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A pragmatic approach to the ontology of models

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Abstract
What are scientific models? Philosophers of science have been trying to answer this question during the last three decades by putting forward a number of different proposals. Some say that models are best understood as abstract Platonic objects or fictional entities akin to Sherlock Holmes, while others focus on their mathematical nature and see them as set theoretical structures. Although each account has its own strengths in offering various insights on the nature of models, several objections have been raised against these views which still remain unanswered, making the debate on the ontology of models seem unresolvable. The primary aim of this paper is to show that a large part of these difficulties stems from an inappropriate reading of the main question on the ontology of models as a purely metaphysical question. Building on Carnap, it is argued that the question of the ontology of scientific models is either (i) an internal theoretical question within an already accepted linguistic framework or (ii) an external practical question regarding the choice of the most appropriate form of language in order to describe and explain the practice of scientific modelling. The main implication of this view is that the question of the ontology of models becomes a means of probing other related questions regarding the overall practice of scientific modelling, such as questions on the capacity of models to provide knowledge and the relation of models with background theories.

Keywords Models · Ontology · Pragmatism · Carnap · Linguistic frameworks · Internal/external questions

1 Introduction

One of the most important activities in scientific inquiry is the construction of models. Scientists use models for a number of different reasons—to represent actual and imaginary systems, to learn things about these systems, to test the implications of a

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theory, for educational purposes etc.—and these models come in a variety of forms. A natural question to ask is therefore

[Q] What are scientific models?

A long-standing debate in the literature on scientific models concerns the possible answers to this question. While some authors have voiced their scepticism that this question has a meaningful answer (Callender and Cohen 2006; Suárez 2004; French 2010), others have tried to give a more positive note by arguing that models are best understood as real existing abstract objects (Giere 1988; Psillos 2011), fictional entities (Godfrey-Smith 2006; Frigg 2010; Toon 2010, 2012) and mathematical structures (van Fraassen 1980; Da Costa & French 2003). Each of these accounts comes with its own strengths and weaknesses and faces its own difficulties in giving a conclusive answer to the main question on the ontology of models.

The primary aim of this paper is to adopt a Carnapian meta-ontological stance and show that some of these ostensibly insurmountable difficulties stem from an inappropriate reading of [Q] as a purely metaphysical question. Building on Carnap's (1950/2012) tripartite distinction between (i) internal questions (ii) external practical questions and (iii) external theoretical questions, it will be shown that [Q] should be understood as an *internal theoretical* question within an already accepted linguistic framework or an *external practical* question regarding the choice of the most appropriate form of language in order to describe and explain the practice of scientific modelling. The further reading of [Q] as an *external theoretical* question, that is, as a question about the *real* nature of models, independently of any form of language that might be used to describe them, is deceptive and should be avoided. The conclusion is that, from a Carnapian perspective, the debate on the ontology of models is ultimately about the choice of an appropriate language in order to describe the practice of scientific modelling, and as such, it does not admit of a *unique true answer*. By adopting different 'ontologies' of models, philosophers are in effect advocating for the various alternative ways by which one can understand the abstract nature of models and their role in scientific inquiry.

Rather than arguing for the supremacy of a Carnapian meta-ontological stance in general, the aim here is to take the Carnapian framework as a working premise and demonstrate the implications and payoffs of this view on the debate about the ontology of scientific models.[1] It should also be noted that if one is sceptical about the Carnapian programme in general, there is nothing special in the debate about the ontology of models that favours the adoption of a Carnapian stance specifically about this matter. The aim is therefore not to argue that one should be a Carnapian with respect to the ontology of models, regardless of one's beliefs in other issues of metaphysics. Rather,

[1] Whether one has good reasons to adopt a neo-Carnapian stance in metaphysics in general, is something that has been discussed extensively in the relevant literature and the reader is referred to the original works of Carnap (1937, 1996, 2012), Carnap and Schilpp (1963) and Quine (1951a, b, 1960) for more detailed arguments and responses. In the more recent literature on meta-metaphysics, a number of compelling arguments towards a neo-Carnapian point of view can be found in the works of Price (2004), Price (2007), Price (2009), Macarthur and Price (2007) and Thomasson (2014). A number of responses on the basis of neo-Quinean concerns can be found in the works of Sider (2009), Finocchiaro (2019), and Van Inwagen (2020).

the aim is to illustrate that once one adopts the Carnapian perspective, a number of issues in the debate are resolved and the focus can be shifted to other non-trivial questions about the general practice of scientific modelling. Carnap's motivation in applying his method to metaphysics was to bring to philosophy the kind of progress that is usually found in the natural sciences, and this paper aims in showing how this progress can be achieved in the debate about the ontology of models by applying the Carnapian method.

In particular, the proposed understanding of the debate in Carnapian terms teaches us that the choice of an appropriate linguistic framework—i.e. the choice of an appropriate ontology—is only a practical matter relative to the aims for which the language is introduced. Hence, given that the aim of philosophical investigations on the nature of scientific models is to understand as much as possible about their function as epistemological tools in science, the various existing accounts should not be seen as competing and mutually exclusive theories aiming to find a unique true answer to the question of the ontology of models. Rather, they should be seen as complementary accounts that enable us to understand the different aspects of modelling. The main implication of this view is that the question of the ontology of models is only taken as a means of probing other related questions regarding the overall practice of scientific modelling, such as questions on the capacity of models to provide knowledge and the relation of models with background theories.

This realization effectively dissolves the debate on the ontology of models and urges philosophers to move forward, by arguing that there is nothing more to be gained in trying to settle on a unique true answer to the question of the ontology of models. The main argument is that the two proposed readings of [Q] jointly provide all the necessary conceptual tools for developing a robust theory of models, whilst keeping away from the various insuperable challenges faced by the aforementioned existing accounts. The onus is thus on the proponents of such views in the sense that they need to show what the extra benefit of attempting to settle on a conclusive answer is.

