Chapter 6
Seven Myths About the Fiction View of Models

Roman Frigg and James Nguyen

Abstract Roman Frigg and James Nguyen present a detailed statement and defense of the fiction view of scientific models, according to which they are akin to the characters and places of literary fiction. They argue that while some of the criticisms this view has attracted raise legitimate points, others are myths. In this chapter, they first identify and then rebut the following seven myths: (1) that the fiction view regards products of science as falsehoods; (2) that the fiction view holds that models are data-free; (3) that the fiction view is antithetical to representation; (4) that the fiction view trivializes epistemology; (5) that the fiction view cannot account for the use of mathematics in the modeling; (6) that the fiction view misconstrues the function of models in the scientific process; and (7) that the fiction view stands on the wrong side of politics. As a result, they conclude that the fiction view of models, suitably understood (as an account of the ontology of models, rather than their function), remains a viable position.

Keywords Fiction view of models · Imagination · Falsehood · Data · Representation

R. Frigg
Department of Philosophy, London School of Economics and Political Science, Houghton Street, WC2A 2AE London, UK

R. Frigg · J. Nguyen (✉)
Centre for Philosophy of Natural and Social Science, London School of Economics and Political Science, Houghton Street, WC2A 2AE London, UK
e-mail: james.nguyen@sas.ac.uk

J. Nguyen
Institute of Philosophy, School of Advanced Study, University of London, Senate House, Malet Street, WC1E 7HU London, UK

Department of Philosophy, University College London, Gower St, WC1E 6BT London, UK

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6.1 Introduction

What are scientific models? An answer to this question that has gained some popularity over the last decade is that models are akin to the characters and places of literary fiction. This is the core of the fiction view of models ("fiction view", for short). The fiction view has attracted a number of criticisms. While some of these criticisms raise legitimate points, others are myths. They are based on misunderstandings, misrepresentations, or mischief. This paper identifies seven myths about the fiction view and explains where they go amiss.

The seven myths we identify are (1) that the fiction view regards products of science as falsehoods; (2) that the fiction view holds that models are data-free; (3) that the fiction view is antithetical to representation; (4) that the fiction view trivializes epistemology; (5) that the fiction view cannot account for the use of mathematics in the modeling; (6) that the fiction view misconstrues the function of models in the scientific process; and (7) that the fiction view stands on the wrong side of politics. After a brief statement of the fiction view we discuss the seven myths one at a time.

Every excursion into mythology faces an immediate problem. Some myths have found canonical expressions and their message is well documented. Others are the subject matter of oral traditions. They are passed on through word of mouth, with their content being in flux and difficult to pin down exactly. We relied on myths' "scriptures" wherever possible, and we made an honest attempt to pin down oral narratives where no canonical versions were identifiable.

6.2 The Fiction View of Models

The core idea of the fiction view is clearly stated in the following often-quoted passage by Peter Godfrey-Smith:

> I take at face value the fact that modelers often take themselves to be describing imaginary biological populations, imaginary neural networks, or imaginary economies. […] Although these imagined entities are puzzling, I suggest that at least much of the time they might be treated as similar to something that we are all familiar with, the imagined objects of literary fiction. Here I have in mind entities like Sherlock Holmes' London, and Tolkien's Middle Earth. […] the model systems of science often work similarly to these familiar fictions (2006, p. 735).

On this view, then, models are akin to the characters and places of literary fiction. To illustrate this idea, consider Fibonacci's model of population growth. This model was one of the first mathematical models used to study population growth, and despite its simplicity it is still an important point of reference in population dynamics. Imagine you have a new-born pair of rabbits, one male and one female. Six months after birth they mate, and a further six months later a new male-female pair of rabbits is born. Now you want to know how this rabbit population evolves over time. To aid the mathematical description of the situation, you label the instants of time when

rabbits mate and give birth by t_1, t_2, …, where t_1 is the moment when you get the first pair of rabbits. Two consecutive instants are always separated by a six-months interval. You also let $N(t_i)$ be the number of rabbit pairs at a certain instant of time t_i. Now you assume that the pattern of the first birth continues: each pair of rabbits mate six months after birth, and a new male-female pair of rabbits is born to each pair six months after mating. You further assume that supplies of food and living space are unlimited, and that the rabbits are immortal. Under these assumptions, one can show that the number of rabbit pairs at a given time t_i is the sum of the numbers of pairs at the previous two instants of time: $N(t_i) = N(t_{i-1}) + N(t_{i-2})$. Using this formula one quickly finds the rabbit pair numbers at all times: 1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, 144, …. These numbers are known as the Fibonacci numbers.

What you have constructed is a model of the rabbit population. Your model world is one in which rabbits procreate at fixed instants of time, every female gives birth to exactly one male-female pair, rabbits are incestuous and only mate with their siblings, rabbits are immortal, and food and living space are unlimited. This is an imaginary population. Real rabbits are not like that, and their living environment doesn't match the conditions of the model. Scientists of course know that. When they present this model, as Godfrey-Smith says, they take themselves to be describing an imaginary population. Or, in other words, they take themselves to be describing a fictional scenario. And the Fibonacci population model is no exception. Scientific discourse is rife with passages that describe fictional scenarios. Students of mechanics investigate the motion of perfectly spherical planets in otherwise empty space and economists study economies without money and transaction costs.

This observation is the starting point of the fiction view: models, like Fibonacci's model of a population, are like the places and objects of literary fiction. This idea can be developed in different ways, and a number of different versions of the fiction view have been formulated in recent years. Here is not the place to fully explicate and compare these different options.[1] But laying out some basic distinctions now will prove useful for framing some of our discussions to come. First, we're assuming an indirect view of scientific modeling throughout this paper. According to indirect views, a model description specifies a scientific model (understood as a fictional entity), just as a literary text specifies a fictional world. In turn this entity represents a physical target system.[2] With this in place, one can ask about the ontological status of these models, construed as fictional entities. Here one can distinguish between realist and anti-realist fiction views. According to the former, models should be identified with objects that, in some sense, exist (e.g. abstractly in the actual world, or concretely in another possible world). According to the latter, models, still construed as fictions, should not be identified with existing objects and their fictional nature should be understood differently. A version of this anti-realist approach that has gained attention

[1] For a review of the various options see Chap. 6 of Frigg and Nguyen (2020).

[2] Other versions of the fiction view take the descriptions to be fictional direct descriptions of their targets. See, for instance, Levy (2015) and Toon (2012); for a discussion of their views see Frigg and Nguyen (2016). The distinction between the two versions of the fiction view is not too important for our current purposes.

in recent discussions of the fiction view of models appeals to Walton's (1990) pretense theory in order to understand the nature of fictions. For a discussion of this view see Frigg (2010a) and Salis (2019).

