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Global vs. local arguments for realism

1 Introduction

There has been considerable discussion in recent years over the right level of generality at which to conduct the scientific realism debate. In the 1960's, the debate took a turn towards a more naturalistic approach, which took scientific realism to be a high level empirical hypothesis that could be 'tested' against the history of science. The ensuing debate came to revolve around two opposing arguments: the No Miracles Argument (NMA) in favour of realism, and the Pessimistic Induction (PI) against realism. However, this whole debate has met with a persistent strain of criticism. The NMA (and PI) are said to be too 'global', too 'sweeping', too 'general', and insufficiently attentive to the details of science on the ground. It has been urged that a more effective and productive approach for the scientific realist is to 'go local'. Localists urge that realists should make the case for realism about particular elements of scientific theories on a case-by-case basis based primarily on the first-order scientific evidence.

In this chapter, I will examine a particular case which is often invoked as a prime example by localists. This is the case of Perrin's experimental arguments for the existence of molecules in the early 20th century. In this case, as Peter Achinstein points out, local arguments can give some traction against certain kinds of anti-realist challenge, in particular challenges from constructive empiricism. This is because the realist may use local arguments to undermine the significance of the observable-unobservable distinction. However, I will argue that the local approach is less successful in evading anti-realist challenges based on the history of science. In order to evade these challenges, the local realist has to give up valuable resources for making her own case. Thus, in fact the global arguments play a key role in supporting any arguments localists could make.

The plan for the paper is the following. In section 2, I will outline the global approach to the scientific realism debate. Section 3 introduces the local approach. Section 4 gives a short description of the Perrin case and section 5 outlines the local arguments for realism about molecules that can be built on it. Discussion of the relative merits of the local and global approaches follows in section 6.

2 The global approach

Hilary Putnam has given the classic formulation of what has become known as the No Miracles Argument (NMA). Scientific realism, Putnam said, is the only way to account for the striking predictive and explanatory success of science as a whole:

> The positive argument for scientic realism is that it is the only philosophy that does not make the success of science a miracle. That terms in a mature science typically refer (this formulation is due to Richard Boyd), that the theories accepted in a mature science are typically approximately true, that the same terms can refer to

> the same even when they occur in different theories – these statements are viewed not as necessary truths but as part of the only scientific explanation of the success of science, and hence as part of any adequate description of science and its relations to its objects. (Putnam 1975)

The NMA was developed, primarily by Richard Boyd and later Stathis Psillos, into the 'explanationist defence of realism' (Boyd 1980, Boyd 1983, Psillos 1999). The key idea here is that scientific realism is the best explanation of scientific success. Realism is treated as a high level empirical hypothesis, which is supported, just as ordinary scientific hypotheses, by an inference to the best explanation. The realist defends a general inference from success to approximate truth of something like the following form:

> R: If theory T is from a mature science and successful, then T is [probably] approximately true.

Since the argument is presented as an empirical one, 'to be tested in the court of experience', it becomes possible, as Laudan points out, that it is refuted rather than confirmed ((Laudan 1981), p. 20). Laudan points to cases in the history of science where a theory T_1 at time t_1 is replaced by theory T_2 at a later time t_2, both of which are mature and successful, yet T_2 is sufficiently different from T_1 that it is not possible that both are approximately true. Thus, such cases are counterexamples to the realist inference from success to approximate truth. For example, Laudan argues that theories such as the caloric theory of heat, the theory of the electromagnetic aether, theories of spontaneous generation all experienced considerable success, yet could not have been approximately true, by the lights of subsequent theories (((Laudan 1981), p. 33). With enough counterexamples, one can even argue that since theories from the past with much success were so often replaced or abandoned, probably current theories will be too, even if they have been very successful. Therefore we should not have too much confidence that our best theories are approximately true. This argument has become known as the 'Pessimistic Induction' or PI.[1]

The explanationist defence of scientific realism is a 'global' argument in the sense that it argues for a hypothesis which says that *any* theory which is mature and succcessful is likely to be approximately true. There is thus a criterion for realist commitment which can be applied generally to theories in science, regardless of their field or specific subject matter. In responding to the PI, realists have typically tried to refine the criterion in the realist hypothesis in a principled way to exclude the counterexamples, while still maintaining the idea of a global criterion which applies across science. Thus there have been a number of new proposals by realists which all take the following general form:

> R: If Crit(T, E) holds, then T is [probably] approximately true.