The paper is organised as follows. In Sect. 2 the problem of the ontology of models is described in more detail with references to the relevant literature. In Sect. 3, Carnap's distinction between internal and external questions is presented, followed by a discussion of how this distinction can be exploited for the development of a theory of models. Section 4 discusses French's main argument for quietism as a possible route towards a pragmatic approach. The argument is found susceptible to a number of objections and thus further justification is needed. Finally, in Sect. 5, an objection to the proposed pragmatic approach is addressed. The conclusion is that the objection does not succeed in rendering pragmatism about the ontology of models an unattractive position.

2 The problem of the ontology of models

More than thirty years ago, Giere (1988) presented a theory of models as abstract systems that possess the properties ascribed to them and satisfy the equations by which they are governed. Giere's theory has been highly influential in the large discussion that followed regarding the ontology of scientific models, and which still carries on

unresolved. By separating models from their descriptions, Giere ascribed to the former a status of independent abstract entities for which certain ontological questions regarding their existence and nature should be answered. With this in mind, Thomson-Jones (2010) has more recently described scientific models as 'missing systems'. These missing systems have the surface appearance of a precise description of actual concrete objects, however, we know that there are no such objects in the actual world fitting that description. The challenge is therefore to find an appropriate way to understand the nature of scientific models as missing systems, and it is often referred to as 'the problem of the ontology of models'.

A further motivation for tackling the question of the ontology of models is the fact that it is closely connected to the puzzling question of scientific representation; that is, the question of the exact nature of the relationship between models and the physical systems they represent, which Giere described in terms of similarity. The standard argument is that if representation is a relation between models and physical systems, and if models indeed carry some kind of representational capacity, then the only way to flesh out the nature of this relation is by providing a detailed ontology of models.

It is no surprise then that several attempts have been made so far to provide a positive account on the ontology of models. For example, following Giere, Psillos (2011) takes models to be real existing abstract objects, whereas authors like Godfrey-Smith (2006), Frigg (2010) and Toon (2010, 2012) have argued that models are useful fictions which, literally speaking, do not exist. An alternative approach, stemming from the seminal works of Suppes (1960) and van Fraassen (1980) on the semantic view of theories, focuses on the mathematical aspect of models and sees them as mathematical structures that represent physical targets in terms of some form of isomorphism. Da Costa and French (2003) are also strong opponents of this approach.[2]

This ongoing reflection on the problem of the ontology of models during the last three decades has, unsurprisingly, led to a further discussion regarding the metaphysics of abstract objects and their properties, bringing forward a host of difficult and well-known problems in traditional metaphysics. A standard objection against the abstract objects view concerns the attribution of physical properties to abstract systems (Teller 2001, p. 399; Thomson-Jones 2010, p. 290). If models are existing abstract objects with no spatiotemporal location, then how is it possible for them to instantiate the spatiotemporal properties that make them similar to their targets? Similarly, against the fictionalist view the objection is that it is hard to see how a non-existing entity stands as a representation of a physical system in a way that allows a fruitful comparison between the two (Morrison 2015, p. 89). As for the structuralist approach, a standard worry is that if models are mathematical structures, then it is hard to understand how they stand in isomorphic relations with real systems (Frigg and Nguyen 2017, p. 71). What does it mean for a physical system to possess a structure, and where in that system is the structure located? These and other criticisms along these lines often come forward as challenges for all three main accounts on the ontology of models making the problem of ontology seem unresolvable.

[2] For a recent review of the literature on the ontology of models see Gelfert (2017). See also Frigg and Nguyen (2017) for a review of model-based theories of representation.

French (2010) was the first to clearly point out the futility of trying to give a conclusive answer to the question of the ontology of models. By putting forward a quietist approach, French claimed that when it comes to questions about the *real* ontology of models and theories one should remain silent. Such a quietist conclusion musters support from the fact that metaphysical questions about the ontology of models and theories are both unanswerable and unnecessary, given that our aim is to understand and explain the scientific practice. This gives rise to the following two questions that need to be addressed:

[1] Can we answer questions about the ontology of models?
[2] Do we need to answer questions about the ontology of models in order to understand and explain the practice of scientific modelling?

Notice how these two questions are connected with the central question of the ontology of models. The first question asks whether or not [Q] is an answerable question, while the second asks whether or not answering [Q] is necessary in order to have a fruitful theory of models. In what follows, it will be shown that the answer to these questions depends on whether [Q] is understood as an internal or external question in a Carnapian sense. As will become clear in Sect. 3, an understanding of [Q] as either an internal question or an external practical question trivialises both [1] and [2] and allows for a positive answer. This approach takes all references to abstract entities merely as a fruitful and efficient way of talking about scientific models and stays away from any form of metaphysical enquiry on the nature and existence of abstract entities. On the other hand, if [Q] is understood as an external theoretical question regarding the *real* ontological status of models, it then becomes a pseudo-question and therefore the answer to these questions is negative.

3 Unfolding the pragmatic approach

3.1 Internal and external questions

Carnap's principal goal in 'Empiricism, Semantics and Ontology' (1950/2012) is to clarify an ongoing bewilderment deriving from, what he calls, the problem of abstract entities. That is, the problem of referring to abstract entities, such as properties, classes, relations, numbers, propositions etc., while at the same time remaining faithful to the basic principles of empiricism and avoiding any sort of commitment to a metaphysical ontology of a Platonic nature.[3] What Carnap aims to show is that accepting a linguistic framework which involves reference to these abstract entities, does not imply the acceptance of the reality or existence of these entities in the traditional metaphysical sense, as understood, for instance, in the context of Platonism in mathematics. To be a Platonist about mathematical entities is to hold the view that abstract mathematical

[3] What is interesting here is that although Carnap explicitly states in the very first paragraph of his text (2012, p.241) that his focus is on abstract entities like numbers, properties etc., his overall approach is a general one against ontology and his distinctions essentially apply to all kinds of existence questions, including existence questions about physical entities such as electrons, black holes and so on. This point becomes clear later on through Carnap's thing-language example which will be discussed in the following paragraphs.

objects exist independently of us and our language. Carnap's claim is that existence claims about such entities are only meaningful *within* a linguistic framework.