6.3 First Myth: Fictions Are Falsehoods

A frequent complaint is that regarding models as fictions misconstrues the epistemic standing of models because it relegates models to the barren land of falsehoods. Portides submits that to label something a fiction is to draw a contrast with something being a truth and therefore "we label X fictional in order to accentuate the fact that the claim made by X is in conflict with what we observe the state of the world to be" (2014, p. 76). For this reason we only classify X as a fiction "if we think that the truth valuation of the claim 'X represents (an aspect of) the world' is false", and classifying models in this way, Portides argues, "obscures the epistemic role of models" (ibid.). Teller notes that "[t]he idea that science often purveys no more than fictional accounts is very misleading" because even though science has elements that are fictional, the presence of such elements "does not compromise the ways in which science provides broadly veridical accounts of the world" (2009, p. 235). Winsberg says that "[n]ot everything […] that diverges from reality, or from our best accounts of reality, is a fiction", which is why "we ought to count as nonfictional many representations in science that fail to represent exactly" (2009, pp. 179–80). Among those nonfictional representations we find models like the "frictionless plane, the simple pendulum, and the point particle" (ibid.). The point that Teller and Winsberg make is that even though models often have fictional elements, it would be a mistake to count the whole model as fiction. In a similar fashion, Morrison argues that calling all models fictions is too coarse and a finer grained distinction should be introduced, namely "one that uses the notion of fictional representation to refer only to the kind of models that fall into the category occupied by, for example, Maxwell's ether models" (2015, p. 90). She characterizes the ether model as one "that involves a concrete, physical representation but one that could never be instantiated by any physical system" (ibid., p. 85). Hence "[f]ictional models are deliberately constructed imaginary accounts whose physical similarity to the target system is sometimes rather obscure" (ibid., p. 90). Finally, the proposal for this book states that "fictionalism" is a position according to which "scientific models are just useful fictions that do not intend to provide truthlike descriptions of natural phenomena or to explain their causes".

Common to each of these criticisms is the characterisation of fictions as falsehoods, and hence interpreting the fiction view of models as a view that portrays models as falsehoods. First appearances notwithstanding, the fiction view is not committed this kind of nihilism. To see why this is so, we have to distinguish between two different notions of fiction and clarify which notion is at work in the fiction view of models.

The two notions are what we call *fiction as infidelity* and *fiction as imagination*.[3] Let us discuss each of these notions in turn. In the first usage, something is qualified as a "fiction" if it deviates from reality. The nature of this deviation depends on what is qualified as fiction. If we qualify a sentence (or proposition) as a fiction, the relevant kind of deviation is falsity: the sentence is a fiction if it is false. If we qualify an object as a fiction, the relevant kind of deviation is non-existence: the object is a fiction if it does not exist. We use "fiction" in this sense if we say "the Iraqi weapons of mass destruction were a fiction" to express that there are no, and never were, such weapons.

In the second usage, "fiction" applies to a text and qualifies it as belonging to a particular genre, literary fiction, which is concerned with the narration of events and the portraiture of characters. Novels, stories, and plays are fictions in this sense. Rife prejudice notwithstanding, the defining feature of literary fiction is not falsity. It's not the case that everything said in a novel is untrue: historical novels, for instance, contain correct factual information. Nor does every text containing false reports qualify as fiction: a wrong news report or a flawed documentary do not become fictions on account of their falsity—they remain what they are, namely wrong factual statements. What makes a text fictional is not its falsity (or a particular ratio of false to true claims), but the attitude that the reader is expected to adopt towards it, namely the attitude of imaginative engagement.[4] Readers of a novel are invited to imagine the events and characters described. They are expressly not meant to take the sentences they read as reports of fact, neither true nor false. Someone who reads Tolstoy's War and Peace as a report of fact and then accuses Tolstoy of misleading readers because there was no Pierre Bezukhov just doesn't understand what a novel is.

The two usages of "fiction" are neither incompatible nor mutually exclusive. In fact, some of the places and persons that appear in literary fiction are also fictions in the first sense because they do not exist. But compatibility is not identity. From the fact that something appears in a fiction of the second kind one cannot—and must not—automatically infer that it also is a fiction in the first sense. Pierre Bezukhov and Napoleon both appear in War and Peace, but only the former is a fiction in the first sense; it would be a grave error to infer that Napoleon does not exist because he appears in a work of fiction.

Returning to the fiction view of models, the crucial point is that the notion of fiction involved in the fiction view is the second notion. When models are likened to fictions, this is taken to involve the claim that models prescribe certain things to be imagined while remaining noncommittal about whether or not the entities or processes in the model are also fictions in the first sense. Just as a novel can contain characters that exist and ones that don't, and prescribe imaginings that are true and

[3]The notion of fiction as infidelity is common sense and can found in most dictionaries. The online version of Oxford Living Dictionaries, for instance, defines fiction as "something that is invented or untrue". The idea that fiction is defined in terms of imagination is developed in Evans (1982) and Walton (1990).

[4]Imagination can be propositional and need not amount to producing mental pictures. For a discussion of the notion of imagination with special focus on imagination in scientific modeling see Salis and Frigg (2020).

ones that are false, models, understood as fictions, can feature existing and non-existing entities alike, and they can ground true and false claims. An assessment of which of a model's elements exist and which of its claims are true is a separate issue, one that is in no way prejudged by the fact that a model is a fiction. Different versions of the fiction view do this in different ways, and we will discuss one version in more detail later. But all versions of the fiction view of models share a commitment to the second sense of fiction and do not mean to brand models as falsities when they liken them to fictions. For this reason, as an anonymous referee points out, it might have been more apt to refer to this position as the "imagination view of models" rather than the "fiction view of models". We agree that the "imagination view of models" would be a more informative label, and if one could turn back the wheel one could consider labelling the position in this way.[5] However, for better or worse, the position has become known as the "the fiction view of models", and it is critisized as such. For this reason, we stick to the (by now) conventional label "fiction view of models".

One might worry that this proclamation is in tension with the way in which the fiction view has been introduced and motivated earlier.[6] In our example we introduced immortal rabbits living in an unlimited environment mating with their siblings and producing offspring according to a strict rule, and we noted that there are no such rabbits. If examples like these provide the motivation for the fiction view, then, despite invoking fiction as imagination rather than fiction as infidelity, isn't it the case the latter notion is required to account for the use of fictions in modeling?

Not quite. Thinking about model descriptions as describing objects that don't exist doesn't preclude them from, at least in part, being true of actual systems. In the context of model building and investigation, the question of whether model descriptions additionally describe actual target systems, or are related to actual target systems in some other way, is put aside. The motivation for doing so is to gain creative freedom. Scientists need to have the freedom to play with assumptions, consider different options, and ponder variations of hypotheses. In doing so they bracket the question whether the model-objects correspond to real-world objects for a moment to investigate a certain scenario that seems interesting enough to have a closer look. But this does not commit them to believing that the scenario is completely false when taken to be about a real-world target. In fact, what often motivates scientists to consider a certain scenario is that they think that the scenario has something to do with the target system that they are interested in. However, what that something is can only be assessed ex post facto, once all the details in the model are worked out. Fibonacci didn't consider a population of immortal rabbits thinking "oh, it's all false but it's fun". Fibonacci's motivation to consider such a population was that he

[5]This would be in line with Friend (2020, p. 103) who speaks of an "account of models as imagined systems" and Frigg (2003, p. 87) who speaks of "models as imagined objects". It would also be in line with Thomson-Jones (2020, p. 75) who notes that scientists "devote considerable time and energy to describing and imagining systems that cannot be found in the world around us", and Thomasson (2020, p. 51) who sets herself the task of analyzing the core idea of regarding models as "imaginary" objects.

