Aim-Oriented Empiricism: David Miller's Critique

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Abstract
For three decades I have expounded and defended aim-oriented empiricism, a view of science which, l claim, solves a number of problems in the philosophy of science and has important implications for science itself and, when generalized, for the whole of academic inquiry, and for our capacity to solve our current global problems. Despite these claims, the view has received scant attention from philosophers of science. Recently, however, David Miller has criticized the view. Miller's criticisms are, however, not valid.

For over thirty years I have expounded and defended a view of science which, I claim, solves a range of problems in the philosophy of science – from the problem of induction, the problem of the rationality of science, to the problem of what it means to declare of a theory that it is "unified" (Maxwell, 1974, 1984, 1993, 1998, 2002, 2004, 2005). This "aim-oriented empiricist" view, furthermore has, I claim, important implications for science itself. When generalized it has far-reaching implications for the whole of academic inquiry – and even for our capacity, in the long term, to tackle successfully the immense global problems that confront us (Maxwell, 1976a, 1980, 1984, 1992, 2000, 2004). Despite all this, aim-oriented empiricism has, by and large, been ignored by philosophers of science.[1]

Recently, however, aim-oriented empiricism (AOE) has received a modicum of attention. David Miller has subjected it to sharp criticism (Miller, 2006, pp. 92-94). Unfortunately, Miller does no more than criticize a parody of the view. Karl Popper (1961, p. 3) held that one should do one's best to strengthen a view before going on to criticize it. Miller does the opposite.

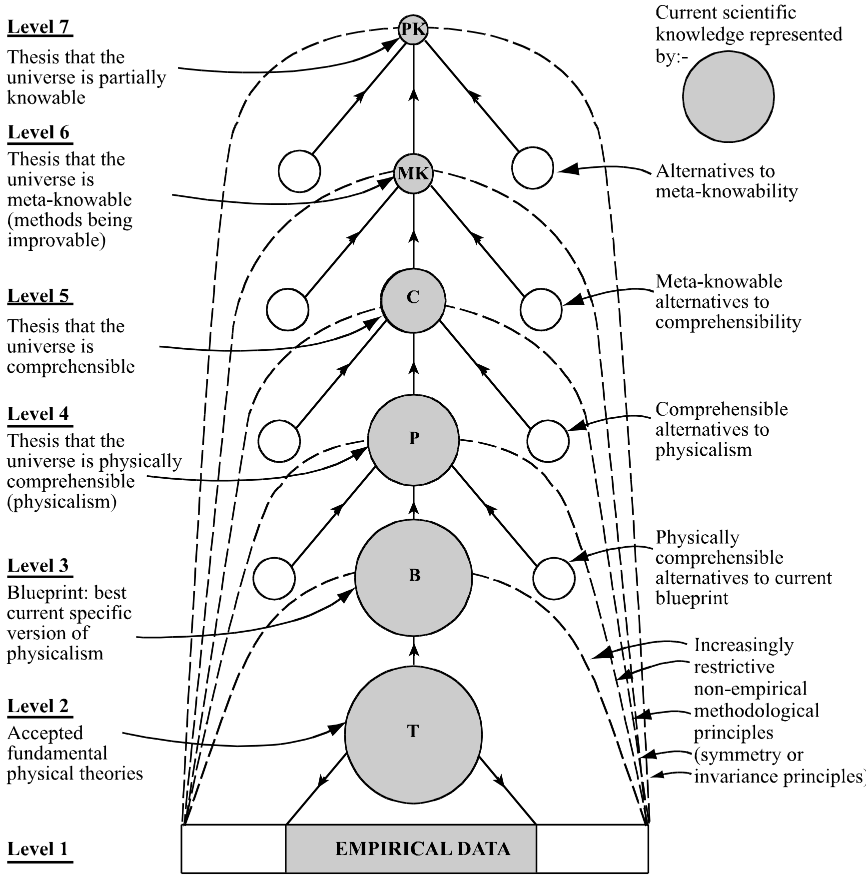
The basic argument in support of AOE can be summarized like this. Theoretical physics persistently accepts unified theories, even though endlessly many empirically more successful, but seriously disunified, *ad hoc* rivals can always be concocted. This persistent preference for and acceptance of unified theories, even though endlessly many empirically more successful disunified rivals are always available, means that physics makes a persistent untestable (metaphysical) assumption about the universe: the universe is such that no severely disunified, *ad hoc* theory is true. Intellectual rigour demands that this substantial, influential, highly problematic and implicit assumption be made explicit, as a part of theoretical scientific knowledge, so that it can be critically assessed, so that alternative versions can be considered, in the hope that this will lead to an improved version of the assumption being developed and accepted. Physics is more rigorous when this implicit assumption is made explicit even though there is no justification for holding

