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Models as make-believe

Often, in order to explain or predict the behaviour of a system, scientists must first model it. Modelling a system usually involves making assumptions that are false of that system. Planets are not perfect spheres, molecules are not billiard balls and the nucleus is not a liquid drop. This characteristic feature of scientific modelling poses a philosophical problem. The various descriptions and theoretical laws that scientists write down when they model a system are false, and are acknowledged to be so. And yet it seems that scientists do represent a system when they model it. How are we to understand this form of representation?

According to the prevailing view, which I shall call the *non-linguistic object view* of models, the false descriptions and theoretical laws that the scientist writes down do not represent the world directly. Instead, they define an abstract object. It is this object that is the model and it, in turn, represents the system. This view seems to be supported by much ordinary talk about models. But it also leaves us with a significant problem. For we now require an account of the non-linguistic representation relation that is purported to exist between model and system.

This paper proposes an alternative approach to understanding scientific modelling. To do so, it draws upon an account of representation advanced in the philosophy of art. This is Kendall Walton's 'make-believe' theory.[1] A number of authors have described models as 'fictions'. In *How the Laws of Physics Lie*, for example, Nancy Cartwright claims that 'a model is a work of fiction', and compares the task of constructing a model to that of staging a historical drama.[2] This paper will take the comparison between models and works of fiction seriously and show how Walton's theory may be used to develop an account of what models are and how they represent.

According to the account I shall outline in this paper, the false descriptions and theoretical laws that scientists write down when they model a system are not definitions of an abstract

[1] Walton's theory has recently been used to provide an account of scientific representation by Mary Leng (Leng (forthcoming)). While I focus on scientific modelling, Leng is primarily concerned with the status of mathematical entities invoked by scientific theories. Perhaps as a result of this, my use of Walton's theory is somewhat different to Leng's. The suggestion that Walton's theory may be applied in the context of scientific modelling has been made by Anouk Barberousse (Barberousse (2006)).
[2] Cartwright (1983), p153

object. Instead, like the words of a novel or the brushstrokes of a painting, they are prescriptions to imagine. What scientists do when they model a system, I shall argue, is to ask us to imagine that the assumptions they make are true of that system. Like the non-linguistic object view, this account will allow us to make sense of ordinary talk about models. But it will not require us to postulate any abstract objects of which scientists' modelling assumptions are true. And as a result, it will not saddle us with the task of understanding how such objects represent the world.

The structure of the paper is as follows. Section I will set out the non-linguistic object view of models. Section II will then provide a brief introduction to Walton's theory of representation. In Section III, I shall show how Walton's theory may be used to develop an alternative account of scientific models.

I The non-linguistic object view of models

Suppose we are interested in predicting the motion of a bob bouncing on the end of a spring. One way to do this would be to model the bob as a simple harmonic oscillator. With Hooke's law in mind we might write down Newton's Second Law for a mass *m* subject to a linear restoring force:

$$m\,d^2x/dt^2 = -kx$$

where *k* is the 'spring constant' and *x* is the displacement from the 'equilibrium position'. Inputting the mass of the bob and the value of the spring constant, we could then solve our equation of motion to give the position of the bob at any given time after its release. We could also calculate that the period of oscillation of the bob, *T*, is given by the formula $T = 2\pi\sqrt{m/k}$. And our predictions may well be rather accurate.

If pressed, however, we would readily admit that the equation we have written down is not, strictly speaking, true of the bouncing bob. By writing the Second Law in the way that we did we assumed, for instance, that no air resistance acts on the bob. We are aware that our assumption is false: the bob is not bouncing in a vacuum. We also assumed that the spring exerts a linear restoring force on the bob. Indeed, we make many such assumptions when we model the bouncing spring: we take the bob to be a point mass *m* subject only to a uniform gravitational field and a linear restoring force exerted by a massless frictionless spring with spring constant *k* attached to a rigid surface. This is what Cartwright calls a 'prepared description' of the bouncing spring system.[3] By describing the system in this way we are able to apply our equation of motion and calculate predictions for the bob's behaviour. But we are aware that this description is false, and that a full or 'unprepared' description of the system would make reference to the air resistance on the bob, the mass of the spring, and so on. This is a characteristic feature of scientific modelling. As Cartwright puts it, 'our prepared descriptions lie'.[4]

And yet it seems that when we model the bouncing spring we do *represent* it, in some sense. Intuitively, we might say that we represent it *as* a simple harmonic oscillator. Moreover, this may even be a very good representation, capable of yielding accurate predictions of the bob's behaviour. How are we to understand this form of representation? And how are we to

[3] Cartwright (1983)
[4] Cartwright (1983), p139

understand our prepared description and equation of motion? Despite Cartwright's terminology, it seems we cannot regard them as descriptions of the bouncing spring system. As such they are false, and are known to be so. If we had wanted to provide a description of the bouncing spring, we would have mentioned the air resistance on the bob, the mass of the spring, and so on.

