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Editorial introduction to scientific realism quo vadis? Theories, structures, underdetermination and reference

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The papers collected in this special issue are written versions of talks delivered at the *Theoretical Frameworks and Empirical Underdetermination* workshop which we organised at the University of Duesseldorf on April 11–12 2008. Early in the summer of 2007 we were still immersed in the planning stages of the workshop. At the time our main concern was to invite philosophers that were making and would continue to make significant contributions to the scientific realism debate. With this aim in mind, we prepared a list of invitees. One of the names at the top was that of Peter Lipton. His work on inference to the best explanation had established him as one of the most prominent and formidable defenders of scientific realism. When Peter accepted the invitation our confidence in the workshop's prospects was greatly enhanced. Alas it was not meant to be. Peter unexpectedly passed away in November 2007. His absence from the workshop was strongly felt not least because quite a few of the participants had known Peter both on a professional as well as on a personal basis. David Papineau was drafted in as a replacement. Since David had a long and entwined history with Peter he was entrusted with the honourable task of delivering a eulogy on the opening day of the workshop. We are very thankful to David for delivering a moving eulogy as well as for agreeing to replace Peter at such short notice. We would like to dedicate this special issue of *Synthese* to the memory of Peter Lipton, a fellow philosopher and to some of us a dear friend.

To help the reader navigate this collection we have decided to divide its 13 papers into four themes: (i) theory-development, approximate truth and reference (ii)

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underdetermination—red herring, vice or virtue? (iii) underdetermination and structuralist accounts of modern physics and (iv) reconsidering the Logical Positivist contributions to the debate. As with most such classifications they tend to be somewhat crude. For example, some papers focus on one theme, while others have multiple foci.

Let us start with those papers that primarily fall under the first theme. Although Papineau was understandably unable to contribute a paper for publication in time, it is worth saying a few words about his talk since its content is intimately tied with some of the papers in this collection. Papineau's talk is based on a paper he co-authored with Pierre Cruse (Cruse and Papineau 2002). According to them, the cognitively significant content of a scientific theory—roughly what the scientific theory is really about—is captured by its Ramsey sentence. Since the Ramsey sentence of a theory existentially quantifies over theoretical predicates and turns them into variables, such predicates presumably cannot be said to refer to any particular object. Cruse and Papineau take this to mean that the reference of theoretical terms is irrelevant (p. 174). If Cruse and Papineau are right, realists need not worry about referential continuity between successive theories anymore. Realists typically worry about such continuity in their bid to reinstate the inference from the empirical and explanatory success of theories to their (approximate) truth and to the referential success of their theoretical terms. This link is contested by those who advocate the pessimistic meta-induction argument (PMI), claiming that there are past successful theories that are neither (approximately) true nor referentially successful. Thus, if these realists can argue in response that the superseded theories are to some degree true and that in some sense their theoretical terms are referentially continuous with modern day counterparts then there is hope for the inference from empirical and explanatory success to (approximate) truth and referential success. Cruse and Papineau make this response redundant.

The antagonism towards standard referential semantics that is present in Cruse and Papineau (ibid.) also permeates two of the papers included in this issue. One is that of John Worrall which we discuss below. The other is that of James Ladyman. In his contribution, Ladyman reasons that whether or not theoretical terms refer is in a sense a red herring when it comes to coming up with the right strategy against historical anti-realist arguments like the PMI. Ladyman demonstrates his point with the help of the phlogiston theory of combustion. Contrary to what some philosophers have argued so far, he reasons, the phlogiston theory did to a certain extent uncover correct information about the causal-nomological structure of the world. Yet this information is purely structural and in no way requires that there be a referent to the term 'phlogiston'. According always to Ladyman, the case of the phlogiston theory supports ontic structural realism (OSR) for the latter makes the term by term reference of theories unnecessary. More precisely, the phlogiston theory supports OSR because it fulfils three of its demands: (a) that the empirical success of a theory must be preserved in subsequent theories, (b) that a theory's central terms cannot plausibly be said to refer to anything and (c) that our knowledge does not extend to the intrinsic natures of unobservable individual objects.