Here Crit(T, E) is some criterion for realist commitment which concerns how a theory T relates to the evidence E , and which is accessible to us. Since the criterion can be applied to theories across science, the realist hypothesis is still testable against the history of science.

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[1] See Chapter on History of Sciences arguments against realism (Vickers).

One of the first attempts to refine the realist criterion was to impose a strong requirement that the success be 'novel' (Leplin 1997). However, since this did not appear to rule out all the counterexamples, another prominent strategy has been to argue for realism at the sub-theory level, an approach called 'selective realism'. Rather than looking for criteria for taking theories as a whole to be approximately true, selective realists specify criteria for taking some subset of the theoretical statements in the theory to be approximately true. For example, some claim that the elements of the theory which should be picked out are structural in nature (Worrall 1989, Ladyman , French 2006), or that realist commitment should be reserved for entities (Hacking 1982, Cartwright) (Chakravartty 1998). Others argue that the criterion is to pick out those parts of the theory which are critically involved in explaining the predictive or other success which the theory has enjoyed (this is called the *divide et impera* strategy) (Kitcher 1993, Psillos 1999).

3 Going local

The global approach to the scientific realism debate has come in for criticism on a number of fronts. The NMA and EDR have been criticised as ineffective arguments (Laudan 1981, Fine 1986, Matheson 1998, Arnold 2010). Aside from claims that these arguments are circular, there have also been recent accusations that the NMA commits the base rate fallacy (Howson, 2013). There has been a sense in some quarters that the dialectic between the NMA and the PI has led to a degenerating debate (Magnus and Callender 2004). Some have argued that the proposals for refined realist criteria are not sufficiently principled, and particularly prospectively applicable, to count as the needed criteria (Stanford 2003). There has been the sense that the whole discussion has become rather baroque, with no obvious and clear candidate for a workable realist criterion emerging.[2]

Some have suggested that the underlying reason for the lack of consensus is that selective realist criteria are still too broad, insofar as they are supposed to be applicable to science generally. Science, they urge, is not a unified category but is very inhomogeneous (Saatsi 2009, Saatsi 2016, Fitzpatrick 2013). There is a huge amount of difference throughout different parts of science in terms of methods, explanations and reasoning. Saatsi asks

> Why think that we are apt to latch onto reality in the same way throughout the sciences, or even in a single discipline? Quite plausibly, some areas of science are more likely to exhibit underdetermination than others. Some subject matters are very far removed from everyday reality (e.g. quantum fields), while others are relatively close to it despite being about thoroughly unobservable entities and processes (e.g. causal-mechanistic systems in microbiology). In the face of all the diversity, why think that one (or even a handful) of recipes uniformly and fairly

[2] Such questions have been raised even by those working on the projects. For example, Peter Vickers says 'In all this, we find ourselves even 30+ years after Laudan (1981) unsure of the extent to which the divide et impera strategy can succeed' ((Vickers 2013), p. 209).

> captures – across the board – the way in which theories' empirical success is correlated with the way they latch onto reality? ((Saatsi 2016), p.6)

Magnus and Callender are motivated by a similar thought:

> Reflecting on the vast complexities of various historical episodes in science, there is no reason to think that the general assumptions one finds will be at all simple, natural, or even non-disjunctive; in short, there is no guarantee that the criterion one finds will be either interesting or useful. ((Magnus and Callender 2004), p. 335).

All this has provided the spur for an influential movement to adopt a different kind of approach – a local approach. The key idea is that the realist will be on stronger ground if she focuses on the 'first-order' scientific evidence. After all, the scientific community appears, often after extended periods of disagreement, to decide on whether to take a realist attitude towards a theory. And the scientific community appears to be moved not by philosophical meta-arguments but by force of particular evidence. A realist then can make a case for particular entities or properties on a case-by-case basis.

Localists frame the realism debate as a debate over particular cases. However, they do not necessarily suggest that there is no legitimate question to be asked about the epistemic status of science more broadly. Rather they recommend a 'local strategy' for answering it. Insofar as there is a general position to be had, it will be had by conjoining the results of all the particular investigations. So we may end up realist about electrons, but anti-realist about quarks, etc. The type of position that the localist recommends then is supposed to be a more modest kind of conclusion.