A linguistic framework is a system of possible ways of speaking about new kinds of entities, subject to certain rules. In other words, it is a set of rules dictating the use of certain terms and predicates referring to new entities, such as properties and numbers, in order to be able to speak meaningfully about a given subject. Given a linguistic framework, Carnap makes a distinction between three types of questions concerning the existence or reality of the introduced abstract entities: (i) *internal* questions, (ii) *external practical* questions and (iii) *external theoretical* questions. As we shall see, for Carnap, the first two types of questions are legitimate and often trivial, whereas the latter is problematic. This may come as a surprise to those who read Carnap as rejecting all external questions, but as will be shown below, this is not the case. Carnap does welcome external statements about the existence of abstract entities, insofar as they are understood in a practical and pragmatic fashion.

Internal questions are questions asked *within a linguistic framework* and for which the answer can be found either by logical analysis or empirical observation. For instance, to use Carnap's example (2012, pp. 244–5), once we accept the linguistic framework for numbers, the question 'Is there a prime number greater than a hundred?' is an internal question and the answer can be found by analysing the rules of the linguistic framework for numbers. In other words, in order to answer this question one merely has to check whether or not the existence of such a number follows from the rules of the already accepted system of numbers within which the question is raised. Questions like 'Is there a piece of paper on my desk' are internal questions within the framework of the 'thing-language'—i.e. the linguistic framework we use to speak about the external world—and the answer to such questions is a matter of empirical observation, since the rules of our chosen thing-language imply that a physical object exists if it can be empirically observed. Both logical and empirical internal questions are thus subject to the internal rules of the relevant linguistic framework. Internal questions are therefore *theoretical*; that is, they are questions for which there is a definite answer that follows logically or empirically from the rules of the relevant framework.

Internal questions are often (but not always) trivial, in the sense that a positive answer says nothing more than that the given linguistic framework is not empty. For instance, the question whether there exists a real number between five and six is trivial, since the answer comes easily from the rules of the linguistic framework for real numbers. Examples of less trivial internal questions are questions whether 'glueballs' exist[4] or whether there is a prime number between nine billion and nine billion and ten for instance. What makes an internal question non-trivial is the fact that the empirical observations about the existence of an entity may not be so clear—e.g. in the case of glueballs—or the fact that the application of the internal rules of the

[4] In particle physics, glueballs are hypothetical colourless particles that consist only of interacting gluons without any valence quarks. The existence of glueballs is predicted by Quantum Chromodynamics but the results of various indirect experimental observations are still not universally accepted. For a relatively non-technical review of the physics of glueballs and their connection with the MIT bag model, see Mathieu et al. (2009).

chosen linguistic framework may require extensive computational analysis—e.g. in the case of very large prime numbers.

External theoretical questions on the other hand, concern the existence of the system of abstract entities as a whole, *prior* to the acceptance of a new linguistic framework. Such questions are not raised within the scientific community or in common parlance, rather they are typically asked by philosophers in traditional metaphysics when, for instance, they pose the metaphysical question of the existence of natural numbers or the reality of the external world. What philosophers usually mean when they raise these questions is 'whether or not numbers [for instance] have a certain metaphysical characteristic called reality [...] or subsistence or status of independent entities' (*ibid.*, p.245). These ontological questions must be raised and answered, according to this approach, before the introduction of the new language. Hence, questions like 'Do numbers *really* exist?' or 'Is the external world *real*?' are external to the linguistic framework since the answer to these questions is supposedly independent of the language we use to speak about numbers and material things.

The problem with such external theoretical questions, Carnap says, is that they are devoid of any cognitive content; they are pseudo-questions. That is, they are ill-formed questions in the sense that they are '*disguised* in the form of a theoretical question while in fact [they are] non-theoretical' (*ibid.*, p.245, emphasis added). These disguised external questions cannot be answered, simply because it is impossible to frame them in terms of the common scientific language in a way which succeeds in giving them any cognitive content. To see why, recall that accepting a certain linguistic framework amounts to accepting a set of statements regarding the existence and nature of the abstract entities in question. For instance, within the system of numbers, the assertion that there is a prime number larger than one hundred simply states that this prime number is an element of the already accepted linguistic framework. However, the further external question of whether such a number *really* exists, is not part of the set of the accepted statements since it cannot be formulated in a meaningful way within this framework or any other theoretical language. In other words, the concept of existence cannot be applied to the system itself independently and prior to the acceptance of a given framework. As an alleged opponent of Carnap on this matter pointed out in a rather astute way, 'to ask what reality is *really* like [...] apart from human categories, is self-stultifying. It is like asking how long the Nile really is, apart from parochial matters of miles or meters' (Quine 1992, p. 9).[5]

Another useful way to understand Carnap's view on external statements is to compare them with moral statements under the scope of the more familiar doctrine of non-cognitivism in Ethics. For the non-cognitivists, moral statements such as 'Killing is evil' do not have any propositional content and thereby do not have any truth conditions. Rather, they only express beliefs and other non-cognitive attitudes such as

[5] Contrary to the seemingly widespread view among philosophers which sees Quine as saving metaphysics from Carnap, this quote from Quine goes on to suggest that Quine's views on metaphysics are, to a large extent, on par with Carnap's meta-ontological stance. Price (2007, 2009) and more recently Verhaegh (2017) provide a convincing line of arguments to this direction showing that not only Quine does not undermine Carnap's main thesis, but in addition he 'overtakes him, and pushes further in the same direction' (Price 2007, p. 393).

revulsion and disapproval.[6] As one of the first non-cognitivists, Carnap also drew an analogy between metaphysical and ethical claims in his earlier works (1935/1996, pp. 22–30; 1937, p.278) stating that the latter are mere commands in a misleading grammatical form, and thus they should not be treated as assertions. Similarly, metaphysical statements related to external questions—e.g. that numbers *really* exist independently of the adopted linguistic framework—only have an expressive function in that they only express personal beliefs. Nonetheless, they have no theoretical content and thus they should not be treated as truth-apt assertions.

