van Fraassen, Bas C., *Scientific Representation: Paradoxes of Perspective*, Oxford: Clarendon Press, 2008, [remaining publication details].*

Bas van Fraassen's latest book is an extended inquiry into the workings of representation in the sciences. Although scientific representation has only become a topic so named in the philosophy of science over the last ten years or so, it can be seen as the development and continuation of the inquiries into theory structure and into the nature of models and modelling which have been amongst the central issues in the field for significantly longer. Given that van Fraassen was one of the progenitors of the semantic view of theory structure, and that the rise of the semantic view has been one source of the interest in models, it is thus hardly surprising that he should have something to say on the matter of representation. But this is a very rich book, with lots to say about lots of things; and there is lots to say about what van Fraassen says. Accordingly, what follows can only hope to give a sense of some of the main themes, and to pick out a few points for discussion. The book comes in four parts; I will attempt summaries of all four, but limit my critical comments to the first and third.

Part I lays out the central components of a general picture of representation, both in general and in science. Van Fraassen begins with a formula: all representation involves the use of an 'artifact' by an agent to represent [23]. (Note that even a 'found object' becomes an artifact when someone uses it to represent [24].) He then focusses in on a particular variety of representational act which he takes to be central to science: those which 'trade on selective resemblances' between the object used to represent and the thing represented [34]. Some time is spent stressing the presence and importance of unlikeness in this sort of representation, too, with special attention to the ways in which abstraction, scale models, and the use of mathematical objects as representations can introduce distortion.

There are two points at which one might hesitate here. First, one might question the generality of the starting formula. Amongst philosophers of science thinking about representation

---

* *Note to the reader*: This earlier version of the review is almost one and a half times the length of the published version. Some of the material contained in this version was simply cut; other parts were condensed in a way which resulted, inevitably, in some loss of nuance and qualification. But it should also be noted that my critique of van Fraassen's proposed dissolution of what he sees as the central problem for a structuralist account of scientific representation (pp. 5-7, below) is modified in one or two substantive ways in the published version.

with mathematical structures and concrete models, the claim that there is no representation without use is quite widely accepted by now (although not of course entirely uncontroversial). But can this thesis be generalised? Both propositions and thoughts provide potential counterexamples: on at least some standard ways of thinking about each, they do not come to represent by being used in a certain way by an agent. Van Fraassen does not discuss propositions, but he quite emphatically rules talk of mental representation out of court [2, 24]. Why? It is tempting to reply that it does not matter, on the grounds that these broader worries are irrelevant to understanding *scientific* representation; but that will not work if models are collections of propositions (which, in fact, I think at least some are); or if something like theoretical hypotheses in Giere's sense [1988: 80] are central to scientific representation, as van Fraassen seems to allow [309–10], and are propositions.

The second point of hesitation emerges when we note that the main kind of artifact scientists use to represent on van Fraassen's account is the mathematical object (or mathematical structure, if mathematical structures are not mathematical objects). For scientific representation to proceed in this way, however, there must actually be mathematical objects; and one might of course worry that such a commitment is in tension with the guiding empiricism of van Fraassen's thought (cf. [Rosen 1994: 164–9], for example). Van Fraassen has said that any acceptable philosophy of mathematics will have to legitimate the sort of talk about mathematical objects his own philosophical accounts require [2005: 97], and he appeals to this claim to underwrite a bracketing of such concerns. But what if, say, nominalism of some stripe is the right view of mathematics? A nominalist account might legitimate the sort of mathematical talk van Fraassen engages in, but if in doing so it insists on a paraphrasing away of all mathematical entities, then it will not really be true that scientists typically represent by using mathematical entities in certain ways; or, indeed, that they ever do.

The next significant turn comes in Chapter 3, where van Fraassen first places the notion of indexicality at the centre of his attention. The primary thesis here is one van Fraassen attributes to Kant, and it declares 'the *inevitable indexicality of application*' [80]: using a representation requires the user to supply some additional information not contained in the representation itself, and to supply it in indexical terms. The simplest examples involve maps: if I am to use a map of the museum to find my way around, I have to be able to point at a part of the map and

say ‘A-hah! So I’m *here*’ (cf. [79–80]). Van Fraassen allows that the information supplied by the user is information which *can* be presented in non-indexical terms, and which could appear on a map [79, 83] (though see [261]); nonetheless, I must present some information not included in the map in hand, and present it in indexical terms, if I am to use that map. And in this respect, he also insists, theories and models are exactly like maps. To use a theory, I have to be able to point at a part of it, so to speak, and say to myself ‘A-hah! Here’s the situation I’m in now’ or ‘This is the sort of system I have in front of me’. And it is important to note how widely van Fraassen means to apply the word ‘use’: we use a scientific representation (such as a theory or model) not only when we consult it for engineering purposes, say, or making weather forecasts, but also when we ‘test it or use it to explain something, or add to it through research’ [82].