[6]This point has been made by Martin Zach in his presentation at the workshop 'Scientific Contents: Fictions or Abstract Objects?' at University of Santiago de Compostela in January 2017.

would eventually be able to learn something true about real rabbits from the model. But to be able to say what the true bits are, he first had to work out what happens in the model. The fiction view of models utilizes fiction as imagination to understand this practice, and this remains compatible with the idea that model descriptions are, at least in part, true (i.e. not fictional in the sense of infidelity) when applied to an actual system.[7] The point is that this latter question is simply irrelevant with respect to the questions that the fiction (in the sense of imagination) view is attempting to address.

This notion is not just a philosophers' fancy. It is rooted in scientific practice, where, when a model is proposed, it is often unknown whether the entities in a model have real-world correspondents, and if they do what the nature the correspondence is. Consider the example of the Higgs boson. Elementary particle models that featured the Higgs boson were formulated in the 1960s. Much scientific work was dedicated to studying these models and understanding what was true and what was false in them by teasing consequences out of the model's basic assumptions. Yet, this implied no commitment to either the existence or nonexistence of the Higgs boson. In fact, modelers remained expressly non-committal about this question and referred it to their experimental colleagues in CERN, where, after much work, a Higgs particle was found in 2012, and it was agreed to be "the" Higgs boson in 2013. Viewing models as fictions does not prejudge the matter either way. The question whether there is a Higgs boson stands outside the model in which it appears.

Before moving on then, it is worth noting that there is a use of "fictionalism" in the philosophy of science that is more amenable to being interpreted in terms of infidelity. This occurs in the context of the debate about scientific realism. Scientific realists hold that mature scientific theories provide a (at least approximately) true account of the parts of the world that fall within its scope. Scientific anti-realists disagree and submit that we should only take claims about observables at face value and, depending on the kind of anti-realism one advocates, either remain agnostic about, or downright renounce commitment to, the theoretical claims of a scientific theory. Fine advocates such a position and calls it fictionalism:

> "Fictionalism" generally refers to a pragmatic, antirealist position in the debate over scientific realism. The use of a theory or concept can be reliable without the theory being true and without the entities mentioned actually existing. When truth (or existence) is lacking we are dealing with a fiction. Thus fictionalism is a corollary of instrumentalism, the view that what matters about a theory is its reliability in practice, adding to it the claim that science often employs useful fictions (1998, p. 667).

Being a fictionalist in this sense means being an anti-realist about a certain domain of discourse, and the domains that can be, and have been, given a fictionalist treatment range from morality to mathematics (for contemporary discussions see the contributions to Armour-Garb and Kroon (2020)). Regardless of the merits of this view in the context of the realism debate in the philosophy of science, it has not been

[7] Usually, at best parts of such descriptions are true of actual systems, but nothing rules out the existence of limiting cases where even the entire description can be true.

offered as a systematic account of modeling, and we stress again that the fiction view of models is not a version of fictionalism in that sense.

6.4 Second Myth: Fictional Models Are Data-Free

The second myth is a cousin of the first in that it portrays the fiction view as being committed to there being an unbridgeable gap between model and fact. The difference is that second myth is couched in terms of data rather than model-world correspondence. Kvasz notes that "when working with the model we often must supplement the data of the model description by some empirical observation. E.g. geophysicists used astronomical data of the Babylonians to fix the value of friction between the Earth's kernel and its mantel".[8] He then claims that the fiction view cannot accommodate data because "[i]t is absurd, that Flaubert would need to ask experts to fix the size of Bovary's foot, her hair length, and after filling this information into the novel, its plot would start to work. The quality of the plot of a work of fiction does not depend on empirical data. So models and fiction may be also in this respect dissimilar."

This is begging the question against the fiction view. As we have seen in the introductory example, mathematics can be part of what is imagined when dealing with a model (more on the use of mathematics below), and there is just no reason why data could not be part of an imaginary activity too. Fibonacci could have observed how rabbits breed and built empirical facts into the model, for instance by replacing the assumption that each rabbit pair produces exactly one pair of offspring by an empirical figure for the number of offspring. This would have complicated the arithmetical treatment of the model, but it would not have caused any problems for the philosophical analysis of it. Likewise, when Newton modeled the Sun-Earth system, his model system consisted of two imagined perfect spheres with homogenous mass distributions in empty space attracting each other gravitationally. This is a fictional system. But there is nothing stopping us from adding data to this model, for instance by inserting values for the masses of the Sun and the Earth, as well as for the gravitational constant. As far as the fictional status of the model system is concerned, there is no difference between imagining a perfect sphere tout court, or a perfect sphere with a mass of 5.972×10^{24} kg (the mass of the Earth).

Furthermore, it is patently false that fiction and fact are antithetical and that no facts—or "data"—are ever inserted into fictions. Historical novels like War and Peace contain a plethora of historical facts, and authors who write such novels often carefully research the history on which they base their novel. The question concerns only which facts are inserted into the novel. Kvasz is of course right that facts about the size of Emma Bovary's feet are not part of the novel. But that's not because novels,

[8]The point has been made in a talk in Prague on 29 May 2018. The quotes are from the slides; italics are original; bold-face has been removed for typographical unity. The talk is available online at http://stream.flu.cas.cz/categories/representation-in-science.

as matter of principle, resist facts; it is because her foot size is irrelevant to the plot.[9] Imagine another author, Maubert, who works on a novel whose protagonists are a dancer, and orthopaedic surgeon, and a foot fetishist. Maubert is a social realist and sees it as his mission to document everyday lives. We can be sure that plenty of facts about feet will go into that novel![10]

6.5 Third Myth: The Fiction View Is Antithetical to Representation

Another myth concerning the fiction view of models is that it is antithetical to representation. To motivate her own proposal, Knuuttila rhetorically asks "if scientific models are considered as fictions *rather than* representations of real-world target systems, how are scientists supposed to gain knowledge by constructing and using them?" (2017, p. 2, emphasis added), thereby driving a wedge between fictions and representations. In the same vein, the proposal for this book says:

> Fictionalism and artifactualism remove the concept of representation from its central place in the philosophical analysis of scientific models. Regarding idealization, it remains to be seen how this concept could be accommodated by these accounts.

Artifactualists can speak for themselves. But in the context of the fiction view of models, the assumption seems to be that the view highlights the ontological status of models at the expense of according them representational content. As we have seen, the fiction view emphasizes thinking about model descriptions as describing and investigating the features of fictional systems. In some cases, this may be done at the expense of focusing on the target system, and the relationship between the things that are written down in scientific papers and textbooks and the parts of the world one might think they are trying to describe falls into oblivion. The focus is on the fiction rather than the actual world. Our discussion of the nature of fiction in Sect. 2 might be thought to lead to something like this view. If, as we suggested, the relevant notion of fiction involved here is that such descriptions are "fictional" in the sense that whether they are true or false when applied to a target system is irrelevant to their function, just as readers of literary fictions are expressly not meant to take the sentences they read as reports of fact, neither true nor false of the world we inhabit,

[9] A parallel point is true of models, which are often poor in detail because certain details don't matter in a given context. It would, however, be mistaken to take models to be defective just because they do not contain certain details. Thanks for Martin Zach for pointing this out to us.

