 1991: 353)

A general theme in the scientific thinking of Descartes' period was that of mechanism and mathematical harmony (Holton, 1973). In terms of Lipton's (2004) models of explanation, this represents a strong combination of the unification and causation styles of explanation. The unification principle behind most phenomena is the mechanical interaction of extended matter, while the causal aspect is provided by detailing a particular interaction. A philosophical tension arises between the diverse, laboriously deduced teleological principles of final causes (Aristotelian substantial forms) and the initially intuitive (and seemingly easily visualisable) unified mechanical principles. For Descartes, all corporeal substances "create" phenomena through extension and motion, without the need to introduce a gratuitous multiplicity of explanatory principles (Della Rocca, 2002). The scales eventually tipped in favour of the mechanists, despite such surprising results as colours being reduced to a colourless geometrical microstructure. There are, of course, many pitfalls involved in such a simplification, but at present we must assume that the general picture holds (for some of these "pitfalls", see Shapin, 1996: 52ff).

Turning to the present day, the established expectations for any explanation of observed phenomena include the following requirements:

(a) Showing the possibility of explaining the phenomena using only a small selection, or special language, of the key qualities of the world (see above for the crossover between the unification and causal models of explanation). Without hindsight, we might be tempted to call these the *primary qualities* of the world, a set of special concepts employed in scientific (and also realist) descriptions of the world.

(b) Making the explanation acceptable without arguing for its certainty (the lesson of post-modern fallibilism). We cannot hope today to produce an explanation whose acceptability will rest in part on its certainty, for such certainty can no longer be guaranteed.

[1] This is not to say that scientists do not generally accept explanations in which the phenomenon being explained itself provides an essential part of the reason for believing the explanation to be correct. However, there are other characteristics of explanatory models that contribute to their credibility; and we are not claiming here that Newton's gravitational action does not possess these (Lipton, 2004).

Descartes' own attempt at an explanation of natural (mechanical) phenomena fails to satisfy both (a) and (b) (Williams, 1978: ch. 8); and the cause of this failure is his overall method, not the technical details of empirical findings available in the 17th century. Moreover, the errors in his method stem not from the philosophy of physics,[2] or scientific metaphysics, but from Descartes' philosophy of mind and epistemology. Stated briefly, he jeopardises the possibility of selecting primary qualities through his strong dualism, whereby the mind performing the selection has access only to ideas and their features, not the things supposedly behind these ideas.[3] He also demands strict certainty from clear and distinct ideas, a demand which has been shaken by contemporary criticism; it was also criticised in his own day (by Gassendi) for the confusion in its criteria for selecting clear and distinct ideas.

Cartesian Methodological Lessons for Constructing Explanations

Nonetheless, there are lessons to be learned from Descartes' approach. In order to reach an explanation/understanding, we must take the common experience, i.e. the observed/encountered phenomena (which has a composite nature), and break it down into simple natures. These should consist of principles expressed in terms of self-evident (intuitive) key features of the world (primary qualities). This leans on Galileo's principle that the objective is what is really in the world, while the subjective is peculiar to individuals or the human race as a whole. The objective must be measurable, leaving all that is immeasurable to the subjective. In Galileo's (and Descartes') time, the measurable was that which was subsumed under geometrical abstraction or the calculus of discrete ratios – position, volume, and temporal change of position. Descartes sees temporal *identity*, spatial *extension* and resistance to *penetration* as clearly and distinctly characterising matter. In fact, extension is the essence of matter, since to have any other property that can be clearly and distinctly perceived, matter must first and foremost be extended (Descartes, *Meditations*).

[2] It is also arguable (Losee, 1993: 75) that even the philosophy of physics fails in attempting to move from basic metaphysics to kinematics, i.e. from a description of the constitution of material bodies to a description of their motion, since Descartes is ambiguous about using "extension" as synonymous with the material plenum, but also the metaphysical manifold against which the motion of material bodies is identified.

[3] Although he invokes God's guarantee that the correspondence between ideas and things will be the right one, this does not actually hold; for there might be good reasons in this case for God to deceive, and yet still remain benevolent.