The view is usefully summarised by Simon Fitzpatrick as follows:

> [according to the local approach] the defence of realism is best constructed on a case-by-case basis. The idea is that the best foundation for a realist attitude towards a particular theoretical claim of modern science (e.g. that there are atoms, that past and present organisms on earth are the product of evolution by natural selection, that the continents move laterally on tectonic plates, etc.) is the weight of the particular first-order evidence that led scientists to accept the claim in the first place. Realism is thus to be defended through close consideration of the specific theoretical claims that realists want to be realists about, the particular empirical evidence for such claims, and questions about what epistemic attitude towards these claims is licensed by this evidence, with anti-realist challenges to be rebutted as they arise. (Fitzpatrick 2013)

4 The case of Perrin

The local approach is best understood by considering an example. Almost without exception, those advocating the local approach have suggested that realists could make a strong argument for the existence of unobservable molecules based on Perrin's experiments in the early 20th century. Therefore we will look at this example more closely.

Perrin conducted his ground-breaking experiments in 1908-9. By that time the atomic theory had been developing over about a century. It had been used to account for the masses of substances produced in chemical reactions in terms of the putting together or breaking up of molecules composed of basic building blocks (atoms) of definite types. This required a number of more specific hypotheses about the nature of atoms and molecules. Prominent among these was Avogadro's hypothesis which stated that

> Equal volumes of different gases under the same conditions of temperature and pressure, contain equal numbers of molecules ((Perrin 1916), p. 18)

Scientists then defined a 'gramme molecule' of a substance to be the mass of the substance in the gaseous state which occupies the same volume as 32 grammes of oxygen at the same temperature and pressure. Then, according to Avogadro's hypothesis, every gramme molecule contains the same number of molecules. This number is called 'Avogadro's number' *N*.

Atomic theory also had the potential to explain a variety of other phenomena by assuming that they arose due to the motion of molecules composing the substances in question. Thus, for example, the movement of molecules amongst one another explains why two gases in contact diffuse into one another, even if they start off in two layers with the denser gas below. The pressure exerted by a gas or fluid on the walls of its container can be explained by impacts of the moving molecules on the walls. A substantial body of 'kinetic theory' had been built up, based on applying the laws of mechanics to molecules, together with some assumptions which allowed the consequences for the bulk properties of the substance to be determined.

Motions of molecules also offered an explanation for the phenomenon of Brownian motion. This is the seemingly haphazard jiggling of small particles suspended in a liquid that can be seen under a microscope. It appears not to depend on the nature of the particles, apart from being more pronounced for smaller particles. The atomic theory explains the jiggling of the relatively large visible particles by taking it to be a consequence of the jostling exerted upon them by the molecules of the liquid in which they are suspended. Perrin realised that this qualitative explanation could be extended to allow a more quantitative investigation of the phenomenon. He suggested that if the movement of molecules is really the cause of Brownian motion, it could provide a way to measure the dimensions of the molecules, even though the molecules themselves are unobservable. In fact, it was possible to derive an expression for Avogadro's number in terms of quantities which could be measured on an emulsion of Brownian particles. In his famous 'law-of-atmosphere' experiments, Perrin carried out the ingenious and painstaking experimental procedures required to determine the measurable quantities, thus arriving at an estimate for Avogadro's number. He also repeated the procedure under a wide range of experimental conditions, varying the volumes of the particles, the liquid used for the emulsion, and the density of the particles. His collaborator conducted experiments to vary the temperature. The result was

> In spite of all these variations, the value found for Avogadro's number N remains approximately constant, varying irregularly between 65×10^{22} and 72×10^{22} (Perrin 1916).

These results were also in good agreement with a measurement of Avogadro's number, made in a completely different experiment, based on a kinetic theory treatment of the viscosity of gases, which had yielded 62×10^{22}.

Perrin's own interpretation is that ‘such constant results [found with different versions of the emulsion experiment] would justify the very suggestive hypotheses that have guided us', and 'The objective reality of the molecules therefore becomes hard to deny' ((Perrin 1916), p. 105). But Perrin did not stop there. A theoretical treatment of the diffusion of Brownian molecules had been given by Einstein and Smoluchowski in 1905-6. This theory also provided another expression for Avogadro's number in terms of measurable quantities, including the viscosity, temperature and rate of diffusion. In deriving this expression, Einstein had made the supposition that the Brownian movement is completely irregular. This was a supposition that Perrin checked experimentally, by verifying that the displacements of the Brownian molecules followed a Gaussian distribution. He was then able to confirm Einstein's prediction that the displacements would be proportional to the square root of the time elapsed. Perrin then determined Avogadro's number according to the expression provided by Einstein and Smoluchowski’s theory. Again, there was striking agreement with the value of Avogadro's number obtained by other methods.