The non-linguistic object view of models proposes that we understand representation in modelling as occurring in two stages. First, prepared descriptions and theoretical laws define abstract objects (models). Next, these objects represent the system being modelled. This account allows us to make sense of our prepared description and equation of motion: these are not descriptions of the bouncing spring, but definitions of our model. The model is not a linguistic entity made up of our prepared description and equation of motion; it is some form of non-linguistic abstract object of which they are true by definition. This view fits well with much ordinary talk about models. As Roman Frigg observes,

> 'We say that the model of the solar system consists of spheres orbiting around a big mass, that the population in the model is isolated from its environment, or that the force connecting two beads in a chain is harmonic. But these statements are sheer nonsense when we take models to be descriptions.'[5]

Talk about modelling often takes as its exemplar the use of actual, material models. If an engineer wishes to learn about the properties of a bridge, she might first construct a scale model of it. By finding out about the properties of the model she hopes to learn something about the properties of the bridge itself. Cases of theoretical modelling, such as our model of the bouncing spring, are often discussed in a similar way. What we do when we model the bouncing spring, we might say, is to construct a simplified and idealised version of it. We then investigate the behaviour of this idealised bouncing spring in order to learn about the more complex behaviour of the spring itself. But, of course, we did not construct a simplified version of the spring as the engineer constructs a scale model of the bridge. Indeed, we could not do so: there are no point masses or massless springs. The non-linguistic object view offers to make sense of this common way of talking about theoretical modelling by providing us with an analogue of the engineer's scale model: a non-linguistic abstract object. On this view, just as the engineer investigates the properties of the scale model, so we investigate the properties of the abstract simple harmonic oscillator that we define.

[5] Frigg (2003), 'What are Scientific Models?', p12

Perhaps the most prominent proponent of the non-linguistic object view is Ronald Giere.[6] But this conception of models is found in much philosophical work on modelling. Often, it is adopted implicitly, or appears alongside conflicting views. For example, although Cartwright sometimes suggests that she thinks of models as descriptions, she also writes that 'fundamental laws do not govern objects in reality; they govern only objects in models'.[7] The popularity of the non-linguistic object view is perhaps unsurprising. As we have seen, it appears to be supported by much commonsense talk about models, and offers a way to make sense of scientists' prepared descriptions and theoretical laws. However, by interpreting these not as statements about the world, but as definitions of abstract entities, the non-linguistic object view creates a new semantic problem. For we must now give an account of the relation between these entities and the systems they model. This problem, often referred to as 'the problem of scientific representation', is the subject of a burgeoning literature in the philosophy of science.[8] A number of different accounts have been offered within this literature, many of which look to work on other forms of non-linguistic representation, such as pictorial representation. But all face serious difficulties, and the question of how models represent on the non-linguistic object view remains very much open.

[6] See, in particular, Giere (1988) and (1999).
[7] Cartwright (1983), p18
[8] For example, see Callender and Cohen (2006), French (2003), Frigg (2003), Giere (1999b) and (2004), Hughes (1997) and Suarez (1999), (2003) and (2004).

II Walton's theory: representation and make-believe

According to Walton, representations function as props in games of make-believe. Suppose that some children play a game in the woods in which they imagine tree stumps to be bears. In Walton's terminology, in this game the tree stumps are *props* and the convention that the children establish by their agreement that stumps 'count as' bears is a *principle of generation*. Together, props and principles of generation make propositions *fictional*. To say that a proposition is fictional, on Walton's theory, is to say that there is a prescription to imagine it. (A *fictional truth* is simply the fact that a certain proposition is fictional.) Thus, given the rule that stumps 'count as' bears, if a participant in the game comes across a stump in a thicket, they are to imagine that there is a bear there. The presence of the stump, together with the principle of generation, makes it fictional that a bear is in the thicket.