This is not the end of the story however. External questions are indeed non-cognitive but this does not mean that they should be thrown out of the window. Rather, Carnap's insightful remark is that such questions should be understood as *practical* questions concerning the choice of a linguistic framework over another and the structure of rules within them. In other words, external questions like 'Do numbers *really* exist?' are questions concerning whether or not we should accept a linguistic framework with reference to numbers. However, the acceptance of a given framework, which further implies the acceptance of a set of (internal) statements regarding the existence of new entities, cannot be judged as being true or false simply because it does not involve an assertion. Rather, it is a matter of a decision guided merely by pragmatic criteria such as the efficiency, fruitfulness and simplicity of the new language and the degree in which these new ways of speaking are conducive to the purposes for which the language was initially introduced. Nonetheless, the fact that a given language, such as the numbers-language for instance, turns out to be extremely efficient does not provide any sort of confirming evidence for the reality of numbers in the traditional metaphysical sense.

Before moving to the next section, it is important to stress the difference between internal theoretical questions and external practical questions. For Carnap, these are the only two legitimate ways to read existence related questions. The former admit of definite answers depending on the rules of the framework in which they are expressed, and thus, any internal assertion needs to be justified either by empirical evidence or logical analysis. External practical questions on the other hand, are questions of degree, and just like any other practical question, they do not admit of a definite answer. Rather, the answer to these kinds of questions depends on pragmatic criteria relative to the purposes for which a linguistic framework is used. The further reading of external questions as theoretical questions for which a definite answer must be given stems from the fact that external questions are usually grammatically disguised as internal theoretical questions. However, this reading is problematic and should be avoided.[7]

[6] See van Roojen (2018), Blackburn (2006), and Schroeder (2010, esp. Ch.2) for more on Moral Noncognitivism.

[7] For further contemporary discussions on the distinction between internal and external questions, as well as on the debate between Carnap and Quine on metaphysics see Bird (1995), Yablo (1998), Alspector-Kelly (2001), Eklund (2013), Verhaegh (2017), Verhaegh (2018), Morris (2018) and Flocke (2018). Blatti and Lapointe (2016) is a comprehensive collection of essays on Carnap's overall approach on ontology and metaphysics.

3.2 Theories of ontology as competing frameworks

Carnap's conclusion is that the problem of abstract entities is a result of a failure to acknowledge this fundamental distinction between internal and external questions and I want to argue that the same holds for a large part of the debate around the ontology of models. The nature of the objections discussed in Sect. 2 and the fact that the debate appears to be unresolved show that [Q] is sometimes treated in the relevant literature as an external theoretical question for which there is a definite answer. However, from a Carnapian point of view, this reading is problematic and only succeeds in making [Q] an unintelligible pseudo-question. The suggestion here is that [Q] should be seen either as an internal theoretical question or an external practical question. The central question of the ontology of models is thus ambiguous and as we shall see, both readings are legitimate and serve different purposes. On the contrary, the further reading of [Q] as an external theoretical question does not seem to improve our understanding of scientific models in a fruitful way and is therefore unnecessary. Let us elaborate on each one of these three options, beginning with the second.

As formulated above, [Q] is a question about which kind of abstract entities is to be identified with scientific models. As such, it can be understood as an external practical question asking: 'What is the most appropriate and efficient form of language to describe scientific models?'. Given that this is a practical question, it only depends on pragmatic criteria and admits of multiple 'equally true' answers. The preference for a particular linguistic framework in the case of scientific models therefore depends on the specific desiderata for choosing an ontology of models over another. Philosophers like Giere and Psillos opt for an abstract-objects-language (albeit with some differences) because they are primarily interested in explaining the attribution of physical properties like mass and momentum to highly idealized 'non-existing' systems, such as the model of a particle in a one-dimensional box in quantum mechanics. For Giere, an extra motivation for choosing an abstract-objects ontology is the development of a theory of representation in terms of similarity, whereby models and their targets share some of their properties. On the other hand, van Fraassen's state space approach focuses on the mathematical nature of models and aims in capturing the ability of the latter to represent the evolution of the states of physical systems in time by the abstract nature of mathematical state spaces. Different accounts thus serve different desiderata and complement each other in that they offer different insights on the nature of models.

Both of these views are entirely legitimate, and none of them should be judged as true or false simply because they should not be seen as assertions about the *real* ontology of models. The various accounts on the ontology of models should only be seen as representing different linguistic frameworks for speaking about scientific models in a fruitful and efficient way. The only meaningful comparison between them is therefore with regard to their success in being conducive to the aim for which they were initially introduced; namely, the aim of explaining as much of scientific talk about models as possible. What this means may vary from case to case and ultimately depends on the desired explananda of each account. Nevertheless, the ultimate aim should not be to give a definite answer to [Q], but to understand various related questions about models such as how scientists build and use scientific models in different disciplines, what

makes a model a good or bad epistemological tool for acquiring knowledge about a physical system, why scientists often use inconsistent models to represent the same physical system, what the relationship of models with their background theories and the experimental data is, what it means for a model to be empirically inadequate and so on.

Now within a chosen linguistic framework for models, say an abstract-objects-language, further questions arise regarding the *existence* and the exact *nature* of models qua abstract objects. These questions are internal to the framework and thus they are theoretical. Given that one has accepted an abstract-objects-language for models, the question 'Do these abstract models exist?' is trivial and the answer is of course positive.[8] The further question of the exact nature of these models depends on the internal rules of the framework and the introduced mechanisms for ascribing physical properties to abstract entities.