There is an a priori notion of the material exclusion principle here, namely, that two bits of matter cannot occupy the same space.[4] We could also summarise Descartes' triple characterisation of matter as the requirement that exclusive extension (spatial occupation) must persist through time. Extension is the essence or principal attribute of each body, and all of a body's other properties or attributes are simply *ways* of being extended (modes of extension) (Della Rocca, 2002). This is a rational conclusion, because sensory input is confused and deceiving here (phenomena change with no real change in matter), making substantial forms and sensible qualities explanatorily irrelevant.[5] The bottom line is that there are features of the world-conception that are peculiar to humans (or even to individuals), and others that are not. Describing the world as it is in itself (noumenally) relies on the possibility of singling out these latter features and providing a satisfactory description of all others in terms of them: "[T]he perception I have of [a piece of wax] is a case not of vision or touch or imagination, […] but of purely mental scrutiny" (Descartes, *Meditations*, AT VII: 30–3, HR1: 154–6).[6]

Clearer instructions for linking reality and our understanding of it (although not their application) may be found in the explicit rules Descartes provides for the mental scrutiny of real phenomena (Descartes, *Reg. xii*, AT X: 426–8, HR1 46–7).[7] Descartes cautions that all phenomena are conceptually complex, yielding to several possible descriptions or ways of seeing things. Yet the understanding is expected to find a "view", a conceptual reconstruction in terms of primitives, i.e. those concepts which are

[4] Some, in fact, have interpreted Descartes as saying that space is actually matter (space = matter); but this makes him inconsistent in his use of the term "extension" (see fn. 2).

[5] One might wonder whether another a priori principle is at work here, i.e. one which states that only what is explanatorily relevant should be included in metaphysics. As it is, Descartes' account, whereby all corporeal phenomena can be explained in terms of extension and motion, is problematic from the outset. As Leibniz noted, this kind of physics is too austere; independent space seems to be needed for the individuation of bodies (Newton's absolute space), and action at a distance for correlating changes over great distances. On the other hand, since motion is needed to individuate corporeal bodies, and bodies are used to define motion, we will quickly end up in a vicious circle unless other criteria are introduced (Della Rocca, 2002).

[6] Following Williams (1978), references to Descartes' works are made here according to the French edition by C. Adam and P. Tannery (AT), followed by the volume and page number(s), with the English translation by E.S. Haldane and G.R.T. Ross designated as HR, and likewise followed by the volume and page number(s). For clarity, *Meditations* designates *Meditations on First Philosophy*, and *Reg. xii* refers to *Rule XII* of the *Rules for the Direction of the Mind*.

[7] I am indebted to Tom Vinci for pointing out the relevance of this example at the conference mentioned in the note on p. 21.

the most basic and cannot be analysed further – the ultimate epistemological and metaphysical simples.

> [W]e use the term "simple" only for realities so clearly and distinctly known that we cannot divide any of them into several realities more distinctly known, for example, shape, extension, motion, etc.; and we conceive of everything else as somehow compounded out of these. This principle must be taken quite generally[.] (Descartes, *Reg. xii*, AT X: 426–8, HR1 46–7) [8]

Of course, in terms of serving as a guide to metaphysics, this epistemology is not necessarily superior, and Descartes admits as much in this text. Here he offers a theory of colours entirely in terms of microscopic shapes, proposing that it compete with other theories of colour available at the time, on the grounds of explanatory unification. If empirically adequate with other theories, as Descartes hopes it to be, it would achieve explanatory unity in terms of the reduction to conceptual atoms outlined above, without "uselessly" multiplying existents.

In summary,[9] the lessons to be imported from Descartes regarding how to search for the explanation of observed phenomena are the following:

1) Explanations should rest on simple unifying principles (e.g. breaking down composite phenomena into simple natures) and primitive concepts.
2) Complex physical phenomena should be reduced to changes in extended corporeal substance.[10]

The way we come to know the content (conceptual framework) of such explanations in the first place is through the isomorphism – guaranteed for Descartes, in some sense, by God's grace – of qualities and real properties expressed in geometry (and thus measurable).