What is fictional in a game of make-believe need not be the same as what is imagined. A stump which remains hidden under a pile of leaves still makes it fictional that a bear lurks there, even if this is never imagined by anyone playing the game. An oddly shaped stump might prompt one of the participants to imagine a wolf and not a bear, but unless the game is changed the proposition that there is a wolf before them is only imagined, not fictional. Fictional truths therefore possess a certain kind of 'objectivity'. Participants can be unaware of fictional truths and mistaken about them. Finding out what is fictional may be very difficult: in order to find out whether it is fictional that a bear is hiding under some leaves, the children must actually dig down and look. Imagining (or thinking or hoping) that there is a bear there does not make it fictional that there is. What is fictional in a game of make-believe depends only on the props of the game and the principles of generation in effect.

Principles of generation are conditional rules; they prescribe what is to be imagined, given the state of the relevant props. The principle that wherever there is a stump, fictionally, there is a bear, was established by participants in the game by explicit stipulation. But Walton's theory does not demand that principles of generation be established in this way, nor that they be explicitly formulated. It may well be that, in the game we are considering, if the stump in the thicket is taller than the stump under the leaves, then, fictionally, the bear in the thicket is taller than the bear hiding in the leaves. This is not a principle of generation that was explicitly agreed upon at the start of the game, but it may nevertheless be one that the participants implicitly take to be in effect.

The stumps in the children's game are not representations, however. A *representation*, in Walton's sense, is not something that merely happens to be used as a prop in a game of make-believe; it is something of which it is the function to serve as such. Whether it is the function of a given object to serve as a prop depends upon social context. It is not the function of stumps to serve as props in our society, even though they may be so used. Nevertheless, there might be a society for which this was their function, and for this society stumps would be representations. *Authorised* games are those in which it is the function of a representation to be used as a prop. Of course, a representation might be used as a prop in a different game entirely (a child might use a copy of *War and Peace* as an 'island' in a game of toy soldiers); these are *unofficial* games of make-believe.

For Walton, then, representations 'are things possessing the social function of serving as props in games of make-believe'.[9] As he uses the terms, 'representation' and 'work of fiction' are interchangeable (except that, as we have seen, representations need not be artefacts). But it is important to recognise that fiction, in Walton's sense, is not opposed to truth or 'reality'. The propositions that a representation makes fictional may be about actual objects, and they may be true: it is fictional in *War and Peace* that Napoleon invaded Russia in 1812. Works of non-fiction, such as most history books or newspaper articles, are not 'representations' for Walton because their function is not to prescribe imaginings, but to assert certain propositions as true. Works of fiction may still be used to make assertions, however: in writing *War and Peace*, as well as making it fictional that Napoleon invaded Russia, Tolstoy may also have been claiming that he did. The crucial distinction between fiction and non-fiction, on Walton's account, consists not in whether what a work says is true, or whether the author asserts it to be true, but in whether the work functions as a prop in games of make-believe. *War and Peace* is fictional, while a contemporary newspaper reporting the French invasion is not, since it 'was *by means* of making it fictional […] that Napoleon invaded Russia that Tolstoy asserted that this event actually did occur.'[10]

Something is an *object* of a representation on Walton's theory if there are propositions about it which the representation makes fictional. Napoleon is an object of *War and Peace*, as is St. Petersburg. Salisbury Cathedral is an object of Constable's *Salisbury Cathedral from the Meadows*. Some representations have no objects. One may have 'pictures of unicorns' and 'stories about dragons', though there are no unicorns or dragons. Some representations prescribe imaginings about themselves, like the stumps in the children's game, and are thus their own objects. A doll makes it fictional of itself that it is a baby. It is fictional of the first

[9] Walton (1990), p69
[10] ibid., p79. Emphasis author's own.

chapter of Bram Stoker's *Dracula* that it is an excerpt from Jonathan Harker's journal. *Representation-as* is a matter of what propositions about an object a representation makes fictional. *War and Peace* represents Napoleon as invading Russia. In this respect it corresponds to Napoleon. If a representation corresponds completely with its object then it *matches* it. But a work may represent something it does not match and match something it does not represent. It is fictional in *The War of the Worlds* that London is attacked by Martians in the late nineteenth century. The novel represents London, but does not match it. Conversely, a portrait of John may match his twin brother David, but it represents John and not David.

