Idealisations and the No-Miracle Argument

Quentin Ruyant [*]

Abstract

The fact that many scientific models are idealised, and therefore incorporate known falsehoods, seems to undermine the idea that science aims at truth. Various authors have proposed different solutions to this problem: they have claimed that idealisations are harmless because models can be "de-idealised", that the function of idealisations is to isolate explanatory relevant factors, or that idealised models still convey veridical modal information. I argue that even if these strategies succeed in making idealisations compatible with theoretical truth, a deeper problem remains: the fact that idealisations improve the explanatory power of models contradicts the main argument for scientific realism, which is based on the idea that explanatory virtues are truth-conducive. There does not seem to be any simple solution to this problem.

[*]Universidad Complutense de Madrid

1 Introduction

Scientific realism is the position according to which scientific theories are true or approximately true descriptions of a mind-independent reality. The main justification for scientific realism is the so-called no-miracle argument, according to which scientific realism is the best explanation for the success of scientific theories, in particular, their successful extensions to new domains of experience and new levels of precision. But what does it mean for a theory to be true or false?

The idea that theories are truth-bearers is unproblematic if scientific theories are conceived of as sets of statements about the world. However, it is more common today to conceive of theories as family of models. There is a straightforward tension between scientific realism and this model-based view of theories. A model, contrarily to a linguistic statement, is not generally said to be true or false: instead it is said to be good or bad, or accurate or inaccurate. How, then, shall we understand this idea that theories are truth-bearers?

This problem was acknowledged by van Fraassen (1985), Giere (1989, 85) and Suppe (1989), who claimed that a scientific theory should also be qualified by one or several statements asserting something about how the models of the theory relate to reality (for Giere, "various hypotheses linking those models with systems in the real world", for Suppe, "a theoretical hypothesis claiming that real-world phenomena [. . .] stand in some mapping relationship to the theory structure"). Presumably, this will hinge on a notion, call it veridicality, that is the counterpart of truth when applied to models. A veridical model is a faithful representation of its target. A natural candidate for veridicality is the idea that the model is similar to its target in some respects, or that there is an isomorphism between the model and the (causal, modal or only extensional) structure of the target.

Some difficulties remain, however. A first problem is to go from model veridicality to theoretical truth: this might not be as straightforward as it seems (Ruyant 2020). But this is not the difficulty that I will address here. Another difficulty, which will be the focus of this paper, is that most, if not all scientific models used by scientists are idealised. This means that these models are intentionally non-veridical. Models can caricature the represented system, as do frictionless planes, infinite gases or point masses. They can distort the laws of well accepted theories with the use of mathematical approximation, such as perturbation techniques in quantum mechanics, or with assumptions that are incompatible with said laws, for example, that the Sun is fixed in a referential frame in a model of the solar system.

They sometimes incorporate fictitious entities or elements of superseded theories for explanatory purposes, and they can even combine incompatible theories, for example when modelling a quantum system in a classical environment.

What is particularly problematic for scientific realism is that the non-veridicality of idealised models is not considered a defect, but a feature. Fictions, caricatures and distortions are intentional. They are sometimes indispensable when no analytic solution to the equations of a theory is available, but even when they are not, scientists consider that idealisations contribute to the goodness of scientific models.

Assuming that the truth of a theory is determined by the veridicality of its models in one way or another, how can we maintain that the aim of science is to produce true theories in this context? If falsehoods and theoretical distortions contribute to the success of science, is not the inference from success to truth that characterises realist arguments undermined? Should we assume, as Elgin (2017) does, that understanding is *not* factive?

In this article, I will examine the various strategies that have been employed to salvage truth as a cardinal notion for science. I will argue that even if these attempts succeed in making idealisations innocuous and *compatible* with theoretical truth, a deeper problem remains: the widespread use of idealisations in science undermines the main argument that motivates scientific realism in the first place, the no-miracle argument.

2 Attempts to Salvage Truth

Many authors have defended the view that idealisations do not threaten scientific realism. I shall distinguish in what follows two lines of defence (which are not necessarily exclusive). The first one consists in accepting that idealised models are not veridical, but claiming that this does not threaten scientific realism, because in every case where an idealised model is used, the theory does have a "de-idealised" model that is veridical. One could think of idealised models as placeholders for veridical ones that would make similar predictions. I will call this strategy the *placeholder strategy*. The second line of defence consists in claiming that idealised models are veridical "in a sense": they incorporate a veridical component, in spite of idealisations. This presupposes that the veridical component can be isolated. I will call this the *isolation strategy*. These two strategies can be combined either by applying them to different kinds of idealisations, or by claiming that idealised models are placeholders for models that have a veridical component.