[1] My work has, however, received some excellent reviews: see www.nick-maxwell.demon.co.uk/Reviews.htm

the assumption to be true. Indeed, it is above all when there is no such justification, and the assumption is substantial, influential, highly problematic, and all too likely to be false, that it becomes especially important to implement the above requirement for rigour, and make the implicit (and probably false) assumption explicit.

Once it is conceded that physics does persistently assume that the universe is such that all severely disunified theories are false, two fundamental problems immediately arise. What precisely ought this assumption to be interpreted to be asserting about the universe? Granted that the assumption is a pure conjecture, substantial and influential but bereft of any kind of justification, and thus all too likely in its current form to be false, how can rival versions of the assumption be rationally assessed, so that what is accepted by physics is improved?

AOE is designed to solve, or help solve, these two problems. The basic idea is that we need to see physics (and science more generally) as making not one, but a hierarchy of assumptions concerning the unity, comprehensibility and knowability of the universe, these assumptions becoming, as we ascend the hierarchy, less and less substantial and thus more and more likely to be true and, in addition, more and more such that their truth is necessary for science, or for the acquisition of knowledge, to be possible at all: see diagram.



Aim-Oriented Empiricism (AOE)
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The idea is that by means of this hierarchy we separate out what is most likely to be true, and not in need of revision, at and near the top of the hierarchy, from what is most likely to be false, and most in need of criticism and revision, near the bottom of the hierarchy. Evidence, at level 1, and assumptions high up in the hierarchy, are rather firmly accepted, as being most likely to be true (although still open to revision): this is then used to criticize, and to try to improve, theses at levels 2 and 3 (and perhaps 4), where falsity is most likely to be located. Furthermore, this hierarchical structure helps to determine in what ways theories and assumptions, at levels 2 and 3, need to be revised to give the best hope of progress; evidence at level 1, and assumptions at levels 4 and 5, constrain modifications to theses at levels 2 and 3.

At the top there is the relatively insubstantial assumption that the universe is such that we can acquire some knowledge of our local circumstances. If this assumption is false, we will not be able to acquire knowledge whatever we assume. We are justified in accepting this assumption permanently as a part of our knowledge, even though we have no grounds for holding it to be true. As we descend the hierarchy, the assumptions become increasingly substantial and thus increasingly likely to be false. At level 5 there is the rather substantial assumption that the universe is comprehensible in some way or other, the universe being such that there is just one kind of explanation for all phenomena. At level 4 there is the more specific, and thus more substantial assumption that the universe is *physically* comprehensible, it being such that there is some yet-to-be-discovered, true, unified "theory of everything". At level 3 there is the even more specific, and thus even more substantial assumption that the universe is physically comprehensible in a more or less specific way, suggested by current accepted fundamental physical theories. Examples of assumptions made at this level, taken from the history of physics, include the following. The universe is made up of rigid corpuscles that interact by contact; it is made up of point-atoms that interact at a distance by means of rigid, spherically-symmetrical forces; it is made up of a unified field; it is made up of a unified quantum field; it is made up of quantum strings. Given the historical record of dramatically changing ideas at this level, and given the relatively highly specific and substantial character of successive assumptions made at this level, we can be reasonably confident that the best assumption available at any stage in the development of physics at this level will be false, and will need future revision. At level 2 there are the accepted fundamental theories of physics, currently general relativity and the standard model. Here, if anything, we can be even more confident that current theories are false, despite their immense empirical success. This confidence comes partly from the vast empirical content of these theories, and partly from the historical record. The greater the content of a proposition the more likely it is to be false; the fundamental theories of physics, general relativity and the standard model have such vast empirical content that this in itself almost guarantees falsity. And the historical record backs this up; Kepler's laws of planetary motion, and Galileo's laws of terrestrial motion are corrected by Newtonian theory, which is in turn corrected by special and general relativity; classical physics is corrected by quantum theory, in turn corrected by relativistic quantum theory, quantum field theory and the standard model. Each new theory in physics reveals that predecessors are false. Indeed, if the level 4 assumption of AOE is correct, then all current physical theories are false, since this assumption asserts that the true physical theory of everything is unified, and the totality of current fundamental physical theory, general relativity plus the standard model, is notoriously disunified. Finally, at level 1 there are accepted empirical data, low level, corroborated, empirical laws.