In the 19th century, atoms and molecules had been widely regarded in the scientific community as hypothetical entities, but by early in the 20th century, all but the most die-hard empiricists were convinced of their existence. Perrin's work is widely thought to have played a key role in the change in attitude towards atoms and molecules[3]. In the presentation speech for Perrin's Nobel prize in 1926, Professor Oseen said that his work had

> put a definite end to the long struggle regarding the real existence of molecules.

Thus, indeed Perrin's work seems to be a good place to look for local arguments in favour of realism about molecules.

5 The local realist approach to Perrin

Localists suggest that the realist can build an argument for the existence of molecules by focusing on first-order scientific evidence and reasoning such as Perrin’s. But what does this involve exactly? The realist may well be inclined to endorse Perrin's reasoning, but she cannot simply repeat Perrin's arguments. She must also make the case that they are convincing. After all, Perrin was not the only scientist involved, and different scientists held different opinions. Some, like Maxwell, were already convinced of the reality of atoms even before Perrin's experiments. Others, like Ostwald and Poincare, were indeed persuaded that atoms were real by the early 20th century evidence. But some, like Duhem, resisted even after Perrin's work.[4] Making a

[3] Though see (Van Fraassen 2009) for a different interpretation.
[4] See (Achinstein 2007) and (Psillos 2011) for discussions of the changing attitudes of various scientists.

case for realism then requires giving a philosophical reconstruction of the reasoning to show why it is compelling.

It also involves defending the reasoning against possible anti-realist challenges, which can be raised in the specific context. It will be helpful to distinguish between two different kinds of anti-realist challenge. One is the challenge from the constructive empiricist. The constructive empiricist urges that it is less risky and therefore preferable to take a well-supported theory such as the atomic theory to be empirically adequate rather than approximately true. This is, for the constructive empiricist, a matter of epistemic modesty, which stems from the general thought that conclusions about unobservables really go beyond what can be properly justified by observations and experiments.

Van Fraassen claims that what Perrin really accomplished was to complete the task of 'empirical grounding' for the atomic theory. Empirical grounding has two main requirements:

> *Determinability*: any theoretically significant parameter must be such that there are conditions under which its value can be determined on the basis of measurement.
> *Concordance*, which has two aspects:
> –*Theory-Relativity*: this determination can, may, and generally must be made *on the basis of the theoretically posited connections*
> –*Uniqueness*: the quantities must be 'uniquely coordinated', there needs to be concordance in the values thus determined by different means. ((Van Fraassen 2009), p. 11)

According to van Fraassen, Perrin's experiments critically pinned down key theoretical parameters, in particular Avogadro's number, and also produced concordance in its value. However, he sees no need to adopt an interpretation which reads Perrin's results as providing evidence for the reality of molecules.

The second kind of anti-realist challenge differs from the constructive empiricist challenge, in that it does not necessarily depend on the observable-unobservable distinction. This is the challenge presented by the history of science. The original argument here is the Pessimistic Induction. Although the local realist is not attempting to defend a general connection between success and approximate truth, the PI might still be raised against an instance of the local strategy. For example, the anti-realist might argue that the successful prediction of Avogadro's number and the striking concordance of its measured values cannot be a good reason for thinking that molecules exist, since in the past similar successes have been experienced by theories which were later substantially replaced.

Another historically-based challenge comes from the 'problem of unconceived alternatives'. This problem arises from an induction over the history of science similar to the Pessimistic Induction, but focusing on the capacity of scientists for eliminative reasoning. Kyle Stanford has produced a number of cases in the history of science where he claims that scientists thought they had eliminated all the alternatives, and this later turned out to be untrue (Stanford 2006). Therefore, Stanford thinks, we should not be confident that theory T is approximately true, since it may in fact be an unconceived alternative theory which gives the correct account of how things are.

We will now consider how the local realist can respond to the constructive empiricist and to the historical anti-realist challenge.