[10] There is another objection to the fiction view lurking in the vicinity of this myth. Roughly speaking, it runs as follows: if works of literary fiction contain facts, these facts are not relevant to the aesthetic value of the work of fiction; they are not relevant to the value of the fiction qua fiction. Or more generally, the epistemic value of a work of fiction is not relevant to its aesthetic value. In contrast, whether a scientific model, understood as a work of fiction, contains or doesn't contain the relevant facts is clearly relevant to the value of the scientific model. Therefore, scientific models and works of literary fictions should not be identified, because what makes them valuable qua model and qua work of fiction respectively, are not the same. We return to this objection in Sect. 6.

then it looks like actual target systems have no space in the theory. Thus, the fiction view is antithetical to representation because, whilst it might provide an account of what models are, and moreover, whilst it might provide an account of what sorts of things are true in the model, it does so in a manner that is disconnected from the relevant systems in the world we typically understand models as representing.

This objection fails to take into account the division of labour in philosophical discussions of scientific modeling. The fiction view of models is, first and foremost, an attempt to understand the ontology of scientific models. What is a frictionless plane? What is an ideal agent? What is a population of immortal animals? These things aren't, at least not in any straightforward sense, homely concrete objects existing in our universe. But in order to understand what it is that these models tell us about actual slopes, customers and consumers, and animal populations, we first have to understand what models are and how they operate in a context of investigation. We then have to say how they represent their target systems. The objection, presumably, would insist that this can't be done—and that is simply wrong.

We don't speak for everyone associated with the fiction view of models here, but our own preferred account of scientific modeling combines the fiction view with what we call the DEKI account of scientific representation. We understand scientific models to be fictional systems that in turn represent target systems in virtue of meeting four conditions: the model denotes the target system; the model exemplifies certain features; these features are converted by a key into a collection of other features; and these other features are imputed to the target system (2016, 2018). Logically speaking, the two accounts are independent of one another: one could subscribe to the fiction view and then offer an alternative account of how models represent, and one could adopt the DEKI account of scientific representation but combine it with another account of the ontology of scientific models (e.g. an account where models are construed as mathematical structures). The important point here is that the two accounts can be combined. So, at least on our approach to the question, the fiction view of models does not "remove the concept of representation from its central place in the philosophical analysis"; rather it is supposed to be supplemented with an account of representation to deliver a more encompassing account of scientific modeling.

Whilst this goes some way to alleviating the worry that the fiction view is antithetical to representation, understood in this way, more specific worries can be targeted at the view. Most pertinently, one can now ask whether or not the fiction view is consistent with one's preferred account of scientific representation. If it's not, then although the view isn't designed to downplay the importance of representation, it may nevertheless rule out scientific models from representing for ontological reasons. A worry of this sort is the following: in order for a scientific model to represent its target, we have to provide some way of making sense of ascribing physical features to models and of comparing these features with features of the target. Examples can illustrate what we mean by this. The imagined object sliding down the surface of a frictionless plane in the model experiences a certain degree of friction and is subject to less friction than the skier on the ski run; after a few years, the population of actual rabbits breeding in the back garden has a certain size and is smaller than the

population of immortal rabbits in the model; the bob on the string in the idealized pendulum has a certain mass and weighs less than the weight at the bottom of the pendulum in the clock in the corner of the library; and so on. In order to make sense of such property attributions and comparisons, we have to be able to analyze the apparent ascription and comparison of model-target features.[11]

How to understand these ascriptions and comparisons will depend on the details of the fiction view in question. Fictional realists who think that fictional objects are concrete systems, existing in another possible world for example, presumably won't have an issue with how to ascribe physical features to models, and presumably the comparisons will be phrased in terms of trans-world comparative statements. The objection is more pressing for fictional realists who think that these objects don't have physical features, because they are actually existing abstract objects for example, since such abstract objects, presumably, are not subject to friction, and are not the sorts of things that have size or weight (Thomson-Jones 2010). Given this, it is also difficult to see how we can go about comparing them to their physical targets with respect to those properties. Fictional anti-realists, like those using the Waltonian framework face part of the worry: whilst the view allows us to accommodate what look like ascriptions of physical features by paraphrasing them as occurring in a game of make-believe, accommodating the comparisons is more problematic, given that there is no obvious game of make-believe associated with the comparisons. To illustrate: a claim like "the bob on the end of the pendulum weights x grams" might be true in the game of make-believe, but it remains disconnected from comparisons with the target because the weight at the end of the pendulum in the clock is not part of that game of make-believe. So it seems to remain unclear what is compared with what, and how.

More generally then, if an account of scientific representation requires that we can provide an account of what looks like the ascription of physical features to scientific models, and an account of how these features are compared to features of their targets, and if one's preferred fiction view of models cannot do this, then the view will be inconsistent with the idea that models, understood as fictions, can play a representational role. There are two ways of answering this objection. First, one can deny that an account of scientific representation requires an analysis of ascription and/or comparison of physical features. Second, one can attempt to accommodate them in one's preferred fictional framework, where the details of such an accommodation will depend on the details of the framework in question. We here want to run the first line of argument and set aside the question of whether one can accommodate property ascriptions and comparisons. We note, however, the proponents of the fiction view using the Waltonian framework have number of options available to them if they want to pursue that second avenue (Salis 2016).

[11] Another objection might be that the fiction view cannot account for the idea that models denote their targets, which is a requirement of many accounts of representation. A failure of denotation is supposed to come about because in order for X to denote something X has to exist in some ontologically robust sense which fictions lack. We answer that objection in Salis et al. (2020).

Why think that the way in which models represent requires ascribing and comparing the physical features of models with the physical features of their targets? Presumably this depends on the account of scientific representation that is adopted. A popular account invokes the notion of similarity to establish (at least in part) either representation or accurate representation,[12] the basic idea being that a model represents its target in virtue of someone proposing that the two are similar in certain respects and to certain degrees. The model is accurate if the two are in fact so similar. In general, it is accepted that these sorts of similarities turn on the co-instantiation of certain physical features. So in order for the instances of modeling that we take to be accurate to come out as accurate on such an account, it better be the case that we can ascribe models the relevant physical features (population size, bob weight, and so on), and make model-target comparisons in terms of these features. Thus, a commitment to the similarity view of scientific representation engenders a commitment to understanding the sorts of ascriptions and comparisons offered above. And, so the objection goes, these are difficult to make sense of for, at least some, versions of the fiction view.[13]

However, as noted, the fiction view of models is by no means committed to any particular account of scientific representation.[14] Our account of scientific modeling combines it with the DEKI account of representation. Recall that on this account a model exemplifies certain features, and a key is used to translate those features into other features to be imputed onto the target. If the target has those features, then the model is accurate with respect to them.[15] Notice, then, that there is neither a demand that the model exemplifies physical features, nor that keys have to link features of the same kind. A key has to convert some feature P of a model into a feature Q, which is then imputed to the target. Such an act does not require that P is a physical feature. In fact, generating this claim does not require any explicit feature comparison at all.

[12]For more on the role of similarity in scientific representation see chapter 3 of Frigg and Nguyen (2020); see the rest of the book for more on scientific representation in general.

[13]A related objection that has been directed at the fiction view is that it cannot accommodate "design models" (i.e. blueprints, plans, and so on), precisely because the fiction view requires comparing the features of models with the features of their targets. In the case of design models, there is no target system (at least at a certain stage in the modeling process), and therefore no target features with which to compare to the model's features (Currie 2017). In response to this objection we note, again, that the fiction view concerns the ontology of models, not their representational content. As such, a model doesn't have to represent in order to be considered a fictional object. Such models are a kind of targetless model, and we discuss them in Frigg and Nguyen (2020, see in particular Chaps. 8-9).