As an example, consider the familiar case of the ideal pendulum from classical mechanics. Introducing a framework which sees the ideal pendulum as an abstract object implies that the further (internal) statement 'there exists an abstract object which has all the properties of the ideal pendulum' is trivially true in the sense that such an object is an element of the chosen framework. However, claiming that the abstract ideal pendulum exists, does not amount to any sort of ontological commitment of a Platonic nature, simply because it is not an external statement regarding the *real* existence of such entities independently of the chosen framework. Nor does the fact that such a language may be proven extremely efficient provide any sort of evidence towards these claims. Rather, it merely 'makes it advisable' to accept the specific framework in the sense that it provides all the necessary conceptual and linguistic tools to understand certain aspects of scientific modelling, such as the fact that physicists do indeed seem to refer to abstract objects with spatio-temporal properties when talking about ideal pendulums and frictionless inclined planes.

The further reading of [Q] and other related questions as external theoretical questions is not a viable option. For the Carnapian philosopher of science, this reading of [Q] as a question of the *real* ontology of scientific models, over and beyond any linguistic framework we may use to describe them, is both misleading and unnecessary. It is misleading because, as a supposedly theoretical question, it implicitly assumes that there is a definite answer to the question of the ontology and other related questions on the existence and the metaphysical nature of models. However, insofar as such questions cannot be formulated in a way that renders them intelligible and for which an efficient methodology can be suggested towards their resolution, they remain pseudo-questions and thus should be discarded. It is also unnecessary because the alternative understanding of these questions as external practical questions or internal questions within a chosen framework is sufficient for a fruitful explanation of the practice of scientific modelling.

From a Carnapian point of view, there is thus nothing more to be gained by pursuing metaphysical questions about the existence and the *real* nature of the abstract entities

[8] Things become a bit more complicated in the case of fictionalism, since this doctrine explicitly denies the existence of abstract entities. Part of this complication stems from the fictionalist's failure to acknowledge the distinction between internal and external statements, making fictional statements seem contradictory in the sense that although models do not exist they possess physical properties.

that are often found in theories of models, and the burden of proof is on those who suggest otherwise. Namely, they need to make clear what the extra benefits of pursuing metaphysical (external theoretical) questions are, compared to the proposed Carnapian reading which remains completely neutral as to any kind of ontological commitments in the traditional metaphysical sense. The main advantage of the suggested Carnapian take on the question of the ontology of models is that it paves the way for making progress in understanding the function and nature of scientific models by answering the question of the ontology in an internal sense. We thus have no compelling reasons to consider the pursuit of further metaphysical questions about scientific models as a worthwhile task. What is at stake in the long-standing debate on the ontology of models is not a conclusive answer to the question *per se*, rather, the extent to which the different choices of language illuminate different aspects of the nature and function of scientific models.[9]

As for the further questions [1] and [2], it should be clear by now that the answer to these questions depends on how one reads [Q]. Recall that question [1] asks whether we can provide an answer to the question of the ontology of models [Q] and question [2] whether answering this question is necessary for our purposes as philosophers of science. If [Q] is seen as an external practical question, then [1] merely asks whether we can come up with an appropriate linguistic framework that captures scientific modelling and the answer is of course positive. Similarly, the answer to [2] is also positive since if our aim is to understand what models are, we of course need an efficient linguistic framework to describe them. If [Q] is seen as an internal question, then [1] asks whether we can describe the nature of models *within* a particular linguistic framework, and the answer to this question is again positive and follows from the specified internal rules of the preferred framework. For the same reasons, the answer to question [2] is trivially positive as well.

If [Q] is seen as an external theoretical question, then question [1] asks whether we are able to determine the ontology of models in a language-independent way and the answer is negative since, from the Carnapian point of view, it is simply impossible to provide an answer to an external theoretical answer. Similarly, question [2] asks whether it is necessary to answer these external theoretical questions about models in order to understand and explain the general practice of scientific modelling and the answer is again negative, since the main motivation of the Carnapian approach is precisely the claim that external theoretical questions do not pose any serious concerns

[9] Based on Quine's (1951) famous response to Carnap, one may express a neo-Quinean objection at this point, arguing that internal questions are ultimately just as pragmatic as external ones, and hence, there is no definite internal answer to the question of the ontology of models either. As mentioned in the introduction, Carnap's meta-ontological stance is taken as a working premise and the defence of Carnap's programme against well-known objections like this one is beyond the scope of this paper. However, let us just briefly note that the aim of this paper is to show that the reading of [Q] as an external theoretical question is partly responsible for the lack of progress in the debate about the ontology of models. This conclusion is based on Carnap's doctrine that external questions are ultimately practical questions, which essentially remains unharmed by Quine's claim that internal questions are also pragmatic. The further claim that there is no definite internal answer to the question of the ontology of models even within a chosen linguistic framework is also orthogonal to the argument provided here. Whether or not an internal ontological claim is ultimately a pragmatic issue does not really affect the main claim of this paper, namely, that the question of the ontology of models should only be taken as a means of probing other related questions on the function and nature of scientific models as epistemic tools.

towards our philosophical understanding of various issues. Rather, they often have the opposite effect of impeding our philosophical enquiries. The upshot is that the answer to the two meta-questions [1] and [2] arising from French's discussion on the philosophy of the ontology of models depends on how one understands the central question [Q]. Reading [Q] as an internal theoretical question or an external practical question allows a positive answer to [1] and [2], whereas reading [Q] as an external theoretical question makes the answers to these questions negative.

This does not amount to an outright quietism about the ontology of models however. It is simply a reminder that ontological questions about scientific models do not lie within the sphere of metaphysics. Models are not 'creatures of darkness', as Quine (1956, p. 180) once called 'intensions' and other non-physical entities, and the question of their ontology is not a metaphysical matter. Rather, they are epistemological tools used by scientists and the answer to the question of what models are is to be found in the domains that they are being practically used and studied by scientists, that is, in textbooks, labs, conferences, scientific papers and even verbal discourse.