In order to be acceptable, an assumption at any level from 6 to 3 must (as far as possible) be compatible with, and a special case of, the assumption above in the hierarchy; at the same time it must be (or promise to be) empirically fruitful in the sense that successive accepted physical theories increasingly successfully accord with (or exemplify) the assumption. At level 2, those physical theories are accepted which are sufficiently (a) empirically successful and (b) in accord with the best available assumption at level 3 (or level 4). Corresponding to each assumption, at any level from 7 to 3, there is a methodological principle, represented by sloping dotted lines in the diagram, requiring that theses lower down in the hierarchy are in accord (as far as possible) with the given assumption.

When theoretical physics has completed its central task, and the true theory of everything, T, has been discovered, then T will (in principle) successfully predict all empirical phenomena at level 1, and will entail the assumption at level 3, which will in turn entail the assumption at level 4, and so on up the hierarchy. As it is, physics has not completed its task, T has not (yet) been discovered, and we are ignorant of the nature of the universe. This ignorance is reflected in clashes between theses at different levels of AOE. There are clashes between levels 1 and 2, 2 and 3, and 3 and 4. The attempt to resolve these clashes drives physics forward.

In seeking to resolve these clashes between levels, influences can go in both directions. Thus, given a clash between levels 1 and 2, this may lead to the modification, or replacement of the relevant theory at level 2; but, on the other hand, it may lead to the discovery that the relevant experimental result is not correct for any of a number of possible reasons, and needs to be modified. In general, however, such a clash leads to the rejection of the level 2 theory rather than the level 1 experimental result; the latter are held onto more firmly than the former, in part because experimental results have vastly less empirical content than theories, in part because of our confidence in the results of observation and direct experimental manipulation (especially after expert critical examination). Again, given a clash between levels 2 and 3, this may lead to the rejection of the relevant level 2 theory (because it is disunified, *ad hoc*, at odds with the current metaphysics of physics); but, on the other hand, it may lead to the rejection of the level 3 assumption and the adoption, instead, of a new assumption (as has happened a number of times in the history of physics, as we have seen). The rejection of the current level 3 assumption is likely to take place if the level 2 theory, which clashes with it, is highly successful empirically, and furthermore has the effect of increasing unity in the totality of fundamental physical theory overall, so that clashes between levels 2 and 4 are decreased. In general, however, clashes between levels 2 and 3 are resolved by the rejection or modification of theories at level 2 rather than the assumption at level 3, in part because of the vastly greater empirical content of level 2 theories, in part because of the empirical fruitfulness of the level 3 assumption (in the sense indicated above).

It is conceivable that the clash between level 2 theories and the level 4 assumption might lead to the revision of the latter rather than the former. This happened when Galileo rejected the then current level 4 assumption of Aristotelianism, and replaced it with the idea that “the book of nature is written in the language of mathematics” (an early precursor of our current level 4 assumption). The whole idea of AOE is, however, that as we go up the hierarchy of assumptions we are increasingly unlikely to encounter error, and the need for revision. The higher up we go, the more firmly assumptions are upheld, the more resistance there is to modification.

