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BOOK REVIEW

Anchoring fictional models

Models as make-believe by Adam Toon, 2012, Plagrave-Macmillan

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The practice of modeling

The term ‘model’ was originally imported into the philosophy of science from logic and meta-mathematics. In these fields, a model is an abstract structure that satisfies a formal language, typically given by a set of axioms (plus rules of deduction). A model gives content to a formal language insofar as it constitutes an interpretation for the language and thereby determines what is true, according to that interpretation. This concept of a model formed the basis of the so-called *semantic view* of theories—which emerged as an alternative to the syntactic approach, characteristic of the logical positivist movement (Giere 1988; Suppes 1960; Suppe 1989; van Fraassen 1980). The syntactic view took theories to be formal in nature: sets of sentences couched in a specified vocabulary and conforming to a well-defined syntax. The semantic alternative was to regard theories as what the formal language is about: models, or collections thereof. Like its syntactic foil, the semantic view was meant to be a general account of the content of scientific theories.

The semantic view of theories is alive and kicking (e.g. French and Ladyman 1999; Bueno and French 2011). But alongside it there has emerged a large body of work that centers on the *practice of modeling*, in which ‘model’ tends to name a specific sort of theoretical vehicle. Views about how to carve out the relevant categories differ, of course, but by most accounts a key feature of modeling is idealization: models are simplified representations that do not apply as is to any real-world phenomenon. Examples are common: The ideal gas model treats molecules as non-interacting billiard-ball-like spheres. The Lotka-Volterra model of predator–prey interactions assumes that animals are born and die at uniform rates. The French Flag model of cellular differentiation regards the developing tissue as devoid of internal divisions, such that chemicals can freely diffuse within it. In all

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these cases a simplifying description is offered, the modeler knowing full well that no real-world system meets it.

Modeling raises many questions. Some are relatively descriptive while others are more philosophical in nature. Adam Toon's new monograph "Models as Make-Believe", deals with the latter type of questions. His principal aim is to understand the ontology and semantics of modeling: what models are and how model-based representation works. To answer these questions, a theory is developed on which models are akin to games of make-believe: collective, rule-governed exercises of the imagination. In developing this theory, Toon draws extensively on Kendall Walton's view of representational art. Indeed Toon's chosen title is a riff on "Mimesis as Make-Believe", the name of Walton's seminal 1990 work. Toon is not alone in looking to fiction, and to Walton in particular, in an attempt to make sense of modeling (Godfrey-Smith 2006; Frigg 2010). But his view makes the most precise and dedicated use of such resources. There is much of value in Toon's general approach: the book outlines a way of looking at models that is illuminating and appealing in its metaphysical modesty. But, as I will discuss below, the motivation for the make-believe approach, vis-à-vis alternative approaches to modeling, could be strengthened.

Let me preface the discussion with a methodological remark. Modeling is a widespread practice, with context sensitive features and diverse underlying goals. To attempt to give a general philosophical account of it, especially one that makes contact with other parts of philosophy, such as the philosophy of language and metaphysics, while at the same time preserving a good descriptive match with the practice, is well-nigh impossible. Some reinterpretation (at times, shoehorning) of the practice is inevitable. The question is how much? I shall make some specific comments on this sort of issue below, but they will be tentative, as I do not have a principled view on how to strike the right balance.

Toon's point of departure is what he calls, following Martin Thomson-Jones, *the face-value practice*. Modelers, as well as philosophers discussing the practice, often speak of models as if they were ordinary, actual, concrete things ("prey populations reproduce exponentially", "an ideal gas expands under pressure" etc.). This raises puzzles: no one thinks that there are ideal gases or exponentially reproducing prey populations. At least, no one thinks there are such things in the actual world, the one we inhabit and the one supposedly studied by science. Why, then, do scientists (and philosophers, at times) talk as if there were such things? As Toon puts it: "[G]iven that model-systems are not actual, concrete parts of the world, how is it that scientists seem to be able to talk about them and learn about their properties?" (p. 13).