It is fictional in *The War of the Worlds* that Martians attack London. Sometimes, we might express this by saying that it is *true* that Martians attack London 'in the world of *The War of the Worlds*' or 'in a fictional world', or just 'in fiction'. Walton warns against this. In his theory, for a proposition to be fictional does not mean that it is true is some fictional world. Fictionality is not a species of truth. Nevertheless, we may still say that it is fictional that Martians attack London 'in the world of *The War of the Worlds*'. Another way of expressing this is to say that it is *The War of the Worlds*-fictional that Martians attack London.

The final aspect of Walton's theory that we need in place is the distinction between *primary* and *implied* fictional truths. *Primary* fictional truths are those that are generated *directly* by the props together with the relevant principles of generation. The presence of the stump in the clearing, together with the principle that stumps count as bears, generates the fictional truth that a bear is in the clearing. *Implied* fictional truths are generated *indirectly* by other fictional truths. *Dracula* makes it fictional that a large dog jumps off a deserted boat that sails into Whitby harbour. Given what we have read so far, we realise that this dog is none other than the Count in animal form. Even though the text does not directly say so, then, it is fictional that Dracula jumped off a deserted boat that sails into Whitby harbour. The fact that this is fictional is an implied fictional truth: it is fictional that Dracula jumped off the ship because it is fictional that a large dog jumped off the ship.

With this outline Walton's theory in place, let us now examine how it may help us to understand scientific models.

III Models as make-believe

I propose that we regard models as *representations* in Walton's sense. According to the account I shall set out in this section, our model of the bouncing spring is not some non-linguistic abstract object. It is what we write down: our prepared description and equation of motion. But the non-linguistic object view is right to insist that what we write is not a description of the system we are modelling. In fact, our 'prepared description' is not a description at all, either of the bouncing bob or of any abstract object. Instead, I shall argue that, just like *Dracula* or *The War of the Worlds*, the principal function of scientific models is not to assert certain propositions as true, but to make certain propositions fictional. Our model makes it fictional that the bob is a point mass, subject to a linear restoring force and a uniform gravitational field, and so on. The bob is an *object* of our model; our model *represents* it *as* a point mass, subject to a linear restoring force and a uniform gravitational field.

This account allows us to make sense of our prepared description and equation of motion. As we saw in section I, we cannot regard these as descriptions of the bouncing spring. We are well aware that the bob is not a point mass and when we formulate our model we do not claim that it is. In face of this problem, the non-linguistic object view suggests that we take prepared descriptions and theoretical laws to be statements not about the world, but about abstract objects. And yet surely our prepared description is about the bouncing spring? Intuitively, I think, we take the 'bob' and 'spring' of our prepared description to refer not to any abstract objects, but to the actual bob and spring in front of us. I suggest that, rather than postulating some object that our prepared description and equation of motion may be taken to describe, we should cease to think of them as descriptions at all. Instead, we ought to regard them as a work of fiction.

Consider the following passage from *The War of the Worlds*:

> 'The dome of St. Paul's was dark against the sunrise, and injured, I saw for the first time, by a huge gaping cavity on its western side.'[11]

Clearly, this is not a description of St Paul's Cathedral. When Wells wrote this he was not claiming that there really *was* a hole in the side of St Paul's. Nevertheless, the passage is still about St Paul's itself, and not some abstract or fictional St Paul's. It still represents St Paul's, just as the rest of the novel represents London, or *War and Peace* represents Napoleon.

[11] Wells (2005), p170

According to Walton, works of fiction represent their objects by prescribing imaginings about them. This passage represents St Paul's because it requires the reader to imagine certain things of St Paul's, namely that it has a large hole in its dome. I propose that we understand our prepared description and equation of motion in the same way. These do not describe the bouncing spring, but they do represent it. They represent the spring by prescribing imaginings about it. Just as the passage asks readers of *The War of the Worlds* to imagine that St Paul's was damaged by Martians, so our prepared description and equation of motion ask others to imagine that the bob is a point mass, subject to a uniform gravitational field, and so on.

