
Response to Colyvan
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Response to Colyvan

JOSEPH MELIA

In 'Weaseling Away the Indispensability Argument' (Melia 2000) I argued that although quantification over mathematical objects may indeed be indispensable to our scientific theories, it is not always intellectually dishonest to deny the existence of some of the objects over which we quantify. I argued also that, though the postulation of mathematical objects may increase the attractiveness or utility of our scientific theories, the way in which they do so is unlike the way in which the postulation of theoretical physical entities increases the utility of our scientific theories. Because of this, we can be justified in adopting different attitudes to the different entities postulated by our best scientific theories. In particular, we can have good reason for accepting the existence of theoretical physical entities, but little reason for accepting mathematical ones. Accordingly, I urged that the mere fact that we may have to quantify over mathematical objects in our best physical theory is not enough to establish that we ought to believe that there are such things as mathematical objects.

Colyvan claims that, even if we accept my distinction between the different kinds of utility the postulation of physical and mathematical entities may afford, the indispensability argument still works (Colyvan 2002). For there are clear cases in which postulating mathematical entities has exactly the right kind of theoretical virtues. For instance, *unificatory* power is a clear virtue of a physical theory and postulating complex numbers can increase the unificatory power of a theory. Similarly, *explanatory* power of a theory is also a virtue of a theory and the Minkowski geometric explanation of certain relativistic effects gives us a clear example of an explanation that employs mathematical entities.

In my view, Colyvan's strategy is the best way for those who want to defend the indispensability argument. Were there clear examples where the postulation of mathematical objects results in an increase in the same kind of utility as that provided by the postulation of theoretical entities, then it would seem that the same kind of considerations that support the existence of atoms, electrons and space-time equally supports the existence of numbers, functions and sets. Colyvan is right that only by a careful analysis of the uses to which mathematics is put will we be able to judge whether or not the indispensability argument supports Platonism. However, the two particular examples cited by Colyvan fail to convince me that my beloved nominalism should be rejected.

Colyvan writes 'the Minkowski geometric explanation of the Lorentz contraction is, arguably, a non-causal explanation (indispensably) employing mathematical entities such as the Minkowski metric'. I agree. The Minkowski explanation is a *geometric* explanation of relativistic effects—not a mathematical one. For Minkowski, it is the structure and properties of *space-time* which account for the fact that moving bodies appear to suffer a contraction, which accounts for the fact that moving clocks run slowly, which grounds the difference between an inertial frame and a non-inertial one. Minkowski's insight was that, by dropping our old and familiar geometric explanations in terms of spatial and temporal separation and replacing them with a new notion of *spatio-temporal* separation, we could give a simple geometric explanation of relativistic effects. True, when we come to give the geometric explanation of a certain relativistic fact, we may find ourselves indispensably using mathematical objects. But it doesn't follow from this that mathematical objects play a part in the explanation itself, or add to the explanatory power of the theory—for it may be that it is only by using mathematical objects that we are able to *pick out* a particular geometric property. This much is familiar even in the non-relativistic case: it may be the case that the explanation for some physical fact *F* is that a certain path *P* has a certain length. It may be the case that the only or the simplest or the most elegant way of picking out this length is to use a real number: the length is $\sqrt{2}$ as long as some standard metre. Accordingly, when we come to explain *F*, our best theory may offer as an explanation '*F* occurred because *P* is $\sqrt{2}$ metres long'. But we all recognize that, though the number $\sqrt{2}$ is cited in our explanation, it is the *length* of *P* that is responsible for *F*, not the fact that the length is picked out by a real number. As with this simple example, so with Minkowski. In each case, it is the geometric properties and the geometric properties alone that do the explaining in Minkowski space-time.

The second example that Colyvan gives is in the use of complex numbers to solve differential equations. Colyvan points out that, towards the end of my paper, I focus on the theoretical virtue of simplicity. I urge that, although the introduction of numbers may indeed increase the simplicity of a theory, they do not increase the simplicity in the right kind of way. However, Colyvan is quite right that simplicity is not the only theoretical virtue that theories may possess. Unificatory power must also be considered a theoretical virtue.

I believe that, just as there are distinctions in the way in which the postulation of abstract entities may increase the overall simplicity of a theory, so there are distinctions in the way in which the postulation of such entities may increase the overall unificatory power of a theory. As an example of the unificatory power of a theory, Colyvan has cited Newtonian gravitational theory (Colyvan 1999), which is capable of unifying such apparently diverse phenomena as tides, planetary orbits and projectile motion.

I accept that the fact that Newtonian gravitational theory is capable of giving a unified account of such diverse phenomena is indeed a virtue of his theory. For by postulating just a few properties, force and mass, and postulating that a certain relationship holds between these properties (although, admittedly, a relationship which may be only expressible using mathematical machinery) different phenomena can be understood as nothing more than manifestations of a unified, underlying reality. What is so attractive about this theory is that it gives us a unified account of the *world*. But the kind of unification that the complex numbers provides is quite different. Colyvan introduces two differential equations: (1) $y - y'' = 0$ and (2) $y + y'' = 0$. He points out that the real algebra which can be used to solve (1) cannot be used to solve (2) and that complex methods must be employed. Without complex methods Colyvan writes 'we would have no unified approach to solving the respective equations'. But having a unified approach to *solving equations* seems quite a different matter from having a unified account of apparently disparate phenomena. I do not deny that having such a unified approach may be a useful matter, and I'm sure that physicists are grateful to mathematicians for finding unified approaches to such different equations. Mine is not an eliminativist strategy and I have no desire to eliminate mathematics from scientific theory. But the kind of unification that Newton succeeded in carrying out seems quite different from the kind of unification we get when we find a unified approach to solving different equations. On Newton's account, the tides, the planetary orbits, the trajectory of projectiles *are* all nothing more than examples of massive bodies evolving according to his gravitational and kinematic laws. The introduction of complex numbers does nothing to unify different phenomena in this way. Nobody thinks that, just because (1) and (2) turn out to be solvable by the same methods that systems obeying these laws have been shown to be manifestations of the same unified underlying reality. And why should we? There's no obvious route from the fact that different equations can be solved using the same methods to the fact that physical bodies that obey the same equations are therefore manifestations of the same underlying reality.

Colyvan also says that, without complex methods, we would be forced to consider phenomena described by (1) and (2) as completely disparate. I'm not entirely sure why this should be so. If complex numbers are simply introduced to enable us to solve the two equations in an analogous manner, then those who believe only in real numbers can still see that any two physical systems which satisfy the respective equations are similar—after all, they are both described by similar differential equations. But even granting this, I do not deny that there are cases where embedding simple systems into a more complicated one may enable us to see connections and similarities between the systems that we could not notice before. Again, mine is not an *eliminativist* strategy. Embedding a couple of non-Euclidean two-dimensional geometries into one Euclidean three dimensional geometry may enable us to see all sorts of connections between the two that might not have been noticed before. Indeed, sometimes, it is not until a system has been embedded into one with extra structure that the properties of the simpler system become transparent. As Shapiro has written, 'when one realises that the complex plane … contains an "isomorphic copy" of the natural numbers, then one can use complex analysis to shed light on the natural numbers'. (Shapiro 1991. See also Kreisel 1967). But the fact that such an embedding is possible does not mean that the existence of the embedding *accounts for* or *unifies* the intrinsic structures of the embedded systems. The embedding just enables us to see clearly that there is such a shared structure. I do not wish to deny the practising philosopher, mathematician or scientist his right to do this, or to deny that doing such things affords us theoretical utility. What I do deny is that this kind of utility is similar to the kind of utility that Newtonian gravitational theory affords.

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