AOE is put forward as a framework which makes explicit metaphysical assumptions implicit in the manner in which physical theories are accepted and rejected, and which, at the same time, facilitates the critical assessment and improvement of these assumptions with the improvement of knowledge, criticism being concentrated where it is most needed, low down in the hierarchy. Within a framework of relatively insubstantial, unproblematic and permanent assumptions and methods (high up in the hierarchy), much more substantial, problematic assumptions and associated methods (low down in the hierarchy) can be revised and improved with improving theoretical knowledge. There is something like positive feedback between improving knowledge and improving (low-level) assumptions and methods – that is, knowledge-about-how-to-improve-knowledge. Science adapts its nature, its assumptions and methods, to what it discovers about the nature of the universe. This, I claim, is the nub of scientific rationality, and the methodological key to the great success of modern science. (For more detailed expositions see Maxwell, 1998; 2004, chs. 1, 2 and appendix; 2002; 2005.)

This is the doctrine Miller sets out to criticize. In response to my claim that persistent acceptance of unified theories even though endlessly many empirically more successful disunified rivals are available means, in effect, that science makes the persistent, substantial metaphysical assumption that the universe is such that no grossly disunified theory is true, Miller comments:-

> The words 'in effect' here are tendentious. Since scientific hypotheses in modern times never mention God, it might be said that science 'in effect' makes 'a big assumption' of atheism. But it does not make this assumption, and many scientists privately assume the opposite. Hypotheses that bring in God are simply excluded, rightly or wrongly, from empirical consideration (Miller, 2006, p. 92).

But this does not begin to do justice to my argument, for two reasons.

In the first place, Miller is quite wrong to suggest that disunified theories are like ‘God hypotheses’ in that they are simply excluded from scientific consideration. Many disunified rival theories do in fact receive serious consideration within science.

An example is a disunified rival to Newtonian theory (NT) put forward by Maurice Levy in 1890, which combined in an *ad hoc* way two distinct modifications of Newton's law of gravitation, one based on the way Weber had proposed Coulomb's law should be modified, the other based on the way Riemann had proposed Coulomb's law should be modified: for details see North (1965, p. 47). By 1890, NT had been refuted by observation of the precession of the perihelion of the orbit of Mercury; attempts to salvage NT by postulating an additional planet, Vulcan, had failed. Levy's theory successfully predicted all the success of NT, and in addition successfully predicted the observed orbit of Mercury, just that which refuted NT; in addition, of course, it made predictions different from NT for further Sun-Mercury type systems not yet observed. As it happens, this particular disunified rival to NT, despite appearing in the scientific literature, and despite being empirically more successful than NT, was not taken seriously as a rival to NT, not even by Levy himself.

An example of a highly disunified theory that is taken very seriously indeed by the scientific community is orthodox quantum theory (OQT). Because it fails to solve the wave/particle problem, and thus does not have its own quantum ontology, OQT cannot interpret the Ψ-function as specifying the actual physical states of quantum systems such as electrons or atoms; instead the Ψ-function must be interpreted as containing probabilistic information about the results of performing measurements on quantum systems. This means that OQT consists of two conceptually incoherent parts, quantum postulates (QT) – such as Schrödinger's time-dependent equation – and some part of classical physics (CP), for a description of measurement. QT and CP are incompatible with one another; QT + CP is only rendered consistent by arbitrarily restricting CP to the measurement process, and QT to processes that do not constitute measurement. The result is that OQT is a severely *ad hoc*, disunified theory (see Maxwell, 1976b, 1982, 1988, 1994, 1998, ch. 7)..