[8] When the criterion of "clear and distinct" cognition found here is coupled with Williams' general principle concerning Descartes' method, i.e. "whatever I clearly and distinctly perceive is true" (1978: 227), the result is a metaphysical conclusion about true physical primitives.

[9] For reasons of brevity, and to allow a rough comparison with contemporary explanatory approaches, Descartes' views have mainly been summarised along lines that are undisputed in the majority of the literature. This is why not many references have been made to individual paragraphs in Descartes' own works. A more detailed historical exposition of Descartes' thought would demand more space than a presentation of the contemporary problems and proposed solutions really requires.

[10] I am grateful to Boris Hennig for pointing out the difference between Descartes' account of extension as the "essence" of matter and his more speculative mechanical accounts of physical processes.

Problems for Primary Qualities Today

Fast-forwarding 300 years, clear and distinct perception may be roughly compared with the solutions provided by formalised science, and primary qualities with formalised physical qualities, while isomorphism may be seen as expressed in the mathematical structure of theories. Thus, in classical and relativistic physics alike, reality is made up of particles and space(-time), including force-fields that propagate through space but are not impenetrable. This is certainly not the Cartesian plenum (where space practically equals matter), yet it still essentially accords with the same explanatory framework: complex phenomena are broken down into the interactions of constituents characterised by original primary qualities (with significant, but not contradictory additions). Observable phenomena are reducible to the interaction of these constituents ("beables"),[11] which are expressible, at least in their most crucial part, in terms of those primary qualities. But then quantum theory enters the scene, endangering this by denying separability and locality, while empirical confirmations of this theory demand that a local-realistic understanding of the world be abandoned.[12]

Separability is the principle behind the classical physical explanations of the world, which states that the material occupants (including fields) of any two parts of space sufficiently distant from one another must be considered separate, in the sense that each has its own definite set of qualities and their joint set of qualities is wholly determined by these separate sets (Maudlin, 2002: 97). We break all complex natures down into simple ones, all of which are attributable to bearers transparently related to one another by primary qualities.

In the case of quantum theory's troublesome phenomena (see fn. 11), the postulated simple natures behind complex observed phenomena cannot be regarded as the sole "providers" of these phenomena, since the overall set of observed qualities might include some that are not characteristic of a local region whose objects we can manipulate. In fact, quantum theory calls for non-local interaction, such that there is no exchange of matter, energy or signals, but rather a causal connection and transmission of in-

[11] J.S. Bell insisted that, at the most fundamental level, physical theories ought not to be concerned with observables, i.e. with only those things that can be unequivocally detected empirically, such as the macroscopic constituents of phenomena, but rather with "beables". "The beables of the theory are those elements which might correspond to elements of reality, to things which exist. Their existence does not depend on 'observation'" (Bell, 1987: 174).

[12] To use slightly more technical language, this refers to EPR and teleportation-style phenomena.

formation between objects. This poses a problem for the construction of the special linguistic description required of an explanation (see condition (a) above). Locally characterised "beables", independent and fully defined constituents of reality, cannot alone explain all the phenomena observed in the "quantum laboratory". However, despite the problems concerning the individuation of parts of matter, the whole of the realistic scientific explanation of physical phenomena has been built, from Descartes onwards, on the concept of bits of extended matter as local "beables".

Nonetheless, the lesson to be learned from Descartes' doubt-avoiding metaphysics is that material substance must primarily be extended, while the spiritual need not be. The question spanning the centuries is whether quantum theory's denial of separability really jeopardises this. At first glance, the answer would seem to be no: quantum theory does not directly and explicitly deny that material stuff, the physical system, must primarily be extended in space. Yet it creates potentially insurmountable complications for the picture rationally (scientifically) built thereon. "And so what?", one might be tempted to say – Descartes' own notion of the individuation of bits of matter through motion was problematic, yet that did not stop extension-based primary qualities from serving as the foundation of all physics throughout later improvements.