5.1 The local response to the constructive empiricist challenge

The observable-unobservable distinction is crucial for constructive empiricism, and realists have long attempted to show that it lacks the epistemic significance constructive empiricists attribute to it (Maxwell 1962, Churchland 1985, Hacking 1985). Achinstein has suggested that the localist can offer a distinctive kind of attack on the observable-unobservable distinction in the context of Perrin's arguments (Achinstein 2002). Achinstein argues that there can be local reasons for going beyond the observable with respect to a specific property. These are based on what Kitcher has called the 'Galilean strategy' (Kitcher 2001). When Galileo encountered skepticism about whether the newly invented telescope could provide reliable information about celestial bodies, as well as terrestrial bodies, he argued in the following way. What is seen through a telescope when a terrestrial object is so far away that it cannot be observed with the naked eye, can be confirmed by moving closer to the object. There is no reason to think that it would be any different for the stars and other heavenly bodies, which are even further away. In general, if varying the conditions or properties that makes an object change from observable to unobservable, makes no difference to the property whilst the object is still observable, we can expect that it will not make a difference when the object is unobservable either. Achinstein argues that the local realist can use this type of argument to show that the observable-unobservable distinction does not mark a significant epistemic difference for particular properties – for example, the property of having mass.[5]

5.2 The local response to historical anti-realist arguments

We now consider how the localist may deal with anti-realist arguments based on the history of science.

5.2.1 Challenge from the Pessimistic Meta-Induction

Simon Fitzpatrick has suggested that realists pursuing the local strategy will have an easier time dealing with the PI (Fitzpatrick 2013). Based on the PI, the anti-realist recommends a more skeptical epistemic attitude towards molecules, since in the past success such as the atomic theory experienced has not always resulted in retention of the theory. The localist response to this is to argue that the cases of failure of successful theories in the history of science are not relevantly similar to the case in hand, because realist arguments are highly dependent on context-sensitive detail. The general criterion of 'success' in the PI is too blunt, and misses out on important further reasons for realism which may apply in some cases but not in others.

In the specific case of Perrin, according to Fitzpatrick, the epistemic force of Perrin's argument from his multiple convergent estimates of N 'can only be appreciated within the context of a rich network of background beliefs'. Achinstein's reconstruction of

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[5] Saatsi argues that this result for mass underpins the claim that the law of conservation of momentum also extends into the unobservable realm (Saatsi 2009, p. 15-16).

Perrin's 'legitimate mode of reasoning' brings out what is missing. Achinstein identifies 'two important components' of the reasoning. One is

> an argument to the conclusion that the particular experimental results obtained are very probable given the existence of the postulated entity and its properties. ((Achinstein 2002), p. 492)

The fact that in various experimental circumstances the determinations of Avogadro's number coincide on a value approximately equal $6x10^{23}$ can be argued to be very probable, given the hypothesis that molecules exist and that the number of molecules in a gram molecular weight is approximately $6x10^{23}$. This coincidence or concordance of measured values is recognisable as the kind of 'success' that the No Miracles argument appeals to.

However, Achinstein also identifies another important component of Perrin's reasoning, on which the above depends. This is an appeal to causal-eliminative reasoning to the existence of the postulated entity, and to certain claims about its properties, from other experimental results. For example, Perrin appealed to the experiments of Gouy, which had aimed at eliminating the possibility that Brownian motion was caused by external causes such as vibrations or convection currents.

Achinstein argues that such arguments fit the following causal-eliminative scheme:

> 1) Given what is known, the possible causes of effect E (for example, Brownian motion) are C, C_1 , ..., C_n (for example, the motion of molecules, external vibrations, heat convection currents)....
> 2) C_1, ..., C_n do not cause E (since E continues when these factors are absent or altered).
> So probably
> 3) C causes E . (Achinstein 2002), p. 474)

Achinstein points out that these causal-eliminative arguments are deployed by Perrin to establish that the probability for the atomic hypothesis is not insubstantial, even before the concordance of values for Avogadro's number is taken to boost the probability of the hypothesis even further (see (Achinstein 2002), pp. 475-476).

Overall then, Achinstein's work clearly shows that the concordance is only one component of Perrin's reasoning. Even if the PI demonstrates that such concordance is not a reliable indicator of approximate truth, Perrin's full case for the existence of molecules relied on much more than just that. Most importantly, Perrin also had considerable evidence for the elimination of other possible causes of Brownian motion than the motion of molecules.