The next two papers, those of Schurz and Votsis, favour a more standard approach to referential semantics. In his contribution, Schurz spells out the consequences of a correspondence theorem that he postulated and proved in an earlier work. The theorem establishes that, provided certain arguably natural conditions are met, two successive

and empirically successful theories that have different theoretical superstructures can be referentially continuous to one another with respect to a given domain of phenomena. Put plainly, the theorem enables a realist to argue that a superseded theoretical term which was originally meant to refer to an entity or property that is now defunct may still be able to indirectly refer to a modern-day counterpart of that entity. Schurz demonstrates the usefulness of the theorem with two case studies, (i) the transition from the phlogiston to the oxygen theory of combustion and (ii) the transition from a classical to a relativistic conception of mass. In both cases the fact that certain theoretical expressions of the old theories were actively responsible for their empirical success guarantees that these expressions indirectly refer to modern-day counterpart entities. For example, the term 'dephlogistication' indirectly refers to the process of oxidation. Towards the end of his paper Schurz argues that the correspondence theorem motivates a weak form of realism that, unlike other realisms, obviates the need for the no-miracles argument thereby evading its associated problems.

Votsis' paper aims to clarify the concepts of referential success and referential continuity that are so crucial to the formulation of arguments in the scientific realism debate. He begins by drawing our attention to the fact that the three dominant theories of reference, i.e., descriptivist, causal-historical and causal-descriptivist theories, are motivated by different and often conflicting intuitions. Three options seem available, according to him. First, we can follow the traditional practice and reject all intuitions that clash with a chosen theory of reference. Second, we can reject the evidential role of intuitions altogether and hence try to find other means through which we can justifiably choose a theory of reference. Third, we can try to save conflicting intuitions and their evidential role by rejecting the idea that the relevant referential concepts are monolithic; they are what he calls 'polylithic'. So long as we identify which concept is employed when, Votsis claims, some disputes about reference are dissolved. With this in mind, he sketches a hierarchy of concepts of referential success and continuity, each satisfying different sets of intuitions and illustrates to what extent each such concept can make sense of the historical record of science and hence be used to evaluate scientific realist claims.

Another realist defence can be found in Ludwig Fahrbach's contribution. Fahrbach compares realism to two types of anti-realism, each of which is motivated by its own distinct argument. Projective anti-realism is motivated by the PMI and empiricist anti-realism is motivated by underdetermination arguments. Focussing mostly on projective anti-realism, he argues that the PMI is unwarranted for it is based on a set of theories that enjoyed low degrees of success. According to Fahrbach, the PMI fails to take into account that the growth of science is exponential. Theories in the last few decades have been under much more refutational stress (e.g., in terms of the increased quality of our instruments) and therefore enjoy higher degrees of success than theories at any other period in the history of science. If we run an induction on these theories, Fahrbach argues, we have no reason for pessimism since virtually none of them have been overturned. In other words, because our current theories enjoy very high degrees of success we have good reasons to believe in their truth or approximate truth.

Let us now proceed to those papers that direct their attention to whether or not underdetermination should be considered a red herring, a vice or a virtue. In his contribution, John Worrall rejects term-by-term correspondence, like Ladyman, in favour

of the global correspondence between the descriptive structure of a theory and the world. The characterisation of a theory's descriptive structure is most adequately captured by the Ramsey-sentence formulation of that theory, a move that in Worrall's view amounts to the endorsement of epistemic structural realism. According to Worrall, the underdetermination problem has no effect on such a view because two empirically equivalent theories are cognitively equivalent from the perspective of Ramsey-style epistemic structural realism. This is so since the Ramsey sentence of a theory is formulated in a purely observational language. Contrary to appearances, Worrall claims, this is not a concession to the anti-realist empiricist since empirical equivalence is a stronger requirement than data equivalence. The former notion requires that all the consequences formulated in a purely observational vocabulary (which include sentences with rather complicated quantificational structure) are shared between two or more theories whereas the latter requires only that they share those observational consequences which can be directly checked by observation. Therefore, two theories may be data equivalent and yet be empirically inequivalent.

Paul Hoyningen-Huene is not so upbeat about the prospects of realism. He argues that provided a certain version of underdetermination that he calls 'transient' holds the no miracles argument is unsound. In simple terms, transient underdetermination is present when we cannot decide on the basis of the currently available evidence between a number of rival theories, so long as these theories are not only consistent with the evidence but also have an appropriately relevant relationship to it. To make matters more precise, Hoyningen-Huene employs measure theory to formalise transient underdetermination as well as a version of the no miracles argument that relies on the notion of 'use novelty'. He then argues that this version of the no miracles argument is falsified by the existence of transient underdetermination. The latter is established by means of a mathematical example taken from the domain of curve fitting. Though artificial, Hoyningen-Huene argues that the mathematical example is illuminating because it bears structural similarities to various instances of use-novelty in 18th and 19th century physics.