However, the problem in this case is not quite the same. While motion and individuation had been disentangled through an investigation of the dynamic interaction of bodies and the effects that certain types of motion have on them intrinsically (such as the change in shape in Newton's bucket of water), the general physical explanation of phenomena and separability cannot be untied so easily. Einstein, in a letter to Born, provided the best-known formulation of this:

> [W]hatever we regard as existing (real) should somehow be localized in time and space. That is, the real in part of space A should (in theory) somehow "exist" independently of what is thought of as real in space B. When a system in physics extends over the parts of space A *and* B, then that which exists in B should somehow exist independently of that which exists in A. That which really exists in B should therefore not depend on [interventions] carried out in part of space A; it should also be independent of whether or not any measurement at all is carried out in space A. […] However, if one abandons the assumption that what exists in different parts of space has its own, independent, real existence, then I simply cannot see what it is that physics is meant to describe. For what is thought to be a "system" is, after all, just a convention, and I cannot see how one could divide the world objectively in such a way that one could make statements about parts of it. (Born, 1971: 164)

As Einstein cautions, in order for the standard physical conception of the material world to work, we must assume that spatially separated instances of the material substance (or instances isolated in some other physical way likewise describable in terms of properties based on extension, e.g. boxes or barriers) possess an independent identity whose behaviour can be investigated (control inputs and outputs). Howard (1994) turns this relationship on its head by claiming that separability is a physical necessity for any account of extension; material extension must come in discretely individuated packets in order to be of any use to physical explanation. Since quantum theory, or at least certain phenomena in its domain, denies separability, it appears to hinder the construction of a detailed physical explanation of phenomena based on the principle whereby extension is the primary quality. We can predict the occurrence of phenomena, but we cannot explain how they arose through the known physical interactions of extended objects in a given region.

This "hindrance" arises from the fact that quantum theory makes the properties of instances of extended matter depend on something other than its (*local*) extension (and any associated physical attributes). The holistic connection creates transformations of separated bits of extended matter (even affecting existence and identity, in the case of teleportation) which, in principle, cannot arise from the physical interaction (i.e. an interaction based on the physics of extended matter: energy, signals, matter) and existing properties of the individual bits. In terms of theoretical mathematical formalism and the supposed structure of the isomorphism between the conception and the real world, one further difference may be noted: in classical theories, phase space is given in terms of position and momentum (both based on the notion of extension as the essence of matter), while quantum theory makes use of a different phase space. We might even expect to see this reflected in metaphysics and the explanation of the phenomena.

Some Proposed Solutions in Light of the Methodological Lessons

Given the empirical adequacy of quantum theory, solutions to this predicament must either find a way to augment the classical picture so as to agree with separability-violating phenomena, or else alter the object of the theory altogether, either by arguing for a new conception of reality, or by claiming that the theory somehow fails to account for the material features of reality in the first place. Three such proposed solutions will be sketched out below. They by no means exhaust all of the options, but rather are those which seem interesting for their relation to the Cartesian lessons discussed above. They may be roughly characterised as follows:

I. The separability violation does not really occur; it is an illusion of the mind (and we can have no idea of what is *really* happening).
II. There are rules for the (apparent) separability violation, which limit what we can learn about the world, rather than reveal its material essence.
III. There is more to the world than extended matter clumped in particles; there is an all-pervading "blanket", and it is the cause of violations of separability.

In terms of escaping Cartesian-style doubt, the first option is the most pessimistic one; here we surrender completely and admit that phenomena are only in the mind after all, with no hope of describing the physical world that produces them. On the face of it, this rubs shoulders with the Berkeleyan response to efforts to build realism on the foundations of primary qualities, and slides dangerously toward a full-blown idealism. Even the primary qualities of the world are not really "of the world", but only a common (and thus "objective") structure of human thought, and the troublesome phenomena merely expose the limits of this "common" aspect. The first option regards formalism as the mathematical encoding of rational expectations conditioned on incomplete knowledge, and shies away from any constructive metaphysical speculation as to the constituents of material objects (Fuchs, 2002). But although this might explain how some phenomena appear to violate separability, it abandons all hope of revealing what ordinary tables and chairs are made of.