5.2.2 Challenge from the problem of unconceived alternatives

However, this still leaves the problem of unconceived alternatives to deal with. Stanford has suggested that eliminative reasoning (such as that used by Perrin) can be shown to be historically unreliable. One strategy that the localist may adopt here is to deal with the problem of unconceived alternatives in a similar way to the PI. The idea here would be to argue that although at some level of generality what scientists are doing may be characterised as eliminating alternatives, in reality the force of the reasoning will be highly dependent on the background context. In the case of atomic theory, by giving more details one may be able to show that the eliminative argument is compelling.

An example of how this might be done is provided by Sherri Roush's discussion of Perrin (Roush 2006). According to Roush, even before Perrin demonstrated the striking concordance between measured values for Avogadro's number, he had already provided very compelling evidence for a 'modest hypothesis' about atoms. This hypothesis states that:

> there are atoms and molecules, understood merely as spatially discrete submicroscopic entities moving independently of each other, i.e. at random ((Roush 2006), p. 219).

Roush argues that Perrin had done more than just eliminating possible causes of Brownian motion (vibrations, light temperature gradients, etc) one by one. Perrin also was able to directly measure the motions of the Brownian particles and show that they did indeed move in a random walk. Random motion is exactly what would be expected if the motion was caused by the jostling of molecules also moving at random. Roush points out that establishing that the Brownian motion was random eliminated a whole swathe of possible alternative causes – namely all those causes which might be expected to produce a systematic effect, 'dependencies or correlations between the motions of one particle and another or tendencies in the motion of a single particle' (((Roush 2006), p. 219).[6] Thus, Roush argues that the only remaining causes to consider are those which would not produce systematic effects. The atomic hypothesis is one such, but there might be others that remained unconceived. However, the atomic hypothesis was able to account for more than just this result. It also could explain 'the constant ratios of chemical combination, the independently suspected inexactness of the Carnot principle, and the perpetuity of the Brownian motion' ((Roush 2006), p. 221). Thus there were already substantial constraints on what could possibly serve as an alternative to the atomic hypothesis.

The local realist could then argue that the 'bad' cases in Stanford's New Induction are not relevantly similar to the Perrin example, because the reasons involved in each case are specific to that case. For example, it is true that Maxwell also had arguments for eliminating any alternative theories that did not postulate the existence of an ether. He remained convinced that the behaviour of light could only be caused by waves propagating in an ether, arguing that the interference of waves could only be produced by 'a process going on in a substance':

> That light is not itself a substance may be proved from the phenomenon of interference? Now, we cannot suppose that two bodies when put together can annihilate each other; therefore light cannot be a substance. Among physical quantities we find some which are capable of having their signs reversed, and

[6] The hypothesis that Kyle Stanford suggests is an alternative overlooked by Roush, namely that Brownian motion is caused by 'the interplay of electrostatic forces among the particles themselve, in conjunction with exchange forces with the medium' (Stanford 2009), in fact would be eliminated by the demonstration that Brownian motion is random since it would introduce correlations between particles (see also (Egg 2014), p. 18.

> others which are not. Thus a displacement in one direction is the exact opposite of an equal displacement in the opposite direction. Such quantities are the measures, not of substances, but always of processes taking place in a substance. We therefore conclude that light is not a substance but a process going on in a substance, the process going on in the first portion of light being always the exact opposite of the process going on in the other at the same instant, so that when the two portions are combined no process goes on at all. (Maxwell 1878))

Whereas Perrin's causal-eliminative arguments were experimentally based, Maxwell's were rather theoretical. Thus, the local realist might argue that Stanford's new induction is missing essential fine-grained detail by lumping all eliminative reasoning together. Each case should simply be addressed on its own merits.

6 Discussion

Localists regard the whole dialectic that has followed from the naturalistic turn in the scientific realism debate as misguided. Part of the reason for this is rejection of the NMA. The status of this argument has been much debated, but recent attempts to show that it commits the base rate fallacy miss their mark (Henderson 2015).

Overall, it has become clear by close examination of the Perrin example that the case for realism about a particular entity can rest on more than just the success criterion that figured in the original global NMA. In such a given case, there are further arguments available to the realist. Galilean arguments may help the realist to undermine the observable-unobservable distinction. There may also be other arguments, such as causal-eliminative arguments, which form an important part of the case for realism. The outstanding question that separates localists and globalists is whether it is possible to regiment the further considerations into general criteria for realist commitment.