On this account, then, models are *fictions*, in Walton's sense. Our model makes it fictional that the bob is a point mass and that it is subject to a uniform gravitational field. It also makes it fictional that the bob's motion satisfies our equation $m\,d^2x/dt^2 = -kx$. These propositions are all false of the bouncing spring system; our model represents the system, but does not match it. However, as we have seen, on Walton's theory, a proposition can be fictional and still be true: *War and Peace* makes it fictional that Napoleon invaded Russia in 1812. Similarly, our model makes it fictional that the bob has mass *m*, but it is also true that it does (if we have measured it correctly). Thus, it is important to note that the account that I am proposing does not commit us to a *fictionalist* position regarding scientific models. Fictionalism is an anti-realist position which argues that a scientific theory may be reliable without being true and without the entities it invokes existing. This claim is expressed by saying that scientific theories, or the entities they postulate, are useful 'fictions'; as Arthur Fine puts it, 'when truth or existence is lacking we are dealing with a fiction'.[12] As I understand it, my own conception of models is perfectly compatible with a fictionalist position. But it does not entail fictionalism. On my account, all of the propositions a model makes fictional might be true of the system it represents (the model might match the system as well as represent it), and models need not invoke non-actual entities like frictionless planes or point masses.

Moreover, as we saw in section II, not only does Walton's account allow that works of fiction may prescribe truths about their objects, it also allows that they may make assertions about them. When he wrote *War and Peace*, as well as making it fictional that Napoleon invaded Russia in 1812, Tolstoy may have been claiming that he did. He asserted this by making it fictional. Similarly, although the primary function of our model is not to describe the bouncing spring, but to prescribe imaginings about it, we may nevertheless make certain

[12] Fine (1998)

assertions about the system when we model it. We may, for instance, be claiming that the bob has mass *m*. We may also be claiming that the system consists of a bob and a spring, that the bob is attached to the spring and that it is released from a certain displacement, and so on. What is asserted through a work of fiction need not always be, and is often not, what its words explicitly express. If a child is told Aesop's fable of the tortoise and the hare, it is usually to get across a point about steadfastness and patience, not merely to state something about tortoises or hares. Similarly, it may be that we make more interesting assertions when we model the bouncing spring. For example, someone who holds what Cartwright calls a 'covering-law' view of explanation might argue that when we use our model to explain the spring's motion, we implicitly claim that it obeys the Second Law in some form, even though we do not claim truth for our particular formulation of the Law, $m\,d^2x/dt^2 = -kx$.[13]

The principal function of our model, however, is to generate fictional truths. Our model makes it fictional that the bob is attached to a spring and that its motion satisfies the equation $m\,d^2x/dt^2 = -kx$, and so on. These fictional truths in turn imply other fictional truths. They imply, for example, that it is fictional that the bob oscillates sinusoidally and that its period of oscillation is $T = 2\pi\sqrt{m/k}$. All of these propositions are fictional in the world of our model; they are *bouncing spring model*-fictional. However, as we have seen, on Walton's theory, to say a certain proposition is fictional is not to say that it is true in some fictional world; it is merely to say that there is a prescription to imagine it. To say that it is fictional that London is attacked by Martians in *The War of the Worlds* is not to say that there is some fictional realm in which it is true that Martians attack London. Similarly, to say that it is *bouncing spring model*-fictional that the bob is attached to a spring and that its motion satisfies the equation $m\,d^2x/dt^2 = -kx$, or that these propositions are fictional in the world of our model, is not to say that there is some non-linguistic abstract entity of which these propositions are true.

On the non-linguistic object view, learning about a model is a matter of discovering facts about an abstract object. On the account that I am proposing, learning about models is a matter of discovering fictional truths; it is a matter of discovering what is fictional in the world of our model. As we saw in the case of the children's game in the woods, what is fictional in a game of make-believe can be unknown to us: the child may not know that it is fictional that a bear is hiding under a pile of leaves. Similarly, we may not know when we formulate our model that it is fictional that the bob oscillates sinusoidally or that its period of

[13] See Cartwright (1983), Essay 2.

oscillation is $T = 2\pi\sqrt{m/k}$. The reason for our ignorance is not the same as in the child's case, however. The child is unaware that, fictionally, there is a bear in the leaves because she is unaware that there is a stump there. Our position is more like that of the reader of *Dracula* who fails to realise that the dog who jumps off the boat in Whitby harbour is the Count. We are quite aware of the state of our props, and of many of the fictional truths these props generate. What we don't know are many other fictional truths that these fictional truths imply.