As an illustration of the placeholder strategy, McMullin (1985) claims that idealisations are harmless because small departures from the truth imply small departures in predictions. These departures from the truth can be justified by the fact that correcting them only improves the predictions. As an example, the ratio between nucleus and electron masses can be taken to be infinite in a model of the hydrogen atom. The model is good as such, and correcting for masses only improves it: it explains some differences between ionised helium and hydrogen. In sum, an idealised model can in principle be "de-idealised", and this makes the model better in terms of predictions. And importantly, the de-idealisations are not ad-hoc corrections added for purely empirical reasons. They are motivated by the model itself. So, rather than threatening truth, idealisations, together with the possibility of de-idealisation, confirm theoretical truth. What seems to justify theoretical truth, in this context, is not (or not only) that the idealised model is empirically successful, but rather that de-idealising it makes it even more successful, and the best explanation for this is that the idealised model is approximately true, and the non-idealised model closer to the truth.

With the placeholder strategy, idealisations play a merely pragmatic role, in the sense that they do not to contribute to the empirical success of scientific theories. They only help us use theoretical models by making them more tractable, more easily computable. They result from a trade-off between predictive power and usability. And they are temporary: ultimately, idealised models are destined to be replaced by better models.

One problem with this strategy is that not all idealisations take this form: some idealisations are not corrigible (Wayne 2011). Another common trend in the literature consists in giving a more positive role to idealisations: they isolate relevant factors. This trend corresponds to the isolation strategy.

According to Strevens (2008, ch.8), idealisations enhance the explanatory power of a causal model by conveying explanatorily essential information: they "point to parts of the actual world that do not make a difference to the explanatory target". He takes the example of the fall of an apple, and observes that the gravitational pull of the moon, or air resistance, are irrelevant to the fact that the duration of fall will be approximately proportional to the square root of the distance. The idealised model is focused on the main causal component, and it describes it accurately.

Our interests can also play a role. The expected degree of precision of the explanation will certainly affect which factors are relevant or not. The target of representation can also be controlled by experimenters so as to eliminate particular factors (for example, free fall in a vacuum). According to Mäki (2009), idealisations and fictions are used to isolate the factors we are interested in, and neutralise uninteresting factors, sometimes by construction. An example of this is the assumption, in economics, that agents have perfect knowledge. In this case, the target of the model is not the way economical agents acquire knowledge, so abstracting away from this aspect with a false assumption is legitimate. The false claim that agents have perfect knowledge, which is a positive claim, is used to eliminate irrelevant aspects.

The upshot of both accounts is that idealised models are still veridical with respect to some aspects of the target system, which happen to be the more explanatorily relevant or the ones we are interested in. The false statements involved in idealisations should not be considered representational. A problem with these accounts is that many relevant "difference makers" are also distorted by idealisations in scientific practice (Rice 2021), so it is not clear that we can easily quarantine the non-representational parts of an idealised model.

Pincock (2021) has recently improved on Strevens's account by proposing that the statements involved in idealisations are partially true (they logically imply true statements on the same subject matter as the false statement involved, in the way that "friction is lower than a given threshold" is implied by "there is no friction"). With this account, idealisations could be used to isolate important factors in the explanation, as in Strevens's account, or they could "commit the agent to the existence of an explanatory derivation that avoids the idealization and that exploits only the truth underlying the idealization" (p. 16). This second option brings us closer to the placeholder strategy, although the way of "de-idealising" the model need not be made explicit by modelers. It does not require that there exist a core causal component that is accurately represented in all explanations, as in Strevens's account.

Other authors also argue that idealised models are still veridical of actual phenomena *in some respect*. This is often cast in terms of modal information.

According to Saatsi (2016), the predictive success of a model is robust with respect to variation in the false assumptions involved in idealisations. The veridical components of idealised models are features that are less specific than the false assumptions they incorporate, but that are realised by these false assumptions. These less specific features are modal, or law-like in nature. For example, an idealised pendulum is one possible realisation of a mechanical law whose parameters could be specified in various ways, and the model is empirically successful in virtue of incorporating this law, which is a veridical component, even though the way the law is instantiated in the model (the values of parameters) is not veridical. Rice (2021) similarly argues that factive understanding in the form of modal information is extracted from non-factive models, assuming that the non-actual system that is represented belongs to the same universality class as actual systems of interest.

Bokulich (2016) provides a somehow similar account that is focused on the use of fictions or superseded theories in explanations. According to her, explanations incorporating fictitious entities need not be veridical. They only need to be "credentialed". Their role is to facilitate understanding. So far, this rejoins the pragmatic understanding of idealisations of the placeholder strategy. However, she claims that fictions still capture patterns of counterfactual dependence between relevant variables, which is a veridical component. These patterns could be assimilated to Saatsi's law-like aspects, or to Strevens's relevant causal factors, except that Strevens's "difference makers" need not be accurately represented, nor need they be exclusive: only the associated modal patterns matter for the explanation.

