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The *Theoretical Frameworks and Empirical Underdetermination* workshop, which I co-organised with Gerhard Schurz at the University of Duesseldorf on April 11-12 2008, is another reminder that philosophy of science in Germany is on the ascendancy. The workshop brought together some of the world's leading experts in the scientific realism debate. Its culmination is a forthcoming special issue of *Synthese*, which consists of written versions of the talks delivered at the workshop.

The workshop was conceived early in the summer of 2007. Our aim at the time was to invite a number of high calibre contributors to the debate. Inevitably this list included Peter Lipton. Needless to say Peter's acceptance greatly boosted our confidence in the workshop's prospects. Alas Peter unexpectedly passed away in November 2007. Quite a few of the workshop's participants had known Peter both on a professional as well as on a personal basis. One of them, David Papineau, delivered a moving eulogy on the opening day of the workshop. We are very thankful to David. We have dedicated the *Synthese* issue to the memory of Peter Lipton.

Thirteen talks were presented at the workshop. For expediency these can be thematically divided into four groups: (i) theory-change and reference (ii) underdetermination, (iii) ontic structural realism and (iv) a reconsideration of the Logical Positivist legacy in the debate.

Let us start with the talks that fall under the first group, namely those of David Papineau, James Ladyman, Gerhard Schurz, Ioannis Votsis and Ludwig Fahrbach. In his talk, Papineau argues that the cognitively significant content of a scientific theory is captured by its Ramsey sentence. The Ramsey-sentence of a theory turns its theoretical predicates into existentially quantified variables. Since the latter presumably cannot be said to refer to any particular object, Papineau reasons, the realist need not concern herself anymore with establishing referential continuity between the theoretical terms of successive theories. This aversion towards standard referential semantics is something that Ladyman's and Papineau's talks have in common. Ladyman argues that anti-realist arguments like the pessimistic meta-induction (PMI) cannot be properly answered by asking whether past theoretical terms refer. Referential issues, says Ladyman, are a red herring. He demonstrates this point by reasoning that the phlogiston theory of combustion did to some extent reveal some knowledge about the causal-nomological structure of the world but that this knowledge is purely structural and in no way requires that there be a referent to the term 'phlogiston'. Indeed, according to Ladyman, the phlogiston theory case lends credence to ontic structural realism (OSR) for the latter makes the term by term reference of theories redundant.

Gerhard Schurz, Ioannis Votsis and Ludwig Fahrbach take a more positive stance towards standard referential semantics in their respective talks. Schurz elaborated a correspondence theorem that he had postulated and proved in an earlier work. Provided certain arguably reasonable conditions are met, the theorem establishes that two successive and empirically successful theories that possess conflicting theoretical superstructures can be referentially continuous in a given domain of phenomena. Schurz demonstrates the fruitfulness of the theorem with two cases: (i) the switch from the phlogiston to the oxygen theory of combustion and (ii) the switch from a classical to a relativistic conception of mass. One of the upsides of this theorem, argues Schurz, is that it allows one adopt a relatively weak form of realism without recourse to the no-miracles argument and its inherent problems. The same preoccupation with reference and theory change also characterised my talk. More precisely, my central aim was to throw light on the concepts of referential success and referential continuity. At first I draw attention to the fact that the existing theories of reference are motivated by different and often conflicting intuitions. I then argue that three options are available. We can either: (a) reject all intuitions that clash with a chosen theory of reference or (b) reject the evidential role of intuitions and find another way to justify our theory of reference choice or (c) try to save conflicting intuitions and their evidential role by rejecting the idea that the relevant referential concepts are monolithic; they are what I call 'polylithic'. I opt for the third option, sketching a hierarchy of concepts of referential success and continuity, each satisfying different sets of intuitions. I end the talk by illustrating to what extent

each such concept can make sense of the historical record of science and therefore be utilised in the evaluation of scientific realist claims. In his talk, Fahrbach also defends realism from theory-change arguments, primarily focussing his attention on defeating the PMI. According to Fahrbach, the theories upon which PMI is based enjoyed low degrees of success when we compare them to contemporary theories in the same domains. This claim is motivated by the fact that the growth of science is exponential. In more detail, theories in the last few decades have been put through much more stringent tests and therefore enjoy higher degrees of success than the kinds of theories cited by Laudan to support the PMI. If, Fahrbach argues, we run an induction on our current theories we will have no reason for pessimism.