So, unlike the non-linguistic object view, the account of models that I am proposing does not require us to postulate abstract objects of which scientists' modelling assumptions are true. And as a result, it does not present us with the task of understanding how such objects represent the world. On my account, the prepared descriptions and theoretical laws that scientists write down when they model systems represent those systems directly, not through an intermediate realm of non-linguistic abstract objects. But where does this leave ordinary talk about models? As we saw in section I, the non-linguistic object view seems to find support here. We might say that 'the model of the solar system consists of spheres orbiting around a big mass', or perhaps, 'our model of the bouncing spring is a point mass subject to a linear restoring force'. Another example of this talk about models might be the 'theoretical hypotheses' that Giere takes to be crucial to the way scientists use models to represent the world.[14] These are statements of the form, 'the system is similar to the model in certain respects and degrees'. Theoretical hypotheses appear to compare two objects, model and system. Even if we do not agree with Giere that they are central to the way that models are used to represent the world, it seems that we do make these statements. How can my account understand such talk?

It is interesting to note that we often talk about works of fiction in a similar way. As we saw in section II, we commonly speak as if novels or paintings create fictional realms in which what they ask us to imagine is true. Rather than saying that it is fictional in *The War of the Worlds* that Martians attack London, we might say that it is true that Martians attack London 'in the world of the novel', or 'in fiction'. Or we might even say simply that Martians attack London. And when we talk about the way in which a work of fiction represents its object we often speak as if we are comparing this fictional realm with the world. We say that someone is 'just like the man in the story'. While standing in front of Jacques-Louis David's *Napoleon Crossing the Saint Bernard*, we might remark that 'David's Napoleon is taller than the real Napoleon'. Along with his account of representation, Walton provides an analysis of

[14] See Giere (1988), (1999) and (2004).

discourse about fiction that attempts to avoid any commitment to fictional entities. Of course, the ontological problems posed by fictional entities are longstanding ones and I cannot discuss them fully here. But a brief outline of Walton's analysis will show how we might make sense of ordinary talk about models without taking such talk literally and conceiving of models as non-linguistic abstract objects.

Walton's analysis rests on the idea that we participate verbally in games of make-believe. Suppose that, while reading *Dracula*, we were to say 'Dracula sucks blood'. We think that we assert something true when we say this. But this appears to require us to grant that Count Dracula exists, in some sense. According to Walton, we may avoid this problem by understanding our utterance as an act of pretence. When we say 'Dracula sucks blood' we pretend to refer to someone called 'Dracula' and we pretend to claim that they suck blood. It is fictional that we do so. But since our reference is only fictional, and not actual, there is no need to postulate any entity to which we refer. We are asserting something when we say 'Dracula sucks blood', but what we assert is not what our words appear to express. What we do when we say 'Dracula sucks blood' is to indicate that pretending in the way that we do is appropriate. It is appropriate because when we pretend in this way, fictionally, we speak the truth. According to Walton, then, what we actually assert when we say 'Dracula sucks blood' is that to pretend in the way that we do is, fictionally, to speak the truth in games authorised for Bram Stoker's novel. And whether *this* assertion is true or not depends only upon the novel and the relevant principles of generation in games authorised for it, and not upon the existence of any entity called 'Dracula'.

When we say 'Dracula sucks blood' we participate in a game of make-believe that is authorised for the novel *Dracula*.[15] However, many statements we make when we discuss works of fiction are not of this sort. For example, we might say 'Bram Stoker created Count Dracula in 1897'. It is not *Dracula*-fictional that Bram Stoker created Count Dracula. However, Walton argues that we may understand such statements in the same way. The only difference is that they involve *unofficial*, rather than authorised, games. On Walton's account, much of our talk about works of fiction is to be understood as invoking unofficial games of make-believe. When we say 'Bram Stoker created Count Dracula in 1897', we suggest a rather common unofficial game, in which to write a novel that makes it fictional that a certain character exists is, fictionally, to create that character. Or again, when we remark

[15] In fact, Walton's theory does not demand that the speaker actually engage in pretence in order to make an assertion. When we say 'Dracula sucks blood', it may be that we merely specify the relevant kind of pretence – the kind that is engaged in when we say 'Dracula sucks blood' in pretence - without exemplifying it.

that ‘David’s Napoleon is taller than the real Napoleon’, we invoke a game in which it is fictional that there exists both Napoleon and someone called ‘David’s Napoleon’ who, fictionally, has all the properties that *Napoleon Crossing the Saint Bernard* attributes to Napoleon.