The second option focuses on the *epistemic* aspect of these "misbehaving" phenomena, and attempts to find principles of isomorphism based on the reception and transfer of information between the physical world and a conscious agent. There is structure in how these phenomena recur, which could reveal a structure in how the physical world enables knowledge-gathering. This epistemic aspect consists in a foreknowledge about changes in the distant object which the conscious agent obtains through a manipulation of proximal objects, even before these are physically confirmed as true of the distant object. Holistically arising qualities can thus be ascertained before any physical contact with that object is made, and predictions of their local effects can even be derived. We can know more than we would expect to "classically", by being ourselves perceptually tied to extended bodies.[13] This option is better equipped to identify isomorphism in the world than the preceding one:

[13] It is important to stress once again that what we can know in this way is strictly controlled by and limited to the peculiarities of a particular experimental situation and what the theoretical formalism permits; we are not advocating wild, science fiction-type speculation here. Hence the focus on the structure of the isomorphism.

> Historically, much of fundamental physics has been concerned with discovering the fundamental particles of nature and the equations which describe their motions and interactions. It now appears that a different programme may be equally important: to discover the ways that nature allows, and prevents, *information* to be expressed and manipulated, rather than particles to move. (Steane, 1998: 119)

So far this suggestion only leads to a research programme whose final outcome remains uncertain, but whose method is to seek constraining principles, rather than structural atoms:

> I would like to propose a more wide-ranging theoretical task: to arrive at a set of principles like energy and momentum conservation, but which apply to information, and from which much of quantum mechanics could be derived. Two tests of such ideas would be whether the EPR-Bell correlations thus became transparent, and whether they rendered obvious the proper use of terms such as "measurement" and "knowledge". (Steane, 1998: 171)

In metaphysical terms, the proponents of this option (for its most notable philosophical expositions, see Clifton et al, 2003; Bub, 2004, 2005, 2006) set out from the assumption that we live in a world where there are certain constraints on the acquisition, representation and communication of information (stemming from a generalised "informational" interpretation of EPR and teleportation-style phenomena) that can be mathematically expressed by information-theoretic principles. They choose to remain agnostic regarding the material structure of phenomena, and focus instead on how the information "making up" these phenomena (from the viewpoint of conscious agents) is received or transmitted. "Information", however, acquires the status of a new primitive concept here. Moreover, although agnostic regarding the details, proponents of this option hold fast to the principle of separability with regard to material reality, focusing on the "informational perspective" of phenomena.

The constraining principles require that *measurement* interactions with a proximal object not alter the *local* theoretical predictions associated with a physically distinct distant object. Although we can know what to expect of the distant object, the distant agent cannot instantaneously know what we know until we transmit it to him via conventional communication channels (such as telephone lines). Once this has been done, he can verify for himself how correct the predictions were. These principles also prohibit the broadcasting of information contained in an unknown physical state.[14] Finally, they forbid a certain type of cryptographic pro-

[14] Unfortunately, any further discussion of this constraint would become too technical, and is not essential here anyhow; we are not arguing for or against individual principles, but merely assessing the worth of an overall method.

tocol whereby the proximal agent seeks to supply the distant agent with an encoded bit (a unit of information) representing a commitment that the distant agent cannot decode, but which can be revealed at a later time, with no possibility for the proximal agent to alter his commitment. This final constraint, along with the other ones, guarantees the existence of non-local entangled states, that is, the very states that give rise to separability-violating phenomena (Duwell, 2007).

In operational terms, proponents of this option start out from the information-theoretic principles mentioned above, deriving from them a theoretical formalism equivalent to that derived by quantum theory from empirical data (i.e. the historical derivation of formalism). This respects Descartes' lesson about looking for (simple?) unifying principles, yet it deviates from mechanistic interaction, as one such principle. We are thus left with a mathematical formalism which, besides some peculiar mathematical characteristics which are not of importance here, makes the physical systems it purports to describe appear to be non-local, i.e. systems that remain in entangled states even as they separate at great distances.