The next section explores French's quietism and shows how this approach lies within the sphere of the suggested pragmatic anti-metaphysical approach. In accordance with pragmatism, French denies that there is a unique *true* answer to matters of the ontology of models and suggests that the way forward is to choose the 'ontology' which best represents scientific models without worrying if this ontology is actually true.

4 French's quietism

As already noted in Sect. 2, French's quietism stems from two major claims. The first claim is that questions about the ontological status of models are unanswerable, in the sense that no unique and true answer can be given which covers all kinds of models. In other words, questions regarding the real ontology of models *cannot* be answered. The second claim takes a step further and asserts that the inability to arrive at definite answers to these questions should not concern us since it does not impede our efforts as philosophers of science. That is, we *need not* answer these questions in order to understand the function and nature of models. The conclusion is therefore that, rather than searching for an objectively true answer, one should focus instead on finding the most appropriate way to *represent* models and theories as having a certain ontological status, based exclusively on pragmatic grounds. In what follows, French's main argument towards a pragmatic view is evaluated and found susceptible to a number of objections. The upshot is that a pragmatic approach cannot and need not be based on the fact that the term 'model' is not a sortal term.[10]

[10] French's discussion equally revolves around both theories and models since the two terms are mostly used interchangeably throughout the text. The main reason for this is French's belief that the function and nature of models and theories cannot be sharply distinguished (*ibid.*, p.241). In what follows, the discussion is limited to models, assuming, rather safely, that even though it is not made explicit in the text, most of French's claims about theories apply to models as well, and vice versa.

4.1 Models and sortals

French's main argument towards our inability to answer ontological questions about scientific models is based on the concept of *sortals*. Its structure can be given as follows:

[A1] The terms 'theory' and 'models' are not sortal terms.
[A2] Ontological questions about terms that are not sortal are unanswerable.
[A3] Therefore, ontological questions about theories and models are unanswerable.

In general, a term is sortal only if it gives a criterion of identity and countability about a thing. That is, if X is a sortal term, then when confronted with instances of X, one should be able to both identify them as Xs and count them. For example, the term 'owl' is a sortal term since it is clear which entities count as owls and which not, whereas terms such as 'gold' or 'heap' are not, since the former is uncountable and the latter has no clear identity conditions.[11] Moreover, according to some views, a sortal also tells us when something continues to exist and when it goes out of existence. Sortals are therefore terms that designate entities for which identity and persistence conditions are clearly determined. Consequently, sortals typically refer to entities of a single ontological kind and therefore, ontological questions about sortals are easier to pursue.[12]

French's starting point for justifying [A1] is the observation that when we ask questions like 'What is the ontological status of theories and models?' we are treating these terms as sortals, since what we are doing is to '[take] the term theory [or model] and ask what it is that this term picks out, what is its referent' (*ibid.*, p.240). However, the great heterogeneity of different types of models makes it impossible to define what a model is in terms of necessary and sufficient conditions, and therefore we lack the desired identity criterion. Just like the term 'works of art', for example, covers too broad a spectrum of an entity (e.g. novels, paintings, sculptures etc.) so does the term 'scientific models', and thus the question of the ontological status of models is unanswerable in the sense that there is no unique answer (*ibid.*, p.241). Moreover, French points out that whether or not one aims for a unified answer to the question of the ontology of models depends on one's understanding of models and their relationship with theories. An understanding of models as some sort of extensions of theories suggests for a single and unified answer, whereas an understanding of models as having a different nature and function than theories, such as in Cartwright et al. (1995) and Morrison and Morgan (1999), suggests that models and theories refer to two different things for which different answers should be given (*ibid.*, p.242).

The same can be said for the persistence criterion, since it is not clear when a theory comes into existence and when (and if) it ceases to exist. French wonders:

[11] The terms countable and uncountable are used here in the ordinary grammatical sense and should not be confused with uncountability in set theory. Countable nouns refer to discrete objects that can be counted—e.g. owls, electrons, planets etc. – whereas uncountable nouns stand for things that are treated as an undifferentiated unit, rather than as something with discrete elements—e.g. gold, electricity, music etc.

[12] There are various views in the literature as to where the term 'sortal' applies (universals, concepts or the things themselves) and French is not explicit on which interpretation he adopts. Following Quine (1960), the term 'sortal' will be treated here as a linguistic notion applying to predicates, since this approach is compatible with French's overall discussion.

'did General Relativity just pop into existence when Einstein thought it up? And when exactly did he do that? Did it partially come into existence in October 1914 and only fully the next year after Einstein's correspondence with Hilbert?' (*ibid.*, p.239). Replace General Relativity with Bohr's model of the hydrogen atom and the same argument holds for models. Did Bohr's model come into existence partially as he was gradually developing it? Or did it suddenly come into existence with the publication of his paper in 1913?

[A2] is supported by the fact that the scientific practices which are supposed to determine the identity and persistence conditions of models draw no sharp lines on whether something should be seen as a model or not. For instance, they do not tell us how much of a model could be altered in order for it to remain the same model, or when the model comes into existence. Hence, this lack of any determinate conditions of identity and persistence makes it hard to see how we can arrive at some determinate answers. In other words, one cannot say what the ontological status of a model is, if one is not sure what the referent of that term is or when the term actually refers to something.[13]

There are two possible ways of response to this argument by challenging each one of its premises. First, one might reject the concept of sortals as an ill-defined concept and press for a definite answer to the question of what exactly makes a predicate a sortal term. Is it the fact that there are clear identity criteria for the term's referents or the ability to distinguish certain things as being instances of that predicate? One might argue for example that even though no clear identity criterion or criteria for what counts as a model can be formulated in terms of necessary and sufficient conditions, surely it is still possible to distinguish and count different cases of models. For instance, physicists have no problems in distinguishing the Fermi gas model of the nucleus from the shell model; and as a matter of fact, there are over thirty different models of the nucleus, each based on different assumptions, which can nonetheless be classified in various ways.[14] It is therefore possible, at least in principle, to identify and enumerate all cases of models in physics say, or even all cases of models across all scientific fields, by making a long open-ended list and leaving any ambiguous cases aside. Once this list is done, one may take its contents as the referents of the term 'models' and thus treat the term as a sortal.