It is often implicitly assumed in the literature that models directly explain. However, Lawler and Sullivan (2021) argues that most scientific explanations are *model-induced explanations*. The idea is that instead of explaining directly, models give us epistemic access to the explanation, with additional assumptions on the part of the user about how the explanation must be extracted, but the fact that the model is not factive does not imply that the explanation extracted from the model is not. This complements the idea that idealised models incorporate a veridical component, which can be extracted by users for explanatory purposes.

In sum, we have two distinct strategies for avoiding the threat of idealisations for scientific realism: either claiming that even though idealised models are not veridical, their closeness to de-idealised models explain their empirical success, or claiming that idealised models incorporate a veridical component, which explains their empirical success.

As said earlier, it is possible to combine these two strategies by assuming that they apply to different cases. Weisberg (2007) distinguishes three kinds of idealisations: Galilean idealisations, minimalist idealisations and multiple-model idealisations. They are mainly distinguished by their motivations. Galilean idealisation "is the practice of introducing distortions into theories with the goal of simplifying theories in order to make them computationally tractable" (p. 640). It follows pragmatic motivations, and can be roughly associated with the placeholder strategy. Minimalist idealisation is "the practice of constructing and studying theoretical models that include only the core causal factors which give rise to a phenomenon" (p. 642). This can be associated with the isolation strategy. Multi-model is similar to minimalist idealisation, except that one does not expect only one model to best represent the target, and in the context of defending realism, it can be associated with the same strategy (the idea would be that each model of a given phenomenon captures one relevant component among many).

Weisberg argues that different accounts of idealisation are actually compatible, because they correspond to different kinds of idealisations which serve different aims. He also briefly argues that none contradict scientific realism. For example, Galilean idealisations are compatible with scientific realism because they are temporary: ultimately, scientists are interested in producing a better, more complete model. As for minimalist and multi-model idealisations, he argues that scientists employing them "aim to uncover real causal structure, or fundamental patterns in common between multiple phenomena" (p. 657).

It might be true that idealisations are compatible with scientific realism. However, a tension remains between the widespread use of idealisations in science and the inference from success to truth that characterises realist arguments, and it is not really solved by all the accounts presented above. A problem that has not been acknowledged in the literature (as far as I know) is that idealisations apparently improve the explanatory power of models, and they do so by taking us away from the truth. However, the exact opposite relation between explanatory power and truth is assumed by the main argument for realism: the so-called no-miracle argument. Thus, even if idealisations are compatible with theoretical truth, a tension remains in the realist's argumentative strategy. Let us present this problem in detail.

3 A Challenge for the No-Miracle Argument

According to Putnam (1975), "the positive argument for realism is that it is the only philosophy that does not make the success of science a miracle". Intuitions of the same kind are given by Smart (1963) and Maxwell (1970). This so-called no-miracle argument is now generally understood as an inference to the best explanation: the best, or only explanation for the empirical success of our theories is scientific realism. What explains the empirical successes of general relativity or quantum mechanics is that these theories are true descriptions of reality, or close enough to the truth. So their success is no miracle.

It is important to note, however, that the argument would not be very convincing if the empirical success of theories was restricted to the phenomena that theories were designed to account for in the first place. More generally, this kind of argument would be question-begging if applied at the level of a single theory, and not at the level of science as a whole: saying that the truth of quantum mechanics explains that quantum mechanics is empirically successful is tantamount to saying that quantum mechanics explains the phenomena that it predicts (per the disquotational property of truth, "quantum mechanics is true" could be replaced by the content of the theory, and "quantum mechanics is empirically successful" could be replaced by its predictions, so claiming that truth explains success is just claiming that the theory explains the phenomena it predicts; see also Levin (1984)). But the whole point of the debate on scientific realism is that there might be other explanations for the same phenomena, perhaps yet unconceived explanations, and the anti-realist generally doubts that our theories constitute the right ones.

In sum, claiming that the best explanation for the success of a theory is that the theory is true is tantamount to a mere restatement of the doctrine of scientific realism. This is the reason why realists often put emphasis on novel predictions: what is remarkable is not empirical success per se, but that a theory that was designed to account for some phenomena is successfully extended to new phenomena, or that it continues to make accurate predictions when levels of precision increase. What needs to be explained is not the empirical success of theories, but the success of scientific inferences for selecting hypotheses and constructing theories that continue to be empirically successful when applied in new contexts.

Psillos (1999) refers to this refined argument as a meta-abductive strategy. The idea is the following: there are many potential explanations for any set of phenomena. Scientists use inference to the best explanation, or abduction, to select the best ones. An explanation is good if it has non-empirical virtues, such as simplicity or scope: it can explain a large variety of phenomena in a simple way. Scientists then extend the theories they have selected to new domains of experience or new levels of precision, and, miracle! Their theories continue to be successful. This success requires an explanation. The best explanation, according to Psillos, is that the inferences to the best explanation used by scientists to select theories are truth-conducive, and as a consequence, their theories are true, or approximately true. In sum, we have justified abduction by abduction, which is why Psillos talks about meta-abduction.