As we will see, this idea that the use of representations introduces indexicality plays an important role later on. Given that, it is worth noting that there is reason to be nervous about exactly how the notion of indexicality is to be understood. In one place van Fraassen writes: ‘[a]mong [the class of indexical terms and phrases] I include demonstratives such as “this”, “those yonder”, as well as the more obvious “I”, “you”, “here”, “now”’ [86], and elsewhere he links indexicality to context-sensitivity [59]. This much is perhaps straightforward, but given that van Fraassen seems to take an act of self-location to guarantee the presence of indexicality, we find ourselves on unfamiliar ground when van Fraassen extends the notion of self-location in a rather striking way:

> Suppose I see letters on a piece of paper. If I take them to constitute a text in my own language, I am locating myself with respect to what I have before me—to be contrasted with taking them as a text in another language.
>
> [83]

In a similar vein, van Fraassen writes that ‘the mere understanding of the inscription as a text requires relating it to one’s own language . . . ’ [84]. So understanding an inscription requires an self-location, because it requires me to take the inscription as a text in my own language; and this brings indexicality onto the scene. Presumably, though, I can understand an inscription without *having the thought* that it is a text in my own language—consider a child who is learning

to read, but who has not yet acquired the concept of a language. If the claim is, nonetheless, that understanding an inscription involves my taking a certain attitude towards it, the 'A-hah! This is something I know to handle' attitude, and that indexicality is present for that reason, it becomes hard to see what sort of activity would *not* introduce indexicality into the proceedings—'A-hah! This [coffee machine] is the sort of object I know to operate', 'Oh dear! This sort of thing is entirely new to me', etc. There is clearly room to worry that the notion of indexicality has been stretched too thin at this point.

In Part II, van Fraassen looks at the roles of instrumentation, measurement, and experiment in the sciences. He argues in fascinating detail that instruments often seen as providing 'windows on an invisible world' can equally well be seen as 'engines of creation', creating new phenomena for theory to accommodate; in the case of the optical microscope, these new phenomena are images, belonging to the same ontological category as rainbows and reflections in water. He also argues that experiments standardly seen as discovering the value of some quantity, such as the charge on the electron, are better seen as playing a participatory role in theory construction. On both these fronts he can be seen as quite directly extending and buttressing constructive empiricism. Then his attention turns to measurement. He argues that measurement *is* representation, and that once we have managed to construct a 'stable representation' of the phenomena, measurement outcomes represent by 'trading on selective resemblances in just the way that perspectival picturing does' [91]. Measurement is, furthermore, indexical: the user of the measurement 'must express the outcome in a judgment of the form "that is how it is *from here*"' [92]. Van Fraassen also offers an account of when a physical interaction counts as a measurement, and, as part of all this, introduces Reichenbach's 'problem of coordination', the problem of understanding how bits of mathematics can come to be connected to the world in such a way that they manage to denote physical quantities.

The discussion of the problem of coordination sets the stage for the main thread of Part III, the part of the book which is likely to attract the most immediate attention. Here van Fraassen sets out a compelling history of structuralism about science, framing it as an attempt on the part of philosophers to assimilate the enormous intensification in the mathematisation of the sciences in the late nineteenth and twentieth centuries. He tells the story of a series of difficulties faced by various incarnations of structuralism, and of the attempts of such figures as

Russell, Weyl, and Carnap to grapple with them. These difficulties are presented as diverse manifestations of a single fundamental problem, a problem which van Fraassen aims to address in his own terms, as part of a defence of what he calls an 'empiricist structuralism'. This culminating part of the story centres on a response to Putnam's infamous 'model-theoretic argument' against metaphysical realism, which van Fraassen sees as hinging on the same fundamental difficulty for structuralism (though his aim, of course, is not to defend metaphysical realism). The key to defending structuralism, van Fraassen claims, is to heed the indexicality of representation [239].