The challenge isn't merely to say how scientists are *able* to talk about models, or why they are wont to do so. The point is that the practice of talking about models is constrained: in the Lotka-Volterra model, the prey population is well-mixed; stating otherwise is incorrect. So one can make mistakes about what a model is like. Moreover, one may learn surprising things about a model—indeed, that is usually the point. In short, there is a right and wrong in talking about these un-actual constructs, a situation that is analogous, at least in some ways, to discourse surrounding actual objects. Toon, therefore, sets out to give a semantics for model discourse, one that explains its surface resemblance to ordinary factual discourse,

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and that supplies a concomitant explanation of the face value practice. This task is closely connected with giving an account of model-based representation, i.e. of how, and what, models tell us about the world. Notice, however, that such an account, insofar as it deals with representation per se, falls short of telling us how models facilitate knowledge about the world. An account of representation may tell us what model discourse means, including what it says about the actual natural world. But it does not, as such, tell us which of the things said about the actual natural world are justified, and thus how, if at all, one can convert the results of modeling into knowledge about the model's actual, natural world targets. I will return to this issue in the final section.

In developing a semantics for model discourse, a tempting move is to posit that *there are such things* as models. Granted, models are not actual, concrete things, but perhaps they are things of some other sort. If so, statements about models might simply be descriptions of these things, the models. This would be an *indirect view* of model-based representation—it implies that modeling is, in the first instance, the construction and investigation of models. These constructed objects may then be used, indirectly as it were, to represent the world (Weisberg 2007). Toon rejects the indirect view, opting for a direct account of model based representation. This is at the root of his approach. While I am sympathetic, I am not sure the case made for directness is strong enough. Let me elaborate.

If there are such things as models, what might they be? One option is that models are abstract, non-spatiotemporal objects—perhaps mathematical objects of some sort. Michael Weisberg's recent book (2013) defends such an approach. Weisberg takes models to be mathematical structures. In his view equations, scientific texts and some sorts of drawings (especially graphs) specify structures. The specified abstract structure then (indirectly) represents the world via similarity relations between it and its empirical target.[1] Relying on Thomson-Jones, Toon offers a brief argument against views that take models to be abstracta. Scientists commonly attribute seemingly concrete properties to models—for instance, they describe them as changing in space and/or time. Molecules in an ideal gas have a certain *average velocity*, predators and prey have a *rate of reproduction* etc. But if models are abstract then "how can [they] possess the spatiotemporal properties we appear to attribute to them?" (p. 15). There is indeed a prima facie tension between treating models as abstract and attributing to them spatiotemporal properties such as velocity. But this tension doesn't strike me as deep. Advocates of the models-as-abstracta view can reasonably interpret such attributions as a way of describing the mathematical properties of the model—say, the time-derivative of a particle's location, in the case of speed. The reason for talking this way is apparent: the time-derivative in question ultimately represents velocity (in the target), and talking of both "in the same breath" is therefore convenient, perhaps to the point of going unnoticed. In many cases an interpretation along such lines would seem very

[1] The target, according Weisberg, isn't a portion of the world, as such. It is a selective description of it. Thus, the similarity relations in question do not hold between a model and the world per se, but between the model a representation of the world (what is sometimes called a *model of data*—Suppes 1960).

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natural. Sometimes it might amount to a mild shoehorning, but as noted earlier this can be expected in any general philosophical discussion of modeling.

A more substantial problem for the models-as-abstracta view, which Toon does not discuss, when one looks at models that appear not to have much mathematical content. One important class of cases are mechanistic models in molecular cell biology. The activity of enzymes or various cellular pathways is typically depicted by qualitative means—often graphically—that depict the structure of the proteins and other relevant molecules, their conformational changes, the reactions they undergo, etc. Such models aim to capture the mechanical goings-on, looking under the hood of the miniature machines at work within cells. Interpreting them as specifications of mathematical structure seems rather implausible—surely less plausible than doing so for an ideal gas or a Lotka-Volterra population. If the latter involves mild shoehorning, the former requires some serious squeezing and jamming.

A second option for those who wish to develop an indirect account of modeling is to regard models as concrete hypotheticals: objects that would be concrete if they were real. One way to further develop such a view is to regard models as akin to fictional objects, where these are seen as robust things. Toon mentions in passing that there are vexing metaphysical problems concerning fictional objects (p. 17), and this seems to be his main reason for not going in that direction. This is a reasonable approach, but it will not apply to ways of developing a models-as-concrete-hypotheticals view that do not appeal to fictional entities. For instance, one may regard models as possible worlds, or as portions thereof. This option isn't discussed in the book, presumably because Toon is wary of its metaphysical extravagance. But it is a surprising omission, given how central the possible worlds framework is in current discussions of semantics. I think this is an unfortunate lacuna in the book.