A central aspect of the realist strategy is thus that non-empirical explanatory virtues such as scope and simplicity are truth-conducive: a simple theory with wide scope is more likely to be true. A typical example to illustrate this idea is Copernicus's heliocentric model of the solar system. This model is more simple than its predecessor, and it eventually turned out to be more successful, even if it was not superior on purely empirical grounds at the time it was proposed. The best explanation for this success is that simplicity, one of the components of a good explanation that favoured Copernicus's model over its predecessor, is truth-conducive.

The idea that inference to the best explanation is truth-conducive has been challenged by many authors (for example van Fraassen (1989) or Cartwright (1983)). I will not rehearse their arguments here. The point that I want to make is that the use of idealisations in science challenges this idea.

I will frame my argument in the context of the semantic conception of theories, where theories are characterised as families of models, so it is worth reconstructing the no-miracle argument in this specific context (my argument could be resisted by returning to a statement-view of theories, but I will not examine this option here). I assume that explanations for phenomena are provided by models, and that theories explain only indirectly, through their ability to provide models for particular phenomena. Now it is important to note that a theory is not a mere collection of disparate models with nothing in common, but that this collection is organised by a common vocabulary and by laws and principles characterising the models of the theory. A theory constrains the form explanations can take. For example, the theory of evolution is associated with a general form of explanation in terms of adaptations to the environment, but evolutionary explanations of this form will incorporate specific adaptations in order to explain.

I assume that a theory is ideally true if it can provide a veridical model for any target system in its domain of application, and that it is explanatory if it can provide an explanatory model for any target system in its domain of application. Presumably, what the realist wants to explain is the success of extending the organising laws and principles that characterise theories to new applications, which could work roughly according to the following stages: (1) a model is constructed to explain a particular phenomenon, (2) some general features of this model (a form of explanation) are abstracted and used to construct a different model for another phenomenon, (3) this extension proves successful in terms of predictions (note that step 2 could come before step 1, or the two could result from a reflexive equilibrium; what matters is that these two aspects, the model-level and the theory-level, are distinct). The best meta-explanation for this success would be that the methods used by scientists in steps 1 and 2 are truth-conducive. In particular, the general explanatory features extracted from their best models have the potential to provide veridical, or nearly veridical models for any phenomena. Step 1 and 2 are underdetermined by experimental data (there is more than one way of constructing a model and extracting its general features), so non-empirical virtues must be involved in the process, and according to the realist, these virtues are truth-conducive.

In this context, the main problem for the no-miracle argument is that idealised models have, in general, more non-empirical virtues than their non-idealised counterparts: they are more simple, and very often, they have a wider scope than non-idealised models that incorporate more details about the target. For example, a model of a free-falling body without air friction applies to any free-fall where air friction can be neglected, whereas a model with a specific value for air friction only applies when the actual friction is in the vicinity of this value. So, it would seem that idealised models are explanatory better than non-idealised models, as acknowledged by many of the authors presented in the previous section (in particular those who follow an isolation strategy). On the other hand, scientists recognise that idealised models are further from the truth than their non-idealised counterparts. If this is the case, then non-empirical virtues are not truth-conducive. Something has to go.

Let us summarize the problem in the form of a trilemma:

1. Idealised models are better explanations than non-idealised models.
2. Idealised models are further from the truth than non-idealised models.
3. Better explanations are closer to the truth.

Statement 3 is an essential component of the no-miracle argument and of inference to the best explanation. One way of rescuing scientific realism, or at least a form of factivity of explanations and understanding, is to give up on abductive defences of realism (Saatsi (2020) considers this possibility). However, my main focus in this article is on the tension between idealisations and inference to the best explanation, so I will not examine this option. In order to retain the abductive defence of scientific realism, one has to deny either statement 1 or 2.

The strategies presented in the previous section are more compatible with one of these two options. In particular, what I have called the placeholder strategy is more compatible with denying that idealised models are better explanations than their non-idealised counterparts: after all, according to this strategy, the virtues exhibited by idealised models are pragmatic and temporary; they do not contribute essentially to empirical success. So perhaps non-idealised models provide better explanations. As for the isolation strategy, Strevens says explicitly that idealised models explain better than non-idealised ones, but according to this strategy, idealised models are still veridical with regards to some relevant aspects, which could be used to deny statement 2.

Let us examine these two options in more detail.

4 Are Non-Idealised Models Better?

The first option consists in claiming that non-idealised models provide better explanations for the phenomena they represent than idealised models. Idealised models would exhibit pragmatic virtues (they would be more easily computable, etc.) that are not essential to the quality of the explanations they provide.