It is of course true that in order to check up on the predictions of a classical theory such as NT, we often need to employ additional physical theories, as when optical theory is used to check up on predictions of NT applied to the solar system. This does not mean, however, that NT is *ad hoc* in the same way in which OQT is. The difference is simply this. Because we can interpret NT as having its own consistent physical ontology (of massive, gravitationally charged particles), NT (plus specification of initial conditions) does issue in quite definite physical predictions about actual physical states of affairs - the positions and velocities of planets at definite times, for example - in the absence of optical or other physical theories, for measurement. NT is a physical theory with physical content in its own right; QT is not. Because it does not have its own quantum ontology, QT, bereft of some part of classical physics for a description of the measuring process, can only issue in *conditional* or *counterfactual* predictions about what would be the outcome *if* a measurement were to be performed. In order to issue in unconditional predictions, QT must call upon some additional theory, with its own consistent physical ontology, for a specification of the physical states of preparation and measurement devices. As Bohr (1949) emphasized, only QT *plus some part of classical physics for a description of measurement* has genuine physical predictive content. (For a more detailed version of this argument see Maxwell, 1998, pp. 229-235.)

Here, then, is an *accepted* theory that is quite seriously disunified and *ad hoc*. Miller is quite wrong when he suggests that seriously disunified theories are like 'God hypotheses', never taken seriously in science. It is of course true that OQT, despite its unprecedented empirical success, has always been a controversial theory because of its reliance on some part of classical physics, or some other theory, for measurement.[2] But this is just a special case of a much wider phenomenon in physics. Most physicists recognize that considerations of simplicity, unity, non-*ad hocness*, conceptual coherence

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[2] It might seem that acceptance of severely disunified OQT refutes my argument that no severely disunified physical theory is accepted, whatever its empirical success. But OQT is a special case. Those who regard OQT as unproblematic tend either to deny that it is disunified, or regard (incorrectly) its disunity as something that any physical theory must suffer from if it is to be testable – testability requiring additional theory for the process of measurement. In any case, severe as the disunity of OQT is, it is not as severe as the rival disunified theories considered by the argument for AOE.

or mathematical beauty play an important role in determining whether a theory should be accepted, in addition to empirical considerations. The history of physics is redolent with debates about such issues.

One of the great successes of AOE is that it solves the problem of what these non-empirical requirements a theory must satisfy to be accepted are. These requirements are problematic because a beautifully simple and unified theory can always be reformulated so that it becomes horribly complex and disunified, and *vice versa*. A number of philosophers of science have attempted to explicate what simplicity or unity of theory is,[3] but none of the attempts known to me succeeds in overcoming the reformulation problem.[4] The key insight required to solve this problem is that the unity of a physical theory has to do, not with the theory itself, its form, axiomatic structure or patterns of derivations, but with *what the theory asserts about the world* – its *content* in other words. In order to solve the problem we need to look, not at the theory itself (which is what previously has been done), but at the world – or rather at what the theory asserts about the world. Thus the fact that one and the same theory (with fixed content) can be formulated in endlessly many different ways, some highly complex and disunified, some beautifully simple and unified, is entirely irrelevant: in order to assess the unity of the theory we need to attend, not to its form, not to the way it has been formulated, but to its content, to what it says about the world (which, by hypothesis, is fixed).

The crucial requirement a dynamical physical theory must satisfy to be unified is that its content, what it asserts about the world, must be the *same* throughout all the actual and possible phenomena to which the theory applies. The theory must specify the *same* dynamical laws governing the range of phenomena, actual and possible, to which the theory applies – and what matters here is that the *content* of the laws remains the same, what is asserted to govern physically actual and possible phenomena, not the form these laws may have when written down on paper.

A theory (like OQT) that asserts that one set of laws apply to one range of phenomena, and a different set of laws apply to a different set of phenomena is, to that extent, *disunified*. And the greater the number of different sets of laws the theory postulates for different ranges of phenomena, so the more disunified the theory is. This provides us with a way of specifying the degree of disunity of a theory. A theory that asserts that different sets of laws apply in N different ranges of phenomena (to which the theory applies) is disunified to degree N. For unity, we require that N = 1.