In principle, the models-as-concrete-hypotheticals faces a problem that is the converse of the one that afflicts the abstracta view: fitting some scientific models into a concrete mold would result in an unreasonable mismatch with the practice. The life sciences do not abound with relevant examples, but other areas, such as high energy physics, appear to involve models that are so closely tied to mathematical description, that it would seem a real stretch to regard them as concrete hypothetical things. (This is not to say that such models are not used to represent concrete systems in the world, but rather: if they are to be regarded as standalone objects, functioning in indirect representation, then it would seem unlikely that they are concrata). As my knowledge of these parts of the physical sciences is very limited, I cannot say how serious such a problem is. Perhaps string theory requires a different sort of account, or perhaps "the standard model" isn't a model in the relevant sense.

Toon's account

Whatever one makes of the prospects for an indirect view, Toon's main contribution lies not in criticizing it, but in offering his own *direct* account of the semantics of modeling. Directness in this context amounts to viewing model discourse as about the actual, concrete world, without the mediation of constructs or entities of any sort. As

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noted, Toon develops this idea by applying Kendall Walton's theory of fiction to models. Walton's theory originates in the context of art, as an account of the content of novels, representational paintings and the like. It is an antirealist view, in the sense that it attempts to account for fiction without appealing to fictional entities. At the heart of the view is the claim that fictions are akin to games of make-believe. Such games are typically organized around two elements: (a) a *prop*, such as a hobbyhorse or a Lego set. The prop is an object that serves as a concrete anchor for the imaginations of the game's participants. (b) A set of prescriptions—Walton calls them *principles of generation*—that tells participants what to imagine, given features of the prop. A principle of generation may imply that sitting on the hobbyhorse, one is to imagine oneself riding a real horse. Such principles are sometimes stated explicitly but more often they're left implicit. For Walton, a book or a painting is a prop which, via the relevant principles of generation, determines what we are to imagine as readers or viewers. Propositions that are to-be-imagined are, in Waltonese, *fictional,* according to the novel or the painting. In "A Study in Scarlet", it is fictional that Sherlock Holmes moves into 221b Baker Street, together with his new acquaintance, Dr. Watson. Fictionality is analogous to truth (truth *in fiction*) in some ways, although Toon, following Walton, avoids this term. The reason is that a proposition may be both fictional and true at once. The depiction of the early Mormon Church in "A study of Scarlet" contains some historically accurate statements (though much of what it says about Mormons was and still is controversial). That Brigam Young led the Church in the late 1840s, and that he later became the governor of the Utah Territory is historically true, and it is also fictional in "A Study in Scarlet".

This compatibility between truth and fictionality is the result of a more basic aspect of Walton's view. For Walton, what makes something a fiction is its socio-cognitive function—specifically, its being a basis for an interpersonal exercise of the imagination. Whether a proposition is fictional has to do with how it is to be employed, not with what it is about. One upshot is that there's no inherent need to posit entities—fictional characters, events and places—to account for the meaningfulness and the conditions of appropriateness of fictional statements. What makes a statement fictional, within some game of make-believe, are the relevant props and principles of generation, regardless of whether there are entities—fictional or otherwise—corresponding to it. Now, in the context of representational art, this is only the beginning of an antirealist account. For novels and paintings commonly appear to be made from whole cloth: they are often about people and events that are plainly non-existent, such as Sherlock Holmes and 221b Baker Street. So the antirealist needs to show that talk of such entities is meaningful, without appealing to fictional entities. But in the case of models the situation is different, and this is perhaps Toon's key insight. Models are typically geared towards explaining or predicting some real-world phenomenon, oftentimes a specific slice of space–time: say, the abundance of fish in the Adriatic Sea. For this reason, models can be regarded as make-believe games that *are about the relevant real-world phenomenon.* In the scientific context, make-believe can be anchored to target systems—i.e. models can be construed as imaginative descriptions of their targets. So the Waltonian philosopher of modeling needn't work hard to show that we can do without fictitious models—they aren't even prima facie necessary.

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Thus Toon's view is that model discourse can be construed as pretense talk, concerning real-world systems. Volterra did not conjure up, from whole cloth, a pair of predator and prey populations. Rather, he proposed a game of make-believe according to which Adriatic fisheries—data concerning which triggered his work on the model—are composed of exponentially growing prey, with constant growth rates etc. The main attraction of this view seems to be its metaphysical modesty: the direct make-believe view allows for idealization in modeling without bringing in additional objects. The objects of modeling are in the actual, concrete world—the systems targeted by modelers. Models are means for directing our imagination to entertain simpler and more tractable descriptions of the selfsame target systems.