However, this option currently raises more questions than it answers: Where do the constraints come from? What is the significance of such constraints for our overall conceptualisation of objective reality? What are the primary qualities? In response to the aforementioned problem of the conflict between an extension-based conceptual framework and contemporary theoretical developments, it passively allows most of the traditional conception to stand firm (by simply shifting attention away from it and not addressing the issue), while holding fast to the principle of separability. It regards phenomena supposedly violating this principle as misinterpretations based on an obsession with reducing everything to a strictly mechanistic picture. Given Descartes' occasional reluctance to enter into the details of such a picture (e.g. "let us not deny anyone else's view", *Reg. xii*), this solution can still be in agreement with lesson 1) above, although it rejects lesson 2).

The final option proposes adding a non-mechanical "blanket" to the mechanical picture in order to explain the troublesome phenomena. Namely, an all-pervading field that guides particles in motion (rather like a curved surface that changes in time, on which the particles ride) is added to roughly the same mechanical picture as that found in "classical" physics, and it is the action of this "blanketing" field which leads to violations of separability.

However, the blanket itself is neither material nor characterised by the Cartesian primary qualities of matter (recall the a priori principle of material exclusion, for example). Of course, the "blanket view" is a simplification, and a more precise, if perhaps less illuminating account would state that non-local phenomena arise from the structure of the theory, being defined in multidimensional-configuration space as an abstraction which, stated roughly, binds the distant particles into a single, irreducible reality (see Goldstein, 2006). "That the guiding wave [the 'blanket'], in the general case, propagates not in ordinary three-space but in a multidimensional-configuration space is the origin of the notorious "nonlocality" of quantum mechanics" (Bell, 1987:115).[15] The "multidimensional-configuration space" view seems to take Descartes' reductionist materialist lesson 2) very seriously, reducing all complex phenomena to mechanistic changes of the extended substance. The picture produced by rational scrutiny is that of an "object" which is "extended" among the all-pervading plenum, yet in a multidimensional space not open to direct perception. It achieves notional simplicity in a manner similar to Descartes' explanation of colour perception in terms of microscopic shapes. Yet in such circumstances Descartes' old problem of individuation returns, unless further interactions between the individual parts of the all-pervading substance can be found. In the regular, three-dimensional world we readily perceive, a blanket has been added to the extended substance to aid reduction.

The problem with this picture is that it needs to posit some special initial conditions for the universe (quantum equilibrium) and introduce a metaphysical entity (the "blanket") which is not open to empirical detection (*modulo* its action on the particles). We then have a universe deliberately constructed to deceive us (empirical equivalence). Also, by retreating into multidimensional space, the isomorphism position becomes harder to maintain: nothing in the world is as it seems, and what we perceive is merely the result of *potentials* of "the real thing". This brings us close to the problem of globalising secondary qualities (global response dependency), which is a serious threat to any realist elimination of doubt as to the veracity of even the basic conceptual scheme (Devitt, 2006).

Conclusion

In order to repeat Descartes' success in the *Meditations* (namely, overcoming post-modernist criticism of the explanatory aims of science), we need to find primitive concepts which are arguably "sufficiently akin" to the real world, according to some set of criteria we can agree upon (thus

[15] For purposes of simplification, non-locality and non-separability, or the violation of locality and the violation of separability, are taken here as interchangeable, although technically they are not. Quantum theories strictly violate locality, whereas separability is violated only when some further assumptions about the unified structure of reality and explanatory conceptual schemes are taken into account, which, in this case, has been done from the outset, and for all the options surveyed.

creating isomorphism). Some of the phenomena that we are trying to explain overturn entrenched notions of what a primary quality is. The solution seems to demand either radically altering the picture based on the interaction of temporally persisting Cartesian extended objects, or trying to construct an altogether new picture whose simple/unifying principles relate to what can be said about *observing nature*, not *nature itself*. Future research should look into resolving the inconsistency between (i) a conceptual framework that refers to the material world primarily via the notion of extended substance; (ii) the separability axiom of the epistemic accessibility of such substance via physical investigation; and (iii) the occurrence of phenomena that violate the axiom in (ii) when cast in the framework of (i), thus jeopardising the overall epistemic accessibility of the foundational material substance.

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