[14]For a discussion of how the fiction could be combined with different accounts of representation see Frigg and Nguyen (2016).

[15]The notion of a key was also invoked by one of us in a sketched precursor to the DEKI account (Frigg 2010b). As stated there, keys work by taking "facts" about the model to claims about the target. Toon (2012, p. 58) and Levy (2015, pp. 789–90) objected that according to the fiction view there are no facts about models, thus there is nothing for the key to apply to. This objection relies on an overly stringent understanding of "model-fact": there's nothing to prevent keys being applied to "facts" which are only fictionally true in the game of make believe associated with the model. Indeed, articulating what is fictionally true in a model is one of the main tasks for the fiction view of models.

As previously noted, the DEKI account can be combined with any of the different fiction views of models. Combining it with a realist view that takes fictions to be concrete possible objects would lead to the view the model can exemplify physical features, and that these physical features can be acted on by a key that links physical features with physical features. Combining it with a realist view that takes fictions to be abstract actual objects, the model can exemplify the sorts of features that such abstract objects have, and these can be acted on by a key linking them to physical features of targets. Combining it with an anti-realist view of the Waltonian stripe, the model can be said to exemplify certain physical (or non-physical) features in the relevant game of make-believe, and then these features can be linked, via a key, to the features of target systems. In none of these cases do we have to compare the model-features with features of targets; the key is simply a way of taking us from a statement of the form "the model has feature P" to one of the form "the target has (physical) feature Q". It makes no difference to the function of the key if the former sentence is embedded in a game of make-believe, and the latter is not.

So, as we have seen, the fiction view of models is not antithetical to representation; in the first instance because it's not designed to be an account of how models represent and in the second, because there are routes available to combine the view with such accounts. These routes can involve embracing the challenge of making sense of ascribing physical features to fictional entities, and comparing them with the physical features of their targets, or they can simply deny that such comparisons need to be made to make sense of scientific representation. Either way, combining the fiction view with an account of scientific representation is not the impossible task that the myth takes it to be.

6.6 Fourth Myth: Fiction Trivializes Epistemology

Another objection that may be directed at the fiction view of models stems from an existing literature regarding the cognitive, or epistemic, value of art.[16] There the debate concerns whether or not works of art, including works of fiction, have epistemic value and the connection that this has to aesthetic value. "Cognitivists" are committed to both (i) the idea that art, at least in part, has epistemic value because we learn from it, and (ii) that art's epistemic function positively contributes to its aesthetic value.[17] "Anti-cognitivists" deny one, or both, of these claims. These considerations can be brought to bear in the context of the fiction view of models via an (anti-cognitivist) argument that runs as follows: works of fiction have no, or at best little,

[16] We use the phrases "cognitive value" and "epistemic value" interchangeably.

[17] As we will see, it's important to distinguish between these two aspects of cognitivism in the context of the fiction view of models, but it is also important in the context of analyzing the value of art itself. Both Gaut (2003) and Thomson-Jones (2005) characterize the debate about art in this way. Gibson (2008) prefers a different characterization according to which the question is whether the artwork itself, qua artwork, contains cognitive content. The difference is not important for our current project.

epistemic value; scientific models have epistemic value; therefore scientific models are not works of fiction.[18]

Obviously we don't deny that scientific models have epistemic value: in fact we take it that they are bearers of such value par excellence. As such we have to address the first premise; that works of fiction lack such value. This leads to two questions: first, is it actually the case that works of fiction lack epistemic value, and second if they do, does this stem from their fictional nature (rather than some other property that some works of fiction happen to have more conventionally) in such a way that this carries over to the fiction view of models? Notice that a positive answer to the first question doesn't entail a positive answer to the second: even if works of fiction, now understood to exclude scientific models, have little to no epistemic value, this need not necessarily arise from their fictional nature (or at least the aspects of their fictional nature that the fiction view of models exploits); and as such, even if it turns out that the anti-cognitivist's arguments against the epistemic value of literary works of fiction are sound, this does not necessarily entail that they carry over to the fiction view of models. As it happens, we think that the anti-cognitivists arguments fail even in the case of literary works of fiction, which we will address first. But we'll also comment on a plausible way in which one could be an anti-cognitivist about literary fiction whilst still adopting the fiction view of models.

In order to address the question of whether works of fiction have epistemic value it is crucial to delineate the kind of epistemic value that is in dispute, at least in the context of defending the fiction view of models from anti-cognitivist arguments. The idea that fiction, and art more generally, has "epistemic value" can be explicated in multiple different ways, and thus, there are many different ways in which this can be denied. So it's useful to disentangle the different kinds of knowledge that fiction might be said to provide. First and foremost, in the current context, is the idea that fiction provides propositional knowledge concerning the actual world. This is to be contrasted with other kinds of knowledge that fiction might plausibly provide: philosophical knowledge, i.e. knowledge of concepts; knowledge of possibilities; practical knowledge, i.e. knowledge of how to do certain things; knowledge of the significance of events; phenomenological knowledge, i.e. knowledge of what it feels like to be in a certain situation; and knowledge of values (see Gaut 2003, pp. 437–90 and the references therein). This is not to say that there is a clear division between these sorts of knowledge, and the fiction view of models does not rule out the idea that models can also provide knowledge beyond propositional knowledge of the actual world (for example, it's very plausible that many models provide us with knowledge of possibilities, sometimes called "how-possible" models (Bokulich 2014) and models in engineering can provide us with practical knowledge, and so

[18] Something similar to this argument is considered by G. Currie (2016, p. 304). Note, however, that he does accept that we can learn from fictions in some sense, albeit in a sense that doesn't support the analogy between literary fiction and scientific modeling. The problem with locating this myth, as Currie points out, is that there is relatively little agreement about the extent to which fictions hold cognitive or epistemic value. As such, those who think they don't will take the fiction view of models to be a non-starter (Portides 2014).

on). But for our current purposes we can put these sorts of questions aside and focus on whether works of fiction provide us with knowledge of the actual world.

In the first instance, it's difficult to deny that works of fiction provide us with knowledge of this kind. We learn much about the academic environments in the UK and USA in the 1970s from reading Changing Places and much about the geography of Dublin at the turn of the century from Ulysses. In light of the above discussion, there are two ways for the anti-cognitivist to respond. They could either accept that we do acquire knowledge from fiction but deny that this contributes to their aesthetic value (denying (ii) above, something we return to later), or they could argue that all that we learn from fiction is, in some sense, banal, or a collection of truisms. This latter approach is argued by Stolnitz (1992). He invites us to consider what we learn from Pride and Prejudice. Presumably, given that we're interested in what we learn about the actual world from the fiction, the cognitive value of the work is not directly concerned with the details of the novel itself. We're not concerned with learning about the events in the fiction alone; we're concerned with how the fiction can help us gain knowledge about actual systems in the world. As such he argues that the cognitivists won't:

> settle for other truths, of which there are a great many, about Elizabeth Bennet and Mr Darcy [but rather t]hey will settle for nothing less than psychological truths about people in the great world, truths universal, more or less […] Hence [what we learn is that]: Stubborn pride and ignorant prejudice keep attractive people apart (p. 193).