In a recent book, Michael Weisberg argues that a direct fictions view does not adequately account for the practice. Weisberg's criticism is not explicitly directed at Toon, but the points he makes are directly relevant.[2] Weisberg thinks that a direct fictions outlook "undercuts accounts about the practice of modeling as a distinct theoretical activity, which I think can be independently motivated." (p. xx). In other words he thinks that what makes the practice of modeling distinct is indirectness. For Weisberg, this rules out direct views, even if they are metaphysically modest and allow, via some notion of fiction, to account for idealization and related features of modeling. Again, we have here a disagreement that concerns the appropriate trade-off between general philosophical considerations and adequate depiction of the day-to-day practice. Weisberg believes the practice is overtly and almost invariably indirect. Toon probably doesn't view the practice as so homogeneous, but at any rate he gives substantial weight to metaphysical modesty. I tend in Toon's direction: I think he is right to prefer general philosophical considerations in this instance, and I disagree with Weisberg that the direct interpretation is a serious distortion of the practice.

From the direct Walton-inspired picture of modeling Toon arrives at a bold thesis regarding scientific representation, which he labels MM. It runs as follows: "M is a model-representation if and only if M functions as a prop in a game of make-believe." (p. 62). The "if and only if" in this formulation may strike you as incredible, but Toon does hold that all props are models and all models are props. This would seem to entail that many works of art are models of sorts—or at least that they represent in model-ish ways. As he puts it: "Walton argues that his theory applies to novels, paintings, plays and films. If he is correct, then according to MM, model representation turns out not to be unique to scientific models, but an instance of a much wider form of representation also found in works of fiction" (p. 62). Thus, Toon turns the tables on the analogy to fiction: he asserts that modeling is a form of make-believe to which works of fiction may be assimilated. This is a bold idea indeed, but it appears that if one buys Toon's arguments up to this point, then one should accept it. Especially if, as Toon believes, modeling involves direct make-believe, whereas accounting for fictions in general might require entities of one sort or another.

[2] Weisberg aims his critique at an unpublished paper by myself, which defends a view broadly similar to Toon's.

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Modeling and the imagination

The final two chapters of the book aim to buttress the in-principle claims made in earlier chapters by connecting them to real-world examples. Chapter 4 is a case study of the use of models during the emergence of stereochemistry—the branch of chemistry that deals with the spatial arrangement of atoms within molecules. Toon looks especially closely at the work of the late nineteenth Century Dutch chemist Jacobus Henricus van't Hoff, a pioneer of organic stereochemistry. van't Hoof made cardboard cutout models, and distributed them widely, in a (successful) attempt to lend credence to his theory. These models were similar to existing chemical models that were in use at time, but van't Hoff's innovation was to treat their three dimensional structure as representing the internal layout of molecules. This was a subtle move, in terms of promoting the reception of his chemical ideas, as use of these types of models was already entrenched and the shift to a new theory was not as dramatic as it would have been if argued for in the abstract. Toon takes this historical episode to show that, by guiding the imaginations of scientists, a prop can enable different scientists to better engage with novel ideas, communicate about them and explore their consequences. I cannot assess the historical significance of the van't Hoff models. But the idea that they served as crutches for the scientific imagination is appealing, on the face of it. However, while the case of early stereochemistry fits well with Toon's view, it might fit alternative views too, such as an indirect fictions account. Furthermore, even non-fiction based accounts can make room for the role of the imagination in modeling (Weisberg 2013, Chapter 4). So it is not clear that this discussion lends specific support to Toon's direct fictions account, relative to philosophical alternatives.

Chapter 5 also deals with models in organic chemistry, but in a different way. Toon describes some experimental work he has done, concerning the use of molecular models. By looking at transcripts from sessions in which a teacher trains students in the use of ball-and-stick models, he argues that imaginative engagement with models is key. The ball-and-stick models are treated, by both the teacher and the students, as if they were molecules themselves. As Walton would put it, they serve as *reflective* props, prescribing imaginings about themselves. Toon compares this with a similar set up in which instead of ball-and-stick models, the teacher relies on computer models. There, he claims, the computer serves as a prop, but not as a reflective one. This study isn't meant to provide empirical evidence for Toon's view (it is not extensive enough for that purpose anyway). Rather, the point seems to be that one can use the make-believe theory to illuminate the practice, highlighting its reliance on imaginative engagement. Toon's discussion bears this out, although it is noteworthy that the experiment was run in a teacher-student setting. Insights concerning the role of models in pedagogy might not generalize to research contexts.