Given a theory that is disunified to degree N > 1, the question can arise as to *how different, in what way different*, are laws in one range of phenomena from laws in another range of phenomena. Some ways in which sets of laws can differ, one from the other, can be much more dramatic, much more serious, than other ways. Thus a theory may postulate different laws in different space-time regions; or it may merely postulate two or more different kinds of particles or forces, there being one kind of particle or force only in one range of possible phenomena to which the theory applies, another kind of particle or force only in another range of possible phenomena. This gives rise to different *kinds* of disunity,

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[3] See Friedman (1974), Kitcher (1981), Watkins (1984, pp. 203-213), Schurz (1999), Weber (1999), Bartelborth (2002).

[4] For criticism of Friedman (1974), Kitcher (1981), Watkins (1984) and others see Salmon (1989) and Maxwell (1998, pp. 56-68).

some being much more serious than others. Maxwell has distinguished eight kinds of disunity. They all exemplify, however, the same basic idea: disunity arises when *different* dynamical laws govern the evolution of physical states in different ranges of possible phenomena to which the theory applies. For details of this account of unity (and of simplicity) see Maxwell (1998, ch. 4, and 2004, appendix, section 2).

This explication of the unity of theory is, I claim, potentially, a contribution to physics as well as to the philosophy of physics. Most physicists recognize that non-empirical considerations of unity play an important role in deciding what theories should be accepted, but at the same time confess that they do not know how to say clearly what these considerations are. Einstein (1949, pp. 23-24), for example, recognized the problem, and confessed that he did not know how to solve it. The solution I have outlined here (and spelled out in detail elsewhere) brings clarity to an important area of debate within theoretical physics that is at present regarded as somewhat murky, baffling and mysterious. (If this explication of unity had been generally understood in the 1920s, there might have been wider agreement that OQT is a problematic theory because of its disunity.)

With this "content-invariant" account of the unity of theory before us, we can be much clearer about the extent to which empirically successful disunified theories are, and are not, taken seriously by physics. Theories that suffer from the most severe kinds of disunity are not, in general, taken seriously, but theories that suffer from much less severe kinds of disunity may well be taken seriously if they also meet with sufficient empirical success. But even less severe kinds of disunity are still regarded as problematic, even in the absence of serious empirical problems. Thus the standard model is regarded as problematic, not because of empirical difficulties, but because of its disunity: it postulates three distinct forces (two of which have been partially unified); it postulates a large number of distinct kinds of particle, and has nearly 30 different constants (such as masses of particles and strengths of forces) which can only be determined experimentally.

Miller is thus quite wrong to say that the disunified theories I consider are like 'God hypotheses', automatically excluded from science. The most severely disunified theories are, in general, excluded (although even here there are exceptions, as OQT reveals). The less severely disunified are not excluded, if sufficiently empirically successful, but are nevertheless regarded as problematic because of their disunity. What AOE and the above "content-invariant" account of unity reveal is a spectrum of disunity, from severe to mild, but all exemplifying the same basic idea.

There is a second, and much more serious, way in which Miller, in the above quotation, fails to do justice to the argument for AOE. What Miller fails to mention is that the disunified rival theories considered by the argument are *empirically more successful* than the accepted unified theory. Any accepted physical theory, T – Newtonian theory, classical electrodynamics, quantum theory, general relativity and so on – (a) runs into some empirical difficulties and is, ostensibly empirically refuted. Furthermore, (b) there are always repeatable phenomena, specifiable by means of low level empirical laws, L say, which T should apply to and predict, but which T fails to predict because the equations of T cannot be solved. And finally, (c) there will be repeatable phenomena, specifiable by means of empirical laws, L* say, which lie outside the range of applicability of T. In order to concoct T* - an empirically more successful rival to T – all we need to do is (a) modify T in an entirely ad hoc way so that the new theory successfully predicts the phenomena that refute T, and then add to this modified version of T (b) the laws L and (c) the laws