However, it is not obvious in what sense a non-idealised model would explain better. What kind of virtue does it have that its idealised counterpart does not have? It is less simple, and less easily extendible to other target systems. There is certainly one virtue that it has: it makes better, more precise predictions than the idealised model. Taking into account air friction in a model of free fall will result in finer predictions. Taking into account wind fluctuations, the shape of the falling body or other aspects will result in an even better model in terms of predictions. But empirical precision is often achieved at a cost in terms of generality and simplicity, and if, ultimately, empirical precision is the only virtue that matters for the goodness of an explanation, then one should better assume that the aim of science is to produce theories that are empirically adequate, and the no-miracle argument fails.

As we have seen, the no-miracle argument attributes the successful extension of theories to new domains of application to the truth-conduciveness of *non-empirical* virtues. But according to the option we are considering here, these non-empirical virtues are merely pragmatic, temporary and inessential to the explanation, and the idealised models that feature them provide worse explanations than their non-idealised counterparts. So, the successful extension of scientific theories to new domains cannot rest on the goodness of explanations, which contradicts the abductive defence of realism.

One possible response to this problem is to distinguish the model-level and the theory-level. After all, as we have seen, the no-miracle argument rests primarily on the successful extension of theories to new domains of experience, not on the success of disparate models. It might be the case that simple models with a wider scope are, in general, further from the truth, while simpler theories with a wider scope are closer to the truth. The relevant non-empirical virtues should be taken into account at the theory level: not when it comes to constructing models for given phenomena, but when scientists extract general features of these models to construct other models (the second step mentioned in the previous section). If this is the case, then complex, de-idealised models could be more explanatory than idealised models in virtue of being models of a virtuous theory, and the fact that they are less easy to handle would be irrelevant to their explanatoriness. This prompts the question: what is it, for a theory (qua family of models, or organising principles) to be simple and to have a wide scope, if it does not simply rest on the fact that its models are simple and have a wide scope?

As noted earlier, a theory provides connections between its various models (they share similar structures, described by theoretical laws), so the rationale could be this one: a model provides a good explanation for some phenomena if it is empirically successful and if it has simple connections to other models applying to a great variety of phenomena, which means that it is a model of a simple theory with wide scope. Each good explanatory model can itself be very specific and complex, so statement 1 from our trilemma is denied. However, the models of the theory together cover a large range of phenomena, and they are all connected by simple principles. This makes the theory explanatory better, and closer to the truth, because these complex models related by simple principles are veridical. In other words, simplicity and scope would indeed be pragmatic at the model-level, but truth-conducive at the theory-level.

This rationale is particularly convincing when idealisations distort theoretical laws. Take for example a model of the solar system where the Sun is fixed in a referential frame. According to Newton's laws, this can only be true if the mass of the Sun is infinite, so that the planets do not alter its position. But on the other hand, the mass of the Sun must be finite to correctly account for the trajectories of planets. The model is thus inconsistent with Newtonian laws. This makes the model simpler for calculation purposes, but such a model is no more connected in a simple way to other Newtonian models, because this kind of distortion cannot be generalised. The realist could argue that in this case, simplicity is a pragmatic virtue that makes the model *worse* as an explanation than a non-idealised version where the position of the Sun would be influenced by planets. Thus the connection between explanatory virtues and veridicality is preserved.

There is work to do for the realist to flesh out this solution in more detail. The notion of simplicity is notoriously difficult to make precise in an objective way. Even then, it is not clear that this solution is viable. Is not a model of the solar system where the Sun is fixed more explanatory when it comes to the trajectory of planets? Examples used to foster the idea that simplicity is truth-conducive are sometimes example of models rather than theories (for example, Copernicus's model). And even when theories are considered, model simplicity seems important: it is not clear that the theory of relativity provides simpler connections between its models than Newtonian gravitation. An impressive empirical success of relativity is its prediction of the deviation of light by massive bodies, but perhaps a model of Newtonian gravitation could account for the same observations by invoking the presence of transparent fluids with refraction indices in the vicinity of massive objects for instance. Surely, the resulting models will be more complex, and that is one reason to favour relativity over Newtonian mechanics. But the notion of simplicity invoked here concerns the model-level, not the theory level. Perhaps another rationale could be given (in terms of the adhocness of postulates maybe) but this account is missing so far.

Finally, the connection between theoretical virtues and truth is quite loose in this picture. Excluding virtues at the model-level as merely pragmatic aspects, and focusing on organising laws and principles only, makes the no-miracle argument less convincing. Other explanations than truth can be given for the fact that simplicity and scope at the *theory* level participate in successful extensions: these theories might offer more flexibility, resulting in more empirical success. After all, new theories often give up central assumptions of old ones, giving us access to a larger variety of models. That a given type of explanation has proved successful for various phenomena gives us confidence that it will continue to be successfully extended to new phenomena, but this can be justified by induction, without necessarily assuming that models are veridical.

In sum, it might be possible to defend that non-idealised models are in a sense more explanatory than idealised models, even though they do not have the virtues normally associated with good explanations, such as simplicity and scope, but the burden of showing how this can be done rests with the realist.