Far from considering underdetermination to be a destructive force in epistemology, Martin Carrier argues that it helps us identify the non-empirical virtues or cognitive values we share and how these affect theory choice. For example, when scientists opt for one theory amongst various empirically equivalent alternatives they reveal to us something about their conception of knowledge. That is, they tell us what sort of knowledge is worth having. What scientists value, Carrier insists, may change over time. As an example he offers the principle of the uniformity of celestial motions. The principle was of paramount importance in early astronomy and guided theory choice in light of recalcitrant phenomena. Its importance eventually faded away in subsequent astronomical accounts taking with it the associated theory choices. In this respect, Carrier reasons the scientists' decisions serve as 'an epistemological test tube' by bringing to the fore their views on what form scientific knowledge should take.

The next three papers also concern themselves with various kinds of underdetermination but from a unique standpoint, namely how underdetermination relates to structuralist and in particular ontic structural realist conceptions of modern physics. F. A. Muller begins his paper with an examination of one of the main motivations for OSR, namely the thesis that quantum mechanical descriptions of similar elementary

particles entail the indiscernibility and hence the non-individuality of such particles. This thesis is taken to support OSR because its ontological account of the world consists of purely structural features that make the individuality of particles superfluous. Muller points out that this thesis and hence the support it provides to OSR may be under threat when one considers recent work that aims to establish the weak discernibility of elementary particles. However, Muller opposes this line of argument and reasons that weak discernibility can most reasonably be understood via a relationalist conception of objects that in fact lends credence to OSR. This is achieved, in his view, by realising that (i) structuralist objects are relationals, i.e., they are determined solely by the specified relations in the structures they 'reside' and (ii) elementary particles are relationals—a result that follows as a theorem of quantum mechanics.

Holger Lyre's contribution investigates how OSR fares with respect to underdetermination arguments. He starts the discussion with a challenge raised by John Earman. The challenge is to find actual examples of empirical underdetermination in the history of science. Lyre attempts to meet this challenge by considering, among other things, a number of cases from mature physics and in particular quantum mechanics, general relativity, and gauge theories. In his view, even though some cases may arguably be genuine examples of underdetermination they are too few to support the general underdetermination thesis. Indeed, Lyre goes on to argue that OSR overcomes some types of underdetermination because its ontic and epistemic commitments are more modest than those of standard scientific realists. Having said this, he believes that OSR may still face a type of underdetermination that afflicts structural aspects of a theory. Lyre concludes his contribution by claiming that underdetermination is not as hideous and dangerous an anti-realist beast as it has hitherto been suggested.

A closely related paper is that of Steven French, who also examines various forms of underdetermination and relates them to OSR. To be specific, French identifies four different kinds of underdetermination. The first is the well-known underdetermination of theories by empirical phenomena. The second, which he calls 'modal', draws our attention to the possibility that science could have developed differently such that alternative theories to the ones we have today would have saved the empirical phenomena. French is more interested in the third and fourth kinds of underdetermination. The third kind, which he calls 'Jones underdetermination' after a paper by Jones (1991), rests on the point that one and the same theory can have different formulations or interpretations. A prime example discussed in this context is the Hamiltonian and Lagrangian formulations of mechanics. The fourth kind is branded 'metaphysical underdetermination'. It arises from the apparent inability of modern physics to determine whether or not particles are individuals. French considers two prominent strategies to defeat these last two forms of underdetermination, namely the appeal to heuristic fruitfulness and the appeal to essential structure—i.e., structure which different theoretical formulations have in common. The best way to tackle the third and fourth kinds of underdetermination, he argues, is to adopt an ontic structural realist approach that focuses on the essential structure of a theory.