Despite their exhortations to go local, localists have tended to argue against the viability of general criteria at a very general level, by making broad claims about the diversity of science (Magnus and Callender 2004, Saatsi 2009, Saatsi 2016), or by appealing to analogies with particularist positions on confirmation such as Norton’s material theory of induction (Saatsi 2009). However, there are also general reasons to think that some considerable commonality in reasons for realist commitment is not precluded. Arguably there is quite a lot of common ground in scientific methods, despite the subject-specific differences. And particularist accounts of confirmation fly in the face of a relatively long tradition of confirmation theory. It is not clear that the question of whether useful realist criteria exist can be effectively resolved at this level of generality.

More pivotal is the question of the prospects for the globalist research programme, particularly the selective realist programme. In this programme, realists attempt to identify a more refined criterion for what counts as a 'good' argument for realist commitment, as opposed to a 'bad' argument, without giving up on the idea that this criterion may be applicable to cases across science. The project requires both careful study of specific cases, as well as a comparison of cases, to test whether particular conjectured criteria might work.[7] The global realist needs to show that the proposed refined criterion is not subject to counterexamples from the history of science. Cases continue to be gathered which challenge various proposed realist criteria (Saatsi and Vickers 2011, Vickers 2013, Lyons 2006). A full assessment of how successful the various proposals from selective realists are cannot be undertaken here, but see entries in this volume on Structural Realism and Experimental Realism.

Going local is often presented as an exciting new approach to the realism debate. For instance, Magnus and Callender suggest that it will make the realism debate more 'profitable' (Magnus and Callender 2004). However, in my view this is not the case. Granted, the local realist appears to have some promising resources for dealing with the constructive empiricist since she can appeal to the type of Galilean manoeuvre suggested by Achinstein to undermine the observable-unobservable distinction in some cases. However the localist has fewer resources than the globalist for dealing with the historical anti-realist.

The globalist hopes to identify the features which reliably indicate that a theory or component of a theory is likely to be approximately true. The absence of counterexamples in the history of science then provides a kind of objective support for the realist argument. It also provides a resource for dealing with disagreements over a particular case, since the realist can argue that the features they are identifying in the case have a good track record historically. It is plausible that this kind of 'second-order evidence' is always, as Psillos suggests, an integral part of the evaluation of first-order evidence (Psillos 2011).

By contrast, the localist response adopts a particularist position, insisting that the reasons for realist commitment are highly case-specific. The localist then faces something of a dilemma. As we have seen, it is important that the local realist provides some argument that the scientific reasoning is legitimate or philosophically respectable. This can be done by showing that the arguments in question conform to a recognised general form of reasoning. For example, Achinstein legitimates Perrin's preliminary arguments by claiming that they are instances of a causal-eliminative reasoning scheme (see section 5.2.1). In a similar vein, Salmon argues that Perrin's concordance arguments are 'philosophically impeccable' because they are instances of a legitimate use of the principle of common cause (Salmon 1984). However, when the reasoning is legitimated in this way, it becomes reasonable to consider whether other cases where the reasoning took the same general form were so successful. Thus, the threat of pessimistic historical arguments needs to be faced.

There is in general a tension between providing a compelling justification for the scientific reasoning and having to face historical counterexamples. By going completely local, the realist avoids having to deal with anti-realist historical arguments, but at the price of losing resources for legitimation of the scientific reasoning. There is then not much more to say than that the scientific arguments 'look reasonable'. Such an approach may well seem compelling enough in a case like atomic theory, where we have the full weight of a further century of experience with atoms backing up our intuitions, and where IBM scientists are now able to manipulate

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[7] Examples are (Psillos 1999), (Kitcher 1993) and (Egg 2014).

atoms one-by-one to spell their company name. Although the specific arguments a local realist can present may indeed sound convincing in a historical case like Perrin's, it is not clear how far this strategy will get us in more contemporary or controversial cases.

There is a significant cost to localism as a response to anti-realist challenges based on the history of science. By going local, one can no longer appeal to historical evaluations of reliability of particular features in order to support a realist argument. The prospects for the success of the global realist project are still unclear, but localism should be seen as a fall-back position, rather than something desirable in itself to grasp.

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