His point, then, is that in moving from the world of the fiction to learning something about the world itself, we have had to abstract from the details. In his own words, if we want to specify what we learn about the actual world from the novel we:

> abandon the setting of the novel in order to arrive at psychological truth. Yet in abandoning Hertfordshire in Regency England, we give up the manners and morals that influenced the sayings and doings of the hero and heroine [and thus] we abandon their individuality in all of its complexity and depth. My statement of the psychological truth to be gained from the novel [that stubborn pride and ignorant prejudice keep attractive people apart] is pitifully meagre by contrast. Necessarily, since the psychologies of Miss Bennet and Mr Darcy are fleshed out and specified within the fiction only. Once we divest ourselves of the diverse, singular forces at work in its psychological field, as we must, in getting from the fiction to the truth, the latter must seem, and is, distressingly impoverished. Can this be all there is? From one of the world's great novels? (p. 194).

Elgin calls this the argument from banality (2017, p. 245). Since the purpose of scientific models is to give us knowledge, and ideally precise and specific knowledge, they cannot, so the argument goes, be works of fiction, or even be like works of fiction.[19]

The question, then, is whether Stolnitz is right that all we can learn about the actual world from works of fiction are banal truisms. It's far from clear whether this is the

[19] G. Currie gestures at a similar worry when he notes that "[w]e have no more than the vague suggestion that fictions sometimes shed light on aspects of human thought, feeling, decision, and action" (2016, p. 304). We take it that the below discussion concerning whether what we learn from fiction is "trivial" or "banal" carry over to whether what we learn "sheds light" on phenomena in the world. A position similar to G. Currie's is also advocated by Portides (2014).

case. Even in his own example, why should we think that it is banal that pride and prejudice keep attractive people apart? Those inexperienced in the trials and tribulations of dating and relationships often don't realize that if they swallowed their pride a little more often, their relationships would go much smoother. (In fact, one could argue that it's precisely because of the fact that we are so familiar with Pride and Prejudice that Stolnitz's example of a psychological truth might appear uninformative; perhaps it's not that the novel reflects something already widely known, perhaps it's widely known because of the cultural familiarity with the novel.)[20]

Other examples of fiction providing us with non-trivial knowledge abound. As previously mentioned, Changing Places teaches us about the difference between American and British academic cultures in the 1970s; Harper Lee's To Kill a Mockingbird provides detailed insights into the racial inequality and its dealing with rape; Harriet Stowe's Uncle Tom's Cabin taught its readers much about slavery in the USA; and George Orwell's Animal Farm provides a fine-grained account of the phoney pretention of communism. And in the latter case, it, along with the likes of Doctor Zhivago, being banned in the USSR suggests that there is something non-trivial about what we learn about Soviet Communism and the Russian Revolution from reading such works of fiction (we are not claiming that all banned books are banned because of what we learn from them; plausibly some are banned for other reasons; but Animal Farm and Doctor Zhivago were banned for what they say about communism rather than for, say, being obscene). Similarly, the Catholic church's Index Librorum Prohibitorum was not restricted to scientific works; it included Milton's Paradise Lost and Voltaire's Candide, amongst others, again suggesting that works of fiction can contain the sort of cognitive content that certain institutions would prefer were not widely accessible.[21]

There is, however, a grain of truth in Stolnitz's argument. In order to learn actual psychological truths about from Pride and Prejudice we abstract away from the details of the fictional novel. Whilst we think that Stolnitz is incorrect to conclude that the result of such a process leads to triviality, he is correct that what works of fiction tell us about the world is, often at least, less precise than the details of the fictional world. But this is by no means unique to novels. Many elements of science, including, but not limited to, models don't represent the world in its full messy detail. Laws of nature only apply ceteris paribus (Cartwright 1983), and scientific

[20] Kvasz offers the further objection that scientific models should be distinguished from works of fictions because the former, but not the latter, provide novel knowledge about their targets. Again, it is unclear to us why one should think that by working through the implications of a fictional novel one would not learn anything new.

[21] In order to handle these sorts of examples in the context of discussing the cognitive, or epistemic, value of art, the anti-cognitivist can accept that we do learn from fiction, but argue that the fact that we do so is irrelevant to the works' aesthetic value (this may seem plausible with respect to learning about Dublin's geography from Ulysses, but we're unsure whether it's correct with respect to the other examples discussed). However, here it serves to distinguish between the debate in the philosophy of art and the fiction view of models. In the case of the latter it's irrelevant as to whether or not what we learn contributes to the works' aesthetic value. So once the anti-cognitivist's target is the connection between learning from fiction and its aesthetic value, rather than whether or not we learn from fiction at all, the fiction view of models is no longer threatened by their claims.

models are also abstractions in the sense of not representing everything in a target system (Thomson-Jones 2005). This is particularly clear in the case of so-called "toy models", where one of us has argued that this process of abstracting from the details of the model is required in order to understand what they tell us about their target systems, and that it's this process that explains why such models are so prevalent in science (Nguyen 2020). The claim is that the representational content of these models is also relatively abstract in the sense of applying broadly to a number of target systems and at a relatively high level of generality, such as "mild preferences tend to lead to social segregation" (Schelling's model), or "asymmetrical information tends to lead to Pareto-inefficiency" (Akerlof's model). One might argue that these propositions are "banal" or "trivial", and there we have no knock-down argument against this claim because there is no clear criterion for when a truth is "banal" or "trivial". We note, however, that both models contributed to their authors being awarded Nobel Memorial Prizes in Economics, which would suggest that the scientific community took a less bleak view of these insights than the "banality argument" would suggest we should.

It seems to us that the works of fiction (and scientific models) in question do teach us important truths about the world, but for the sake of argument, let's suppose, with the anti-cognitivist, that we're wrong. Does this vindicate the argument given at the beginning of this section regarding the idea that the fiction view of models must fail because fictions, in virtue of their fictional nature, have no epistemic, or cognitive value?

Here we see again a disconnect between the anti-cognitivist arguments against the cognitive value of art and attempts to turn those arguments against the fiction view of models. The former arguments take as data observations about what we learn from actual works of fiction; they don't turn on the ontological status of such fictions. Since the fiction view of models is only committed to the abstract mechanism of fiction (as outlined previously), defenders of the view can plausibly argue that the implementation of that mechanism in the context of scientific models is, in an important sense, different from how it has been implemented in the cases of fictional novels. This would allow them to accept (at least for the sake of argument) that literary fictions lack cognitive value, without thereby undermining the fiction view of models itself.

It's worth briefly sketching the sorts of differences that one could appeal to in order to justify such a position.[22] First, one could argue that, in general at least, literary fictions don't have a fully specified target system, and it's this that tells against the idea that they have cognitive value. But as we saw in the previous section, there's nothing about the nature of fiction itself that prevents a fiction playing a representational role, so even if this were true about literary fiction, it has no bearing on the fiction view of models.[23] Second, one could argue that the ways in which literary

[22] See Frigg and Nguyen (2017, pp. 56–58) for further elaboration.