The last three papers have two common denominators. First, their views are substantially informed by a reconsideration of certain central aspects of positivist thinking. Second, even though they deal with scientific realist/anti-realist concerns like the reference of theoretical terms and the empirical content of theories they avoid

taking sides. More precisely, while Hannes Leitgeb's paper is neutral with respect to this debate, the papers by Michael Friedman and Stathis Psillos are somewhat deflationary. Let us start with Leitgeb's paper. Leitgeb revisits Carnap's *Der logische Aufbau der Welt* and argues that, despite the widespread belief in the project's failure, certain core parts can be salvaged. More ambitiously, he begins to draw a sketch of a new *Aufbau* that is similar in spirit to the original but that crucially aims to improve it by solving or dissolving several of its problems. Amongst the problems considered are Goodman's dimensionality and abstraction problems and Quine's holistic challenge to theoretical terms. One major innovation of Leitgeb's project is the development of a general logical method of translation, by which every scientific statement can be translated into an empirically equivalent statement whose components are logico-mathematical signs and terms whose referents are items of experience. Among other things, such translations involve the Ramsey formulation of a theoretical statement. Leitgeb discusses some rather subtle variants of Ramsey sentences. He emphasizes that the use of Ramsey sentences in his new *Aufbau* is neutral with respect to an instrumentalist versus a (structural) realist account of science.

In his contribution, Michael Friedman, who delivered the plenary talk in the workshop, argues that Carnap should also best be understood as neutral with respect to the debate between realists and instrumentalists. Friedman builds up the case for Carnap's neutralism in a stepwise manner. First he demonstrates the evolution of Carnap's thought on theoretical terms towards the Ramsey sentence. Then he proceeds to show that under Carnap's mature conception of scientific theories the conjunction of the Ramsey sentence and the Carnap sentence of a scientific theory exhausts that theory's cognitive content. The Carnap sentence of a theory is a conditional with the theory's Ramsey sentence as the antecedent and the theory itself as the consequent. It is worth noting that the Carnap sentence of the theory is true on purely analytic grounds for the simple reason that if the Ramsey sentence is true then there must be a sequence of values for the existential variables. Contra anti-realist empiricists like van Fraassen, Friedman then argues that no gap exists between empirical adequacy and truth since to accept this Ramsey–Carnap sentence construal of a theory is to believe in both the theory's truth and its empirical adequacy. Contra realists like Psillos, Friedman contends that to believe in the truth of the theory is not tantamount to adopting a realist outlook because the Ramsey sentence only entails that the theoretical terms refer to some, possibly abstract and mathematical, entities—that is, the Ramsey sentence is neutral with respect to questions concerning reference to 'real', 'concrete' or 'objective' entities. Friedman points out that for this reason Carnap's view escapes the Newman problem which is directed towards structural realism.

Finally, in his paper Stathis Psillos provides a nuanced historico-philosophical account of a realist-bound empiricist view that owes much to Schlick, Reichenbach and Feigl. According to this view explanatory entities are acceptable and even indispensable for the explanation of observable phenomena as well as for attaining a maximally coherent causal-nomological view of the world. How is this view different from standard scientific realism? Unlike typical defences of realism (including those found in his earlier work) Psillos argues that there can be no ultimate argument for realism. Rather a realist framework must first be adopted before any questions can be posed about whether or not a particular physical entity is supported by evidence. There is

thus no theory-free vantage point of reality. Significantly, the choice of framework is not forced upon us in any way, though it is decided on the basis of the particular aims we happen to endorse. In other words, one could conceivably opt for an anti-realist framework especially if their aims are in line with such a framework. Provided one's aims are to explain observable phenomena and offer a maximally coherent causal-nomological view of the world then the realist framework is an attractive option. In a nutshell, Psillos adopts a rather deflationary approach towards the way the scientific realism debate is currently conducted.

We hope that readers will find much that is illuminating in this special issue. Our introduction would not be complete unless we thanked a number of individuals at the University of Duesseldorf whose help provided the conditions for a successful workshop. We extend our warmest thanks to (in alphabetical order) Hakan Beseoglu, Alexander Christian, Ludwig Fahrbach, Jens Fleischhauer, Stephanie Korsten, Veronika Linke and Erasmus Scheuer. Finally, we would like to thank the Forschergruppe FOR 600 'Funktionalbegriffe und Frames', an interdisciplinary project at the University of Duesseldorf funded by the German Science Foundation (DFG), for providing us with the necessary financial support to make the workshop and this special issue possible.

References

Cruse, P., & Papineau, D. (2002). Scientific realism without reference. In M. Marsonet (Ed.), *The problem of realism* (pp. 174–189). Aldershot: Ashgate.

Jones, R. (1991). Realism about what? *Philosophy of Science, 58*, 185–202.