Let us now move to the second thematic group which consisted of talks by John Worrall, Paul Hoyningen-Huene and Martin Carrier. Worrall, like Ladyman, rejects term-by-term correspondence. Instead he opts for a global correspondence between parts of the world and the descriptive structure of a theory. In his view, the descriptive structure of a theory can be seen in that theory's Ramsey-sentence, an endorsement of which is tantamount to an endorsement of epistemic structural realism. Such a realism is impervious to the underdetermination problem, Worrall argues, for the simple reason that the Ramsey-sentences of two empirically equivalent theories are cognitively equivalent. Worrall claims that contrary to appearances 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 two theories share all the consequences formulated in a purely observational vocabulary and these inescapably include some theoretical statements. In this respect specification up to empirical equivalence transgresses the anti-realist empiricist's epistemic limits. Throwing doubt on the prospects of justifying realism, Hoyningen-Huene argues for a version of the underdetermination argument that he calls 'transient'. Transient underdetermination holds when we cannot decide between rival theories on the basis of the evidence available at a given time. Employing measure theory, Hoyningen-Huene formalises 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 seemingly strong version of the no miracles argument is falsified by the existence of transient underdetermination. Unlike Worrall and Hoyningen-Huene who seek to establish realist or anti-realist views by defusing or upholding underdetermination arguments, Martin Carrier emphasises what we can learn from them about our epistemic practices. Underdetermination, he reasons, assists us to identify shared cognitive values and non-empirical virtues but also reveals how these values and virtues affect theory choice. Take a scientist who chooses one theory over various empirically equivalent rivals. Since this scientist cannot decide on the basis of empirical virtues, argues Carrier, (s)he resorts to cognitive values and/or non-empirical virtues. The choice then serves as 'an epistemological test tube' for it tells us something about the scientist's conception of knowledge. Crucially for Carrier, the kinds of values and virtues endorsed by a scientific community may change over time. In this respect the resulting approach is anti-realist in outlook.

The next thematic group concerns itself with OSR. Three talks fall under it. In his talk, F.A. Muller examines one of the main motivations for OSR, namely the view that from the perspective of quantum mechanics similar elementary particles are indiscernible and hence lack individuality. This view is thought to support OSR because its purely structural account of the world makes the individuality of particles superfluous. Recent arguments to the effect that similar elementary particles at least satisfy a form of weak discernibility can thus be thought of as a challenge to OSR. Not so, argues Muller, since even weak discernibility relies on a relationalist conception of objects. In this respect weak discernibility supports OSR because both structuralist objects and elementary particles are what he calls 'relationals', i.e. determined purely in virtue of the specified relations. Holger Lyre's talk is also concerned with potential challenges to OSR. To be precise, he investigates how OSR copes against underdetermination arguments. Following standard realist practice, Lyre reminds us that the main problem with underdetermination arguments is the lack of real historical examples. According to him, even though some cases from mature physics may arguably be genuine examples of underdetermination they are not sufficient to support the general underdetermination thesis. Lyre proceeds to argue that OSR has less to fear than standard scientific realists because it makes more modest ontic and epistemic commitments. On

a similar wavelength, Steven French's talk looks into how OSR fares against four kinds of underdetermination arguments. Here we need only concern ourselves with two since they are the ones he gives the most extensive treatment to. The first arises from the fact that sometimes the same theory has more than one interpretations and/or formulations, e.g. the Hamiltonian and Lagrangian formulations of mechanics. The second kind, which he calls 'metaphysical underdetermination', flows out of the apparent inability of modern physics to decide whether or not particles possess individuality. The most promising way to address the aforementioned kinds of underdetermination, claims French, is to adopt OSR and argue that we should only be realists with respect to the 'essential' structure competing theories have in common.

The last thematic group is defined by the speakers' drive to re-examine the Logical Positivist legacy. In his talk, Hannes Leitgeb maintains that despite the general consensus that Carnap's *Aufbau* is a failure, one can salvage enough of its essence to form the basis of a new more successful project. He sketches the outlines of such a project stressing that its success will in part be measured by whether or not it overcomes a number of well-known obstacles. Among these are Quine's holistic challenge to theoretical terms and Goodman's dimensionality and abstraction problems. To overcome them Leitgeb develops a method of translating scientific statements into empirically equivalent statements that owes much to the Ramsey-sentence formulation of theories. Michael Friedman's talk, which incidentally was the plenary talk of the workshop, also focuses on Carnap. Tracing the evolution of Carnap's thought on scientific theories and on theoretical terms, he arrives at Carnap's endorsement of the conjunction of the Ramsey sentence and, what is now called, 'the Carnap sentence'; the latter is a conditional with the theory's Ramsey sentence as the antecedent and the unRamsified theory as the consequent. The conjunction presumably expresses the cognitive content of scientific theories without loss. Friedman reasons that this construal of scientific theories makes Carnap neutral with respect to the debate between anti-realist empiricists and realists. Carnap's view is not a form of anti-realist empiricism because his construal of scientific theories entails that empirical adequacy and truth never come apart. It is not a form of realism because the existentially quantified theoretical variables in the Ramsey sentence need not refer to real entities; for example, they can easily refer abstract mathematical objects. The thirteenth talk is that of Stathis Psillos, who reconsiders the works of Schlick, Reichenbach and Feigl. In so doing, he argues that all three philosophers advocated an unorthodox realist view that he finds very compelling. The view earns the realist badge by making, among other things, the postulation of explanatory entities indispensable for the attainment of a maximally coherent causal-nomological account of the world. At the same time, this kind of realism presupposes something that finds no analogue in standard scientific realism, namely the admission that there is no independent perspective upon which we can judge the reality of entities. That is, one must first adopt a realist framework before any of the usual realist questions can even be raised. Although the choice of framework is conventional, in Psillos' view, our aims play an important role in determining it. In short, nothing prevents one from adopting an anti-realist framework. If, however, we aim to attain a maximally coherent causal-nomological account of the world, then the realist framework, Psillos contends, is the natural choice.

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