[23] We want to further note here that we think many literary fictions do have target systems—Animal Farm is quite clearly targeted at Soviet Communism and further examples are not difficult to find; Erich Maria Remarque's All Quiet on the Western Front and Kurt Vonnegut's Slaughterhouse-Five

fictions are interpreted as representing their targets is much less constrained than the way in which scientific models are so interpreted. Drawing on Friend (2017a) for an example, following the publication of Jean Rhys's Wide Sargasso Sea, adopting a postcolonial interpretation of Jane Eyre yields very different insights from the behaviour of Bertha Antoinetta Mason about Jamaica's colonial past.[24] More generally, considering alternative interpretations of literary fictions is a practice to be celebrated. But in the case of science, if one interprets a scientific model in a non-standard way, it often suggests that the model hasn't been understood. So flexibility of interpretation counts against the claim that works of fiction have cognitive value.

This argument seems problematic for two reasons. First, even if we assume that it is correct that in general that works of literature have more flexibility with respect to interpretation than scientific models,[25] it remains unclear to us why this flexibility should count against the cognitive value of fiction. That we can reinterpret Jane Eyre doesn't make the work cognitively inert. Second, even if this was the case, the point doesn't carry over to the fiction view of models because scientific fictions are, usually at least, much more constrained. Finally then, one could consider the differences with respect to style in literary and scientific fictions. In the case of literature, the way in which a work is written seems to have clear ramifications concerning what, if anything, we learn from it. But, as G. Currie notes: '[m]odels are not dependent for their value in learning on any particular formulation' (2016, p. 305). So this difference could play a role in distinguishing between the cognitive value of literary and scientific fictions. Again it's not obvious how this tells against the fiction view—that models are (supposedly) independent of their formulation, or at least less dependant upon their formulation than fictions, is no reason not to think of them as fictions. And again, the difference seems more of a matter of degree than kind. As noted by, e.g., Vorms (2011, 2012), the ways in which scientific models are presented can make a difference to their epistemic value (consider, for example the importance of the coordinate system used in presenting a mechanical problem!).

To summarize then, it doesn't seem like anti-cognitivist arguments in the philosophy of art put the fiction view of models in any particular danger. First, the arguments can only be brought to bear if it's agreed that fictions don't have epistemic, or cognitive value. And as we have seen, there is no widespread agreement on this issue. Second, even if one were to grant that works of fiction don't have such value, it still remains the case that a defender of the fiction view of models can utilize differences (even if they are matters of degree rather than of kind) between literary and scientific

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are passionate denunciations of the horrors of the First and Second World Wars (respectively)—and as discussed above at least some scientific models lack targets. So this way of distinguishing between literary and scientific fictions seems implausible.

[24] Friend (2017a) argues in favour of pluralism about interpretation—which she construes in terms of what is true in the fiction—but her arguments carry over to what the resulting fictions tell us about the world.

[25] While this may be the case in general, there are cases from the history of science where considering an alternative interpretation of a model has increased its cognitive value in a way to be celebrated. Consider, for instance, Bohr's interpretation of a celestial two-body model in terms of atomic structure, or Goodwin's interpretation of an ecological predation model in terms of economic firms.

fictions in order to explain why the latter hold cognitive value despite the fact that they are on a part with the former with respect to their ontological status.

6.7 Fifth Myth: The Fiction View Is Antithetical to Mathematisation

The main competitor to the fiction view of models is the view that models should be thought of as mathematical structures. From this it is tempting to infer that the fiction view is in tension with the idea that scientific models involve mathematics. And given the prevalence of mathematics in many (although, we submit, not all) modeling contexts, if this were the case then the fiction view would face a serious objection. This brings us to our fifth myth: that the fiction view of models is antithetical to mathematisation. Busting this myth requires explaining how mathematics enters the picture on the fiction view.[26]

Answering this objection requires understanding how model descriptions are related to the models they describe. Again, the exact details of this will depend on the details of the particular version of the fiction view in question. The descriptions can be taken to describe concrete possible objects (or collections of concrete possible objects) in the same way in which as statements about other possible worlds describe those worlds (Contessa 2010). The descriptions can be taken to describe abstract actual objects, or indeed be taken to bring those objects into existence, in the sense of creating abstract artifacts (Thomasson 1999). Or they can be taken to be (partly) constitutive of the fictional entity, understood in the Waltonian sense (by serving to specify the primary truths in the relevant game of make-believe). The point, though, is that all (indirect) fiction views have a role for model descriptions describing, in some sense, the fictional entities in question. And the crucial thing to note in this context is that these model descriptions often include statements in the language of mathematics.[27]

The question then, is how do model descriptions, understood as being at least in part mathematical, relate to the mathematical features of the models they describe. Again, this will depend on the details of the particular fiction view. When they're seen as describing possible concrete objects, the relationship between a mathematical description and such an object will be understood in the same way as we understand the relationship between a mathematical description and an actual concrete

[26]This objection has been put to us in personal conversation, but we have not been able to locate it in print. However, given that the main competitor to the fiction view, at least in terms of the ontology of scientific models, is the structuralist view, understanding how mathematics enters the picture on the fiction view is crucial for understanding what's at stake in the debate. Structuralism about models comes in two versions. The traditional version, associated with Suppes (2002) submits that models are structures, while a contemporary alternative, associated with Bueno and French (2018), regards structures as a meta-level representation of models.

[27]Even in cases where they are not explicitly mathematical, one might still want to apply mathematical tools to them, we discuss these sorts of cases in Frigg and Nguyen (2016).

object. Presumably, whatever is going on when we describe actual rabbit populations in mathematical language is also what's going on when we describe possible rabbit populations in mathematical language. For a discussion of a number of such suggestions see, for instance, Shapiro (1983).

If models are understood as abstract actual objects, the question is trickier: in what sense can we describe such objects mathematically? To the best of our knowledge, there hasn't been much explicit discussion of this sort of position in the literature. However, what's important for our current purposes is that this is a question of metaphysics: presumably how you go about thinking about these sorts of objects will inform how they can be described mathematically. But notice that thinking about models as abstract actual objects isn't antithetical to mathematising them, it just requires that some story be told, and it's not obvious that there is anything blocking such a telling.

In the case of Waltonain anti-realism, mathematics enters into games of make-believe in two places. First, mathematical model descriptions can serve to specify primary truths in the game of make-believe associated with a model. When we specify Fibonacci's model of population growth we use the equation $N(t_i) = N(t_{i-1}) + N(t_{i-2})$. This makes it fictionally true in the model that the population size at a time t_i is the sum of the population size at the two previous time steps. Second, recall that games of make-believe are also associated with rules of generation (for more on the details of the Waltonian framework in the context of the fiction view see Frigg (2010a) and Salis (2019)). These rules act to generate secondary truths, which, when combined with the primary truths, provide the collection of propositions that are fictionally true in the model. The nature of these rules of generation can vary across different games. One that is in operation in many literary fictions is the so-called "Reality Principle" (Walton 1990). According to this rule, the truths of the games of make-believe in which it is in operation are what would be true in the actual world, were the primary truths of the game true.[28] In the context of considering how mathematics enters the picture in the pretense version of the fiction view of models, it's important to note that the rules of generation often (perhaps always) consist of the rules of logic and mathematics. So far from being antithetical, mathematics fits seamlessly into this version of the fiction view.