5 Are Idealised Models Truer?

Let us now turn to the second option. One could grant that idealised models provide better explanations than non-idealised ones, but maintain that idealised models are actually veridical with respect to some aspects of the phenomena they describe, so as to support the idea that inference to the best explanation is truth-conducive.

The problem with this option is that while it makes sense to claim that idealised models are veridical in a sense, claiming that their idealisations make them closer to the truth is something else. The realist can argue that inference to the best explanation must be applied to the relevant factors isolated by the model only. However, even if, as Strevens argues, an idealised model isolates the most relevant causal factor for the phenomena described, surely, a less idealised model could describe this factor just as well. So, there is no reason to think that inference to the best explanation is truth-conducive, because the models that are more explanatory in virtue of isolating the relevant factors are not closer to the truth, not even with respect to the relevant factors: they are just as close as other less explanatory models.

The same goes for Pincock's idea that the statements involved in idealisations are partially true: surely, true statements are closer to the truth than partially true ones, so idealised models cannot be closer to the truth than non-idealised ones. As for the view that models give us modal information, the same modal information could be given by a more accurate model. Finally, concerning Lawler and Sullivan's view that models do not explain directly, but rather induce explanations, they still accept that idealisations foster explanatory power, if indirectly. So, the problem still occurs in this case: why should we assume, as the no-miracle argument does, that better (e.g. more focused) explanations take us closer to the truth?

A response could consist in distinguishing, again, the model and the theory level: perhaps idealised models are less or equally veridical than non-idealised models, but what really matters is *theoretical* truth. The virtues of a good explanation might not be truth-conducive for particular models, but they would nonetheless foster theoretical truth indirectly. Idealisations would be instrumental in achieving theoretical truth. In the previous section, we considered the thesis that explanatory virtues would be relevant at the level of theories only, with truth (or veridicality) being a model-level aim. Here, they are relevant at the model level only, but truth would be a theory-level feature.

The best case that I can think of for this thesis is the idea that scientists adopt a divide and conquer strategy. Remember that according to some authors, idealisations point to the parts of the world that are not relevant in particular contexts. Experimenters often control target systems so as to isolate specific factors. The realist could argue that they do this in order to get closer to the truth with respect to one type of causal factor in the world (or one type of modal information). If the process can be achieved for a variety of factors, then these factors can be recombined into more complex models, and the resulting models would be very close to the truth. Then the theory would be able to describe accurately a wide range of phenomena.

The main non-empirical virtue involved in this picture is the ability of a representation to decompose complex processes into a combination of independent causal factors or modal patterns. According to this strategy, this focus makes explanations better, and this is also a way of getting closer to the truth, presumably because reality is such that various causal factors can be decomposed. This would be the best explanation for the success of this strategy.

I think that this solution captures quite well modelling practices. But is it enough to support the no-miracle argument? There are reasons to doubt it.

Take for example the Newtonian explanation of tides. In this case, the relevant components of the explanation are gravitational forces, as well as inertial forces involved in the Coriolis effect. According to our best theory of gravitation, general relativity, these forces do not really exist: there are only deformations of the geometry of space-time (and even in Newtonian physics, inertial forces are considered fictitious). Decomposing the earth-moon system into component forces enhances our understanding of tides. Arguably, the Newtonian explanation is better than a relativistic one, and this is due to our ability to decompose the explanation into different factors, which makes the overall explanation more tractable. It gives us understanding. A relativistic explanation would not distinguish the causal components implied in tides, or other phenomena, as neatly. As Bokulich (2016) observes, Newtonian gravitation is widely used in oceanography articles, while there is almost no reference to the theory of relativity. But this does not make Newtonian gravitation closer to the truth than relativity theory. Arguably, this way of decomposing forces does not really "carve nature at its joints", since the theory of relativity is generally considered a better, more fundamental theory (Wilson (2007) argues that Newtonian resultant forces exist, but she also denies the existence of component forces (Wilson 2009), so this does not help the isolation strategy). This undermines the connection between the goodness of an explanation and truth that the realist puts forth in the no-miracle argument. Idealisations do make our explanations better, but they do not bring us closer to the truth, and this is the case not only for particular models, but also at the theory level: Newtonian mechanics is still the theory that provides the best explanations for various phenomena today.

Also note that as observed at the end of the previous section, there might exist alternative explanations for the success of the isolation strategy that do not rest on its truth-conduciveness, for example in terms of flexibility.

One last option for the realist is to go structural realist. According to structural realism, our theories correctly describe the relational structure of the world, but not its nature. In order to avoid collapsing into a version of empiricism, authors often put emphasis on the *modal structure* (Ladyman and Ross 2007; French 2014). These positions pretend to explain empirical success, including when it comes to superseded theories such as Newtonian mechanics: these theories, although strictly false, capture structural aspects of reality.