What is more, the desirable identity and persistence conditions given by sortals turn out to be problematic even in cases which prima facie seem clear examples of sortals, such as the term 'apple'. This is because, just as in the case of models and theories, the spatial and temporal boundaries for something to be considered as an apple are not as clear as one might first think. To see why, compare French's questions on the identity and persistence conditions of General Relativity with questions on the identity and persistence of apples. When does an apple come into existence? Does it come partially as it develops from a blossom into a hard mass fruit? If no, at what time then does it stop being a blossom and count as an apple? And how big of a bite

[13] What is presented here is a summary of French's argument as it appears throughout Sect. 3 of his paper (pp. 238–243), which relies heavily on Thomasson's (2006) discussion on the ontology of art.

[14] See Greiner and Maruhn (1996) for a book-length classification of nuclear models based on degrees of freedom.

can someone take after which the apple stops to exist?[15] If even in these simple cases no clear identity and persistence conditions can be given, it is then hard to see when a term successfully counts as a sortal, and more importantly, it is even harder to see why it is a necessary condition for a term to be sortal in order to ask ontological questions about its referents as [A2] implies.

Even if we accept a certain definition for sortals, and grant that models and theories are not sortal terms, we can thus still question the second premise of the argument which after all carries the most important weight. That is, we can deny that it is a necessary condition for a term to be sortal in order to ask ontological questions about its referents and thus deny that ontological questions about models are unanswerable. Take the term 'gold', for instance. Even though it is not a sortal term according to the above definition, it is clear that one can still answer ontological questions regarding the nature of gold. What is more, even if we accept that non-sortal terms such as 'works of art' and 'models' refer to entities of various ontological kinds, one might maintain that different classes of models pick out objects of different ontological kinds, but nonetheless we can categorise these kinds and make separate ontological claims for each one of them. This is the line followed by Contessa (2010) for example, who argues that models should be categorised in three kinds—material models, mathematical models and fictional models—for which questions about their ontological status can be answered separately.

French is fully aware of this possibility, hence his conclusion is not that the question of the ontological status of models is inherently unanswerable *tout court*, rather it is the much weaker claim that it is unanswerable in the sense that no single unified answer of the form 'all models are F's', where F is a specific ontological kind, can be given. It is hard to see how this leads to quietism however. The fact that several answers can be given to the question of ontology does not imply that the question cannot be answered. French's observation that models are not sortal terms nicely demonstrates the vast array of scientific models and the unsystematic use of the term by scientists, which make the task of developing a comprehensive theory of models extremely difficult. However, as an argument towards quietism it suffers both from the fact that the concept of sortals is ill-defined and from Contessa's alternative tripartite approach. The argument thereby does not succeed in showing that the question of the ontology of models is unanswerable, nor does it show that it is not worth pursuing. The good news however, is that all French needs in order to defend the stronger claim that questions about the real ontology of models cannot be answered, is the Carnapian rejection of the disguised external questions as pseudo-questions.

Once this is done, all we need for quietism to follow is to show that answering these questions is unnecessary. French easily achieves this by developing an argument based on the work of Peirce (1940) showing that external ontological questions about the *real* nature of scientific models are not genuine questions since they do not impede in any way our enquiries as philosophers of science (*ibid.*, pp. 243–4). The upshot is that a fruitful theory of scientific representation does not require any kind of metaphysical assertions about the existence of abstract entities. What is needed is a moderate repre-

[15] This argument against the temporal and spatial boundaries of the extensions of predicates is found in Teller (2018), although in a completely different context, in an attempt to show that all human knowledge is inaccurate.

sentational attitude guided only by pragmatic criteria. Whether one finally concludes that models are best seen as mathematical structures or fictional objects, is merely a result of a pragmatic choice based on the ability of the competing theories to explain the nature and function of scientific models in the best possible way, admitting as few counterexamples as possible.[16]

Following these observations, French's quietism does not seem to be as radical as one might first think. Instead, it can be interpreted as stating that external theoretical questions about the real ontology of models do not hamper our efforts towards developing a theory of models since they can be replaced by external practical questions and internal questions within a chosen linguistic framework. Once this premise is granted, quietism about the metaphysics of models follows naturally.

5 Thomson–Jones against the bracketing of metaphysics

In this last section a possible objection to the proposed view on the ontology of models is addressed. This objection comes from Thomson-Jones (2017, pp. 244–5) who, as opposed to French, argues extensively that bracketing metaphysical questions in philosophy of science impedes our overall understanding on issues like the ontology of models and scientific representation. In order to fully appreciate his argument, consider a theory [T] containing a statement [t] referring to abstract objects which, nonetheless, remains neutral as to the existence of these objects:

[t] Scientific models are abstract objects.

By formulating theories in this way, one is engaging with what Thomson-Jones calls the 'as-if practice', namely the practice of talking as if there are X's (in this case abstract objects) and as if they have certain features (*ibid.*, p.234). Thomson-Jones argument then proceeds as follows:

[B1] Either there are abstract objects such as the simple pendulum or not.
[B2] If there are, then [t] should be taken literally.
[B3] If there are not, then scientific modelling does not involve such objects and therefore [t] should not be understood literally.
[B4] If there are no abstract objects but [t] is true nonetheless, then it is not obvious what [t] means.
[B5] If we do not know whether there are abstract objects, we cannot know whether the account of modelling is to be taken literally.
[B6] Therefore, we cannot claim to have arrived at an understanding of modelling by invoking such an account in the midst of such a fundamental uncertainty about the actual meaning of [t].
[B7] Removing that uncertainty will at least involve answering the existence question about abstract objects.
[B8] Therefore, bracketing is not an available option.