L*. The resulting theory, T*, will be seriously disunified and ad hoc. It is made up of different laws that apply to different ranges of phenomena. Nevertheless, T* is empirically more successful than T in that it recovers all the empirical success of T and, furthermore (a) is empirically successful where T is (ostensibly) refuted, (b) is empirically successful where predictions cannot be extracted from T, and (c) successfully predicts phenomena outside the range of applicability of T. Furthermore, T* will make successful new predictions beyond the scope of T. (See Maxwell, 1998, pp. 47-54, for further details.) The crucial point, ignored by Miller, is that the disunified rival theories excluded from consideration are empirically more successful than the accepted theories. Science ignores 'God hypotheses' because such hypotheses fail to have the empirical success of accepted scientific theories. If such hypotheses began to be empirically more successful than currently accepted scientific theories, they might well begin to receive attention from science, and this might well be the correct thing to do.

Miller continues his criticism by attributing to me the claim that science presupposes "Θ everything in the world exemplifies some uniformity" (p. 93). This does not quite do justice to the hierarchy of metaphysical theses of AOE, but we may let that pass. The level 4 thesis of physicalism does imply Θ. Miller goes on "The decisive point of disagreement between Maxwell and critical rationalists or falsificationists is whether there exists any substantial metaphysical doctrine such as Θ that is, as he says, 'permanent'; that is, a doctrine that science not only does presuppose but is obliged to presuppose" (p. 94). This, again, misrepresents my actual view. Only the top two theses in the hierarchy of theses are permanent assumptions of science. The rest, including Θ as an implication of physicalism, are open to revision.

Miller continues "Maxwell … denies that 'theories are assessed impartially on the basis of evidence alone, no permanent assumption being made about the nature of the universe independent of evidence' (Maxwell, 2000, f 19). This doctrine of metaphysical obstipation is a direct consequence of the idea, itself not much more than a corollary of justificationism, that there have to be empirical grounds not only for the rejection of theories, but also for their acceptance and exclusion. What is represented here as in need of empirical justification is of course not any scientific hypothesis, since it is admitted that all hypotheses remain for ever conjectural, or even its acceptance into science for testing, but its exclusion prior to testing. It is a justificationist thesis nonetheless" (p. 94). This yet again is wide of the mark. As far as I am concerned, the whole point of making explicit influential, metaphysical assumptions that are implicit in persistent preference for unified theories when empirically more successful rivals are available is to make it possible to subject these assumptions to sustained critical scrutiny in the hope that this will lead to their improvement, and thus contribute to the progress of science. The whole point of making explicit the hierarchy of assumptions of AOE is to concentrate criticism where (we conjecture) it is most needed, near the bottom of the hierarchy, and to facilitate criticism of a kind most likely to lead to scientific progress. The motivation is, in other words, thoroughly Popperian in character, even if the outcome clashes with Popper's falsificationism. There is nothing "justificationist" about this criticism of Popper whatsoever. It is not AOE, but rather Popper's falsificationism that is anti-critical in character, in that falsificationism denies that science makes substantial, influential and highly problematic metaphysical assumptions, thus concealing the need for these assumptions to be critically assessed as an integral part of scientific inquiry.

Miller concludes by remarking that "if the world has no discernible uniformities then we shall not succeed in learning from experience. But science does not presuppose that its methods will be successful … There is no room anywhere in science for any additional principle so vague and at the same time so devoid of purpose" (p.94). But the argument for AOE is not that science needs to make a metaphysical assumption to guarantee that the methods of science will be successful. AOE does not presuppose that science will meet with success. The argument is the one stated above: persistent preference for unified theories when endlessly many empirically more successful disunified rivals are available implies that science makes a persistent assumption about the world. The assumption is implicit in the existing methods of physics; it is not an "additional principle". And finally, there is a substantial purpose behind making this implicit assumptions explicit: it becomes possible, as a result, to assess critically and perhaps improve assumptions low down in the hierarchy, methodological principles involved in choosing theories in the light of unity being improved as well. Doing this may well be necessary for the discovery of the holy grail of theoretical physics: the true unified "theory of everything".

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