This seems to be the best option for authors who claim that idealised models provide accurate modal information (see section 2). Perhaps isolating causal factors is a good way of unveiling the modal structure of reality, and Newtonian mechanics gets this structure right in the case of tides. However, even restricting oneself to structural claims, Newtonian mechanics cannot be considered closer to the truth than relativity theory, even though it is explanatory better in some contexts. So, the problem remains.

I do not claim to have explored all possible solutions to the problem examined in this paper. But in light of this discussion, the burden is on the realist to tell us exactly what kinds of virtues are involved in inferences to the best explanation, whether they are involved or not in idealisations as well, and how they can be truth-conducive, be it at the model or at the theory level. There does not seem to be any simple way to do so. Without such an account, the no-miracle argument fails.

6 What Alternative to Realism?

As we can see, there is a tension between the fact that idealisations make our explanations better and the idea that inference to the best explanation would be truth-conducive. This weakens the main argument for scientific realism.

This article was not meant to deny that explanations and non-empirical virtues are important in science and guide theory choice and model building. It was only meant to deny that they are truth-conducive. Scientific realism could still be maintained by giving up on abductive defences of realism. However, an alternative to scientific realism that is more coherent with modeling practices is the idea that non-empirical virtues are *empirical-adequacy-conducive*.

The idea is the following. Scientists are in the business of constructing empirically adequate theories, in the sense that these theories are able to predict a large variety of possible phenomena in a unified way. What we want is a theory that is flexible and accurate enough to provide good predictions for arbitrary levels of precision for the largest possible variety of phenomena possible, using, if possible, simple heuristics for model construction. Such a theory captures the general patterns of possible experiences from a human perspective. There is a trade-off between unification, scope and predictive power, so some non-empirical virtues play a role in theory selection. One way of achieving this successful combination of virtues is a divide and conquer strategy: isolate specific causal factors and then recombine them. As defenders of the isolation strategy could argue, this strategy has proved successful in the past. One explanation for this success could be that such theories are easily adaptable to new phenomena, and that an inductive process allows scientists to select the most successful adaptations. But this is not necessarily the only strategy available.

So the aim of science is to produce ideally empirically adequate theories. However, in concrete applications, as when the theories of physics are used in oceanography, ideal predictive power and scope sometimes matter less than explanatory power and usability. What is needed is a cognitive grasp of particular phenomena that helps us control and anticipate these phenomena in a large enough variety of circumstances with as little effort as possible, that is, a good explanation.

Explanations are generally contextual: they depend on the relevant variables to be explained and on background conditions. For example, the relevance of the Newtonian explanation for tides depends on the fact that the earth is located in flat space-time and that we are interested in coarse-grained variables. This means that explanatory power is not necessarily congruent with truth in an absolute sense, nor with ideal empirical adequacy at the theory level. At least, a form of pluralism is acceptable in this context: it makes sense to use superseded theories that are less empirically adequate, or simplified models that are not part of an empirically adequate theory for explanatory purposes. Model simplifications cannot always be generalised, so they should not be incorporated in the theoretical framework itself.

But as argued by defenders of the placeholder strategy, they are harmless because they are close enough, in terms of predictions, to a non-idealised model that makes more accurate predictions. So, the explanatory success of such idealisations does not threaten the idea that theories are *empirically adequate* (and it is important that the corrections added to de-idealise a model are not ad-hoc, because the aim of science is to produce empirically adequate *theories*). Finally, the fact that theories are often constructed by isolating component causes, so as to be easily adaptable to various phenomena, makes them particularly fit for such purposes.

A structural realist could co-opt these arguments and claim that capturing the structure of possible experiences from a human point of view is all that we need to achieve "structural truth". This would mean giving up on the abductive defence of realism. However, in this view, the modal structure that the theory describes does not exists absolutely, but only relatively to a given perspective on worldly phenomena, tied to our epistemic position in the world. As argued in Ruyant (2021, ch. 7), this conception of structure is insufficient to sustain a realist position. At best it supports a modal version of empiricism, according to which theories merely capture relations of necessity between observable phenomena, where necessity is not absolute (as laws of nature could be) but relative to a background context. Such relativity is incompatible with the transcendent notion of truth that characterises realist positions.

This proposal does not suffer from the problems of scientific realism, because it acknowledges that a trade-off between non-empirical virtues and predictive power is necessary, both at the model-level in specific contexts and at the theory-level, and the two levels can come apart. Simplicity and scope are not considered instrumental means of achieving truth: they are valuable for their own sake. Science has been very successful at producing theoretical frameworks with these virtues that can be extended to new domains of experience. The strategies employed by scientists are certainly efficient for this purpose, and incidentally, they can give us a cognitive grasp of phenomena, in the form of modal information about what is observable and doable *from our perspective*. But this is no reason to believe that the entities posited by scientific theories really exist in an absolute sense, or that scientific laws are true in a transcendent sense: at most it makes sense (drawing from van Fraassen (1980)'s distinction between acceptance and belief) to accept them for the purpose of explanations and predictions.