Let me make a couple of brief comments on these two chapters before moving to a more general concluding remark. First, both the discussion of van 't Hoff and the experiments with ball-and-stick models, involve actual physical models, not equations or graphs. This is an odd choice, in some ways, because physical models would seem most amenable to an indirect view. After all, the indirect view treats

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non-physical models on the model of physical ones—as standalone objects with a reality that is distinct from their targets.[3] So it would have served Toon's aims better to look at the role of the imagination in mathematical or graphical cases. Second, throughout the book Toon appears to use 'imagination' as denoting a propositional attitude. He does not state this explicitly, but that is how the term is understood by Walton, and the reliance on the make-believe theory presupposes it. However, the discussion of van't Hoff and of ball-and-stick models appears to regard the imagination, at least to a significant extent, in experiential or phenomenological terms—as involving a "seeing in the mind's eye" or some such. These uses do not necessarily conflict. A propositional attitude may consists of or be accompanied by a visual experience. But the force of the make-believe view comes from treating fiction in terms of a distinctive propositional attitude—different from belief (which is truth-directed) yet compatible with it. It would better serve Toon's account if he showed more clearly that the chemical models he discusses guide users in forming distinctive propositional attitudes, and not merely that they prompt experiential states.

How can fictional bear on the world?

In closing I will say a few words about a topic that is almost entirely missing from the book, but which is both important in itself and may affect one's attitude towards Toon's account. The topic is the epistemological role of models—how models allow scientists to learn about the world. Toon makes a few scattered remarks that suggest that he think models do indeed play an important epistemological role. But he says next to nothing about what that role is. To clarify: the issue isn't whether and how models say something about the world. That is covered by Toon under the heading of representation. A model represents some bit of the world, for Toon, insofar as it indicates what we ought to imagine about that bit of the world. This supplies an answer to the question: what does the model say? But there is a further, perhaps more crucial question: how does the model teach us something about the world? In particular: How can we gain knowledge from playing games of make-believe?

Presumably, Toon would answer this question by appealing to principles of generation. These, recall, are the rules that govern games of make-believe, determining what is fictional in a game and what is not. For a game to play an epistemic role, its principles of generation must, in some sense, mirror the structure of the relevant bit of the world. If the Lotka-Volterra model (i.e. game) is to tell us how real fisheries behave, then the principles that govern its articulation and development must somehow track the realities of real-world fisheries. Insofar as such mirroring holds, we would be justified in treating claims made within the Lotka-Volterra game as informative of real-world fisheries. But what are the relevant principles, and how do they mirror the real world? Walton, in his original

3FL01 [3] It is no coincidence that Weisberg, one of the leading advocates of the indirect view, begins his book
3FL02 with a detailed analogy between a hydraulic Model of the San Francisco Bay and the Lotka-Volterra
3FL03 equations. The analogy motivates and informs his treatment of mathematical models as objects of sorts.

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book, discusses several examples of principles of generation. But none of them seems suitable in the case of models. Are there parallel principles that govern modeling? I suspect that Toon would deny that there are general principles of generation governing models, and prefer a view according to which they vary from one scientific context to another. Perhaps so, but this marks a substantial difference between the case of scientific models and artistic fiction. In art, principles of generation may vary a lot, and may often not be explicit or even well-defined. Not only is that not a bug, it is a feature of sorts: part of what is distinctive of our experience of art is its imaginative open-endedness. But art isn't typically a means of gaining knowledge—at least not specific, robust, empirically relevant knowledge. Artistic fiction can tolerate all sorts of strange happenings, even self-contradictory ones. Not so, for the most part, in science. So some account of the relevant principles of generation would be good, to indicate how scientific games of make-believe are constrained, relative to those of fiction. Even more importantly, one wonders what Toon would say about the kind of relationship that models bear to the world. On an indirect account, model-based knowledge is grounded in similarity. The model is compared to the target, and the resemblance (if any) between them licenses conclusions about the target. In Toon's view, such a picture of doesn't seem possible, because the model isn't an object, and so cannot be compared to the target. But Toon does not indicate what alternative view of model-world relations he has in mind.

One wonders whether such an account can be given in a way that preserves the attractiveness of the make-believe view. On some ways of developing this aspect of the story, there is a "danger" of tying principles of generation very closely to mathematical reasoning, to counterfactuals, or to other philosophical ideas that the make believe view appears designed, in some measure, to steer us away from. Either way, saying more about principles of generation and about the epistemic bearing of models would be an important next step, extending and reinforcing Toon's fine contribution to the philosophy of modeling.

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