What are we to make of the comparison between models and literary fictions in light of this observation? Kvasz argues that: "even though we have the means to go beyond the explicitly stated content by using certain rules of inference, the rules used in fiction are very different from those used in scientific modelling".[29] This objection is hard to pin down because we're not told how the rules are different, and without knowing what the alleged difference is, it is difficult to assess how damaging the difference really is. We suppose that Kvasz alludes to the fact that rules of generation in literary fiction are "informal" while rules of generation in modeling are mostly

[28] Friend (2017b) offers a slightly different rule, the "Reality Assumption", according to which everything which is actually true is fictionally true, just so long as it isn't explicitly ruled out by the primary truths.

[29] Again, the quote is from the slides of his talk, cf. footnote 6.

mathematical. If this is the relevant difference, then it is not a problem for the fiction view. First, even though many of the rules in literary fiction are informal, they are still (usually) constrained by logic and mathematics (when Yossarian calculates bomb trajectories in Catch-22, these trajectories can enter into all sorts of mathematical relationships). That rules of generation in fiction include non-mathematical rules doesn't mean they don't also contain mathematical ones. Second, even if it were the case that the rules used in games of make-believe associated with scientific models were more explicitly mathematical than the rules used in games associated with literary fictions, this does nothing to undermine the (Waltonian version of) the fiction view. As argued previously, the view is an attempt to understand the ontology of scientific models. If, in order to do this, we are lead to understanding their function differently to the function of literary fiction, this is not an objection to the account. In fact, given that the Waltonian framework involves rules of generation, but allows these rules to vary across different games, we can accommodate the differences between scientific models and literary fictions by considering how their rules differ. But, again, the fact that the rules are different does not mean that the ontology story offered by the account cannot get off the ground.

So, again, although there might be differences concerning how mathematics enters the picture on different versions of the fiction view of models, the idea that the view somehow stands in tension with the role of mathematics in modeling is mistaken. Each version of the view can accommodate scientific models being described in the language of mathematics, and having, in some sense, mathematical features.

6.8 Sixth Myth: Fiction Misconstrues the Function of Models

A related objection is that the fiction view misidentifies the aims of models. Giere deems it "inappropriate" to "regard scientific models as works of fiction" even though they are ontologically on par. The reason for this is "their differing function in practice" (Giere 2009, p. 249).[30] Giere identifies three functional differences (ibid., pp. 249–252). First, while fictions are the product of a single author's individual endeavours, scientific models are the result of a public effort because scientists discuss their creations with their colleagues and subject them to public scrutiny. Second, there is a clear distinction between fiction and non-fiction books, and even when a book classified as non-fiction is found to contain false claims, it is not reclassified as fiction. Third, unlike works of fiction, whose prime purpose is to entertain, scientific models are representations of certain aspects of the world. In a similar vein, Magnani dismisses the fiction view for misconstruing the role of models in the process of scientific discovery. On his account, the role of models is to be "weapons" in what he calls "epistemic warfare", a point of view "which sees scientific enterprise as a complicated struggle for rational knowledge in which it is crucial to distinguish

[30] Similar arguments are made by Liu (2014) and Portides (2014).

epistemic (for example scientific models) from non-epistemic (for example fictions, falsities, propaganda, etc.) weapons" (2012, p. 2; cf. 2020). Fictions, so the argument goes, are not involved in any such epistemic warfare.

Neither of these objections is on target. As regards Giere's, it's not part of the fiction view to regard "scientific models as works of fiction" in some vague and unqualified sense, much less to claim that literary fictions and scientific models perform the same function. Proponents of the fiction view are careful to specify the respects in which models and fictions are taken to be alike, and none of the aspects Giere mentions are on anybody's list. Furthermore, even if they were, they wouldn't drive Giere's point home. First, whether a fiction is the product of an individual or a collective effort has no impact on its status as a fiction; a collectively produced fiction is just a different kind of fiction. Even if War and Peace (to take Giere's own example) had been written in a collective effort by all established Russian writers of Tolstoy's time, it would still be a fiction. Vice versa, even if Newton had never discussed his model of the Solar System with anybody before publishing it, it would still be science. The history of production is immaterial to the status of a work. Second, as noted previously, falsity is not a defining feature of fiction. We agree with Giere that there is a clear distinction between texts of fiction and non-fiction, but we deny that this distinction is defined by truth or falsity; it is the attitude that we are supposed to adopt towards the text's content that makes the difference. Third, proponents of the fiction view agree that it is one of the prime functions of models to represent, and they go to great length to explain how models do this. We have discussed this issue in Sect. 5. Magnani's criticism is also based on an understanding of fiction as falsity, which supposedly implies that fictions can play no epistemic role. We repeat that fiction is not defined through falsity and that models, even if understood as fictions in one of the qualified senses discussed in this chapter, can play epistemic roles.

6.9 Seventh Myth: The Fiction View Stands on the Wrong Side of Politics

Finally, Giere (2009, p. 257) complains that the fiction view plays into the hands of irrationalists.[31] Creationists and other science sceptics will find great comfort, if not powerful rhetorical ammunition, in the fact that philosophers of science say that scientists produce fiction. This, so the argument goes, will be seen as a justification of the view that religious dogma is on par with, or even superior to, scientific knowledge. Hence the fiction view of models undermines the authority of science and fosters the cause of those who wish to replace science with religious or other unscientific worldviews.

Needless to say, we agree that irrationalists deserve no support. In order not to misidentify the problem it is important to point out that Giere's claim is not that the view itself—or its proponents—support creationism; his worry is that the view can be

[31] This discussion of Giere's objections is based on Sect. 4 in Frigg (2010c).

misused if it falls into the wrong hands. True, but almost anything can. What follows from this is not that the fiction view itself should be abandoned. What follows is that some care is needed when communicating the view to non-specialist audiences. As long as the fiction view presented carefully and with the necessary qualifications, it is no more dangerous than other ideas, which, when taken out of context, can be put to uses that would (probably) send shivers down the spines of their progenitors (think, for instance, of the use of Darwinism to justify eugenics).

6.10 Conclusion

We've attempted to vanquish seven myths about the fiction view: (1) it does not regard the products of science as falsehoods; (2) it allows that data can be part of models; (3) properly understood (as an account of the ontology of models, rather than their function) it is perfectly compatible with the fact that models represent; (4) it allows that we can learn important truths about the world from models; (5) it allows for this to involve mathematics; (6) it doesn't misconstrue the function of scientific models in practice; and finally (7) it is no more politically problematic than many other philosophical and scientific ideas. Our hope then, is to have cleared away some important misconceptions about the view, thereby making it plain what the view does and does not entail about scientific modeling. This, of course, is not to say that the view faces no difficulties, or is obviously true. But if it's going to be attacked or criticized, or if it's going to be compared to other accounts of the ontology of scientific models, then hopefully such discussions can proceed without repeating any of the misconceptions we have discussed here.

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Roman Frigg is Professor of Philosophy at the London School of Economics. He was Associate Editor of *The British Journal for the Philosophy of Science* and member of the steering committee of the *European Philosophy of Science Association.* He has developed the fiction view of models and the DEKI account of scientific representation. He is the author (with James Nguyen) of *Modelling nature: An opinionated introduction to scientific representation* (Cham: Springer, 2020).

James Nguyen is the Jacobsen Fellow at the Department of Philosophy, University College London and the Institute of Philosophy, University of London. He is also a Research Associate at the Centre for Philosophy of Natural and Social Science, London School of Economics and Political Science. He is the author (with Roman Frigg) of *Modelling nature: An opinionated introduction to scientific representation* (Cham: Springer, 2020).