Sometimes, when we make statements that invoke unofficial games, what we actually assert parallels the assertion we make when we say ‘Dracula sucks blood’: we assert that to pretend as we do in the relevant unofficial game is, fictionally, to speak the truth. Often, however, it is rather implausible to regard our assertion in this way. For example, when we say ‘Bram Stoker created Count Dracula in 1897’, we do not appear to make a claim about pretence or make-believe. In fact, the claim we make would seem to be rather straightforward: we claim that Bram Stoker wrote the novel *Dracula* in 1897. In such cases, we may regard ourselves as asserting that the conditions responsible for the fact that, fictionally, we speak the truth are in place. It is because Bram Stoker wrote the novel *Dracula* in 1897 that, fictionally, we speak the truth in our unofficial game. We make an assertion about when Stoker wrote the novel by indicating how, fictionally, to speak the truth in that game. Similarly, when we say ‘David’s Napoleon is taller than the real Napoleon’, we do not appear to make an assertion about an unofficial game of make-believe. Instead, we compare what is fictional in David’s portrait with the facts about Napoleon. Specifically, we assert that there is a height such that Napoleon did not reach it, but that it is fictional in *Napoleon Crossing the Saint Bernard* that he does. It is because this is the case that, fictionally, we speak the truth in the unofficial game that we invoke. Invoking the game provides us with a simpler, and perhaps slightly more interesting, way of making this assertion.

I think Walton’s analysis may also be applied to commonsense talk about scientific models. Consider Giere’s theoretical hypotheses. These appear to compare two objects, model and system. But I suggest that we interpret them in the same way as our statement about David’s portrait of Napoleon. Suppose we were to form the hypothesis that ‘the period of oscillation of the bob in the model is within 10% of the period of the bob in the system’. When we say this we suggest a game in which it is fictional that there exists both the bob and an entity called ‘the model bob’ which, fictionally, has all the properties attributed to the bob by the model. In doing so we avail ourselves of a convenient way of making assertions about the accuracy of our model: by indicating how, fictionally, to speak the truth in this game of make-believe. When we say ‘the period of oscillation of the bob in the model is within 10% of the period of the bob in the system’ we indicate how, fictionally, to speak truly in our unofficial game, and in doing so we assert that the conditions responsible for our fictionally speaking

truly are in place: that is, we assert that the period of oscillation of the bob has some value T_0 and that it is fictional in our model that the bob oscillates with some period T_1, where the value of T_1 is within 10% of the value of T_0. Understood in this way, theoretical hypotheses do not require us to conceive of models as non-linguistic abstract objects, any more than our remark about David's portrait requires us to postulate a second, taller, Napoleon.

Conclusion

The prepared descriptions and theoretical laws that scientists formulate when they model a system are usually false and known to be so. The dominant view tries to make sense of this by regarding them as definitions of non-linguistic abstract entities. But this merely relocates the problem, since we must say how these abstract entities represent the world. This paper has sketched out an alternative account of scientific modelling. I have argued that we may regard scientists' prepared descriptions and theoretical laws as works of fiction, which represent the world directly by prescribing imaginings about it.

Many points remain to be addressed if this account is to be developed into a fully-fledged theory of scientific modelling. In this paper I have restricted my attention to cases of theoretical modelling, such as our model of the bouncing spring. But sometimes scientists draw diagrams when they model a system or construct actual, material models, such as the engineer's scale model of a bridge or chemists' 'ball and stick' models of molecules. Non-linguistic entities may also be used as props on Walton's theory: the stumps in the children's game and Constable's *Salisbury Cathedral from the Meadows* are cases in point. But I have not attempted to show how my account might be extended to cover such models in this paper. I have also said little about the principles of generation by which models generate fictional truths about their objects or about the various assertions we might make when we model a system. And I have been unable to consider the question of how scientific models might differ from other works of fiction, such as novels or paintings, as well as the normative question of what makes a scientific model a good one. Recent cases studies demonstrating the remarkable variety of models in the sciences suggest these questions are unlikely to have simple answers.

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