References

Bokulich, Alisa. 2016. 'Fiction As a Vehicle for Truth: Moving Beyond the Ontic Conception'. *The Monist* 99 (3): 260–79. https://doi.org/10.1093/monist/onw004.

Cartwright, Nancy. 1983. *How the Laws of Physics Lie.* Vol. 34. Oxford University Press.

Elgin, Catherine Z. 2017. *True Enough.* Cambridge, MA: MIT Press.

French, Steven. 2014. *The Structure of the World: Metaphysics and Representation.* Oxford, United Kingdom: Oxford Univeristy Press.

Giere, Ronald. 1989. 'Scientific Rationality as Instrumental Rationality'. *Studies in History and Philosophy of Science Part A* 20 (3): 377–84.

Ladyman, James, and Don Ross. 2007. *Every Thing Must Go: Metaphysics Naturalized.* Oxford University Press.

Lawler, Insa, and Emily Sullivan. 2021. 'Model Explanation Versus Model-Induced Explanation'. *Foundations of Science* 26 (4): 1049–74. https://doi.org/10.1007/s10699-020-09649-1.

Levin, Michael. 1984. 'What Kind of Explanation Is Truth'. In *Scientific Realism*, edited by Jarrett Leplin, 124--139. University of California.

Mäki, Uskali. 2009. 'MISSing the World. Models as Isolations and Credible Surrogate Systems'. *Erkenntnis* 70 (1): 29–43. https://doi.org/10.1007/s10670-008-9135-9.

Maxwell, Grover. 1970. 'Theories, Perception and Structural Realism'. In *The Nature and Function of Scientific Theories*, edited by Robert Colodny, 3–34. University of Pittsburgh Press.

McMullin, Ernan. 1985. 'Galilean Idealization'. *Studies in History and Philosophy of Science Part A* 16 (3): 247–73. https://doi.org/10.1016/0039-3681(85)90003-2.

Pincock, Christopher. 2021. 'A Defense of Truth as a Necessary Condition on Scientific Explanation'. *Erkenntnis.* https://doi.org/10.1007/s10670-020-00371-9.

Psillos, Stathis. 1999. *Scientific Realism: How Science Tracks Truth.* Philosophical Issues in Science. London ; New York: Routledge.

Putnam, Hilary. 1975. *Mathematics, Matter, and Method.* Cambridge University Press.

Rice, Collin. 2021. 'Understanding Realism'. *Synthese* 198 (5): 4097–4121. https:

//doi.org/10.1007/s11229-019-02331-5.

Ruyant, Quentin. 2020. 'Semantic Realism in the Semantic Conception of Theories'. *Synthese*. https://doi.org/10.1007/s11229-020-02557-8.

———. 2021. 'Modal Empiricism: Interpreting Science Without Scientific Realism'.

Saatsi, Juha. 2016. 'Models, Idealisations, and Realism'. In, 173–89. Cham: Springer International Publishing. https://doi.org/10.1007/978-3-319-28163-6_10.

———. 2020. 'Realism and Explanatory Perspectivism'. In *Understanding Perspectivism: Scientific Challenges and Methodological Prospects*, edited by Michela Massimi and C. D. McCoy. Routledge.

Smart, John. 1963. *Philosophy And Scientific Realism*. Humanities Press.

Strevens, Michael. 2008. *Depth: An Account of Scientific Explanation*. Harvard University Press.

Suppe, Frederick. 1989. *The Semantic Conception of Theories and Scientific Realism*. Chicago: University of Illinois Press.

van Fraassen, Bas. 1980. *The Scientific Image*. Oxford University Press.

———. 1985. 'On the Question of Identification of a Scientific Theory (A Reply to "Van Fraassen's Concept of Empirical Theory" by Pérez Ransanz)'. *Critica* 17 (51): 21–29.

———. 1989. *Laws and Symmetry*. Vol. 102. Oxford University Press.

Wayne, Andrew. 2011. 'Expanding the Scope of Explanatory Idealization'. *Philosophy of Science* 78 (5): 830–41. https://doi.org/10.1086/662277.

Weisberg, Michael. 2007. 'Three Kinds of Idealization:' *Journal of Philosophy* 104 (12): 639–59. https://doi.org/10.5840/jphil20071041240.

Wilson, Jessica. 2007. 'Newtonian Forces'. *The British Journal for the Philosophy of Science* 58 (2): 173–205. https://doi.org/10.1093/bjps/axm004.

———. 2009. 'The Causal Argument Against Component Forces: The Causal Argument Against Component Forces'. *Dialectica* 63 (4): 525–54. https://doi.org/10.1111/j.1746-8361.2009.01216.x.