As it stands, the argument is supposedly directed against all possible ways of bracketing metaphysics in philosophy—i.e. by taking an agnostic stance towards metaphysical existence related questions, by explicitly denying the existence of abstract

[16] French (2017) reinforces this view in a more recent paper.

entities like the fictionalists do, or by taking a Carnapian approach. The gist of the objection is that no matter which approach one takes for bracketing the (external theoretical) question of ontology, [t] is always left unexplained. This is because [T] is an attempt to explain what models are and how they are related to their targets by involving talk of abstract entities. Therefore, the (external) ontology of these entities plays, according to Thomson-Jones, an important role. This is reflected in [B1] which echoes what Thomson-Jones calls the 'existence question' about abstract objects. To claim that they do exist, is to make an ontological commitment and thus—as [B2] shows—[T] as a theory of models provides an understanding and a possible true explanation given that [t] is true. However, any attempt to refuse engaging with the metaphysical question of the existence of abstract entities leaves us with uncertainty as to the actual meaning of [T] and thus, according to Thomson-Jones, provides little understanding. [B3] and [B4] clearly aim for the fictionalist, and [B5] targets the agnostic approach.[17]

What about the Carnapian approach however? Thomson-Jones does not engage with this option in detail, and the reason is that he presupposes that the (external theoretical) existence question, on which [B1] relies, is a legitimate question to ask. That is, he presupposes that it is a matter of fact that abstract entities either exist or not. However, this is exactly what the Carnapian pragmatist denies and thus the argument breaks down at its very starting point. For the Carnapian pragmatist, the external theoretical question of the existence of abstract entities is a non-cognitive pseudo-question. Insofar as this question cannot be formulated in a way that makes it cognitively intelligible, it is simply inappropriate and it should be discarded.

Thomson-Jones justifies [B1] by saying that 'when evaluating an account which engages the as-if practice for X's [e.g. abstract objects], it is prima facie entirely reasonable to ask, as part of the evaluation, whether there are indeed X's, and if so, whether they are the right sort of thing to play the roles the core account would seem to require them' (*ibid.*, p. 248). But this assumption only leaves the Carnapian wondering. What does it mean for an abstract entity to exist? And how can we ever tell whether an abstract entity exists or not? More importantly, what is the difference between an existing abstract entity and a non-existing abstract entity? Until we find an appropriate way to answer these questions in a meaningful and constructive fashion, they cannot be considered as legitimate, let alone as an indispensable part of a theory of scientific models.

In fairness to Thomson-Jones, he clearly states that he is not arguing that our philosophical enquiries should be put on hold until we reach a definite answer to these questions. What he is arguing for is that we have to acknowledge that the answer to one question (say to the question of the ontology of models) 'depends in part on the answer to a number of other, equally difficult and uncertain questions' (*ibid.*, p. 234). And a sensible way of coping with such difficult situations is to make a working hypothesis, a sort of 'educated bet', and develop our theories based on that assumption. One is left wondering however, whether there is any practical difference between this educated guess about the nature of models and the introduction of what one takes to be the most efficient linguistic framework for a given aim.

[17] It is not my purpose to defend a fictionalist approach to modelling here, however it is worth mentioning that with regard to [B4], this is exactly what the fictionalist's theory aims to explain by appealing to pretence and games of make-believe.

Insofar as external ontological questions cannot be formulated in common scientific language in a way that makes them cognitively intelligible, to introduce a tentative answer to such questions – say to make a working assumption of the sort 'models are existing abstract objects'—looks more like giving a pseudo-answer, as Stein has aptly noted (1989, p. 54); and it is highly doubtful whether such claims provide the kind of understanding Thomson-Jones is seeking for, according to his own principles. Recall that Thomson-Jones' criticism to the fictionalist (premise [B4]) is that given that [T] contains a claim which is literally false, an important part of this theory remains unexplained, or even worse, false. Does the introduction of an external assertion as a working hypothesis make things better however? Stein's point is that what is actually happening in these cases, is that a supposedly explanatory notion is introduced which when examined carefully is found to be in effect completely disconnected from the explanandum (hence the 'pseudo-answer'). In other words, given our inability to provide a robust meaning to such metaphysical existential claims, these claims fail in providing a satisfactory explanation as part of our theory. The solution is to see the hypothesis of the existing abstract entity merely as a linguistic tool which facilitates our talk of scientific models, and not as a serious ontological commitment in the metaphysician's sense.

6 Conclusion

This paper is a result of the observation that a significant part of the literature on modelling and scientific representation concerns the metaphysical implications of the debate on the ontology of models. This fact gives the further impression that these matters are closely associated with a number of persisting problems in traditional metaphysics, such as the existence of abstract objects and the nature of properties. Following Carnap, the suggestion here is to see the question of the ontology of models as either an internal theoretical question within an already accepted linguistic framework or an external practical question regarding the choice of the most efficient theory in order to explain and understand certain features of scientific models. The main implication of this suggestion is that the question of the ontology of models is only a means of probing other related questions regarding the overall practice of scientific modelling and the function of models as epistemological tools for gaining knowledge about the physical world. The choice between competing theories therefore depends solely on the relevant pragmatic criteria and the specific desiderata of each account.

The framing of the debate on the ontology of models in Carnapian terms nicely illustrates how Carnap's approach is still relevant for contemporary discussions in the philosophy of science and that several lessons can be drawn from it. Perhaps the most important lesson to be learned is that before setting out to answer a philosophical question, we should first pause and think what the question is really asking and what we seek to understand by exploring the possible answers to it. This way we can avoid 'the danger of getting into useless philosophical controversies' (Carnap, 1935, p. 76) that Carnap was trying so hard to abolish. A fruitful debate is one in which all parts have a clear and common understanding of the problem in hand, and the nature of the debate on the ontology of models shows that this might not be the case. What is being put forward here by appealing to a Carnapian take on the debate is not an outright

quietism about the ontology of models. Rather, it is a gentle reminder that there is nothing to be gained by trying to settle down to a unique answer on the question of the ontology of models.

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