The issues are subtle and complex; I will merely sketch them in simplified form and raise a few questions. But here is one way of coming at (one aspect of) the matter: According to van Fraassen's structuralism, much scientific representation centres on the use of mathematical structures as vehicles of representation; and there is nothing to such a structure that cannot be captured by relations of isomorphism. Thus if we ask 'What makes it the case that mathematical structure *S* represents concrete entity *X*?', it might seem that the answer could only appeal to relations of isomorphism between *S* and some structure constructed from the parts of *X*.[1] Provided that *X* has enough parts, however, we can always find relations between them which will yield a structure isomorphic to *S* (as Putnam points out, and as Newman pointed out to Russell). So *S* stands in the representation relation to almost everything; and that cannot be right.

One way out of this problem is to appeal to a distinction between natural and non-natural relations, and say that *S* represents *X* when there is an isomorphism between *S* and the structure we get by considering only the natural relations obtaining between the parts of *X*. This is at least the beginnings of a solution, but it raises van Fraassen's anti-metaphysical hackles. We can, van Fraassen argues, avoid postulating anything so burdensome as the distinction between natural and non-natural relations if only we attend to the indexicality of representations in use; at that point, he claims, the apparent difficulty for the structuralist evaporates.

Here is van Fraassen's dissolution of the problem as it arises in 'a concrete practical setting', one in which measurements on and observations of *X* have actually been made [246]:[2]

---

1. Or that some structure constructed from the parts of *X* can be embedded in *S*, or another formula appealing to some close cousin of isomorphism.

2. I confess I am not sure I understand how what he says at [247–50] about the problem as it arises in relation to

First, say that *S* represents *X* by embedding a data model (or surface model) of *X*—that is, a mathematical structure constructed from the outcomes of measurements and observations on *X*. This will inevitably provoke a follow-up question: 'But what makes it the case that the data model, *D*, represents *X*?'. The reply to this new question is that nothing internal to *D* itself makes that the case, and nor does any combination of two-place relations holding between *D* and *X*; instead, it is the fact that *D* was 'constructed on the basis of results gathered in a certain way, selected by specific criteria of relevance, on certain occasions, in a practical experimental or observational setting, designed for that purpose' [253]. That is, *D* represents *X* in virtue of the holding of certain three-place relations between *D*, *X*, and the agent(s) involved.

Indexicality, note, has yet to make an appearance; but there is a final step. Van Fraassen imagines someone—a 'metaphysician'—pestering the scientist with a further question: 'I see that *S* matches *D*, and that *D* is your representation of *X*, but does *S* fit *X* itself?' To this the scientist can rightly reply 'But as *D* is my representation of *X*, it would be pragmatically incoherent of me to say "*S* fits *D*, but does not fit *X*." So all I can do in response to your question is repeat that *S* fits *D*; *for me* there is no difference between fitting *D* and fitting *X*' (cf. [254–6]).[3] Now we do have indexicality in the picture, as part of a 'self-locating' by the scientist with respect to *D*—it is *her* representation of *X*.

As I have just reconstructed van Fraassen's dissolution, however, there has been a change of subject by the time indexicality arrives on the scene. Instead of grappling with the question of how a relation of representation comes to obtain between *S* and *X*, we are suddenly (in the last paragraph) asking whether *S* 'fits' *X*; that is, we have moved from representation *simpliciter* to accurate representation. So on this retelling, there is a question about whether indexicality plays any role in addressing the problem with which we began.

Perhaps, then, my retelling missed van Fraassen's intent; perhaps the topic is supposed to be accurate representation all along. (Or both: accurate representation requires representation, after all.) Van Fraassen puts the initial question—the 'most fundamental question' [240]—

---

phenomena 'not encountered in our practice' [246] is supposed to address the issue.

3. Compare this to a situation in which you state your beliefs about *Y*, and show that they cohere nicely with a certain theory, and you are then asked 'Yes, I see that the theory coheres nicely with your beliefs about *Y*, but does it cohere with the facts about *Y*?'

this way, however: '*How can an abstract entity, such as a mathematical structure, represent something that is not abstract*, something in nature?' [ibid.]. Thus if the topic is supposed to be accurate representation at the outset, that is not made explicit. And there are at least two clusters of questions which arise on this reading. First, surely *S* does not come to represent *X accurately* by embedding any old data model of *X*; surely it must embed an *accurate* data model of *X*. But then what makes a data model an accurate representation? Is the answer to that question supposed to be contained in a description of the history of *D*'s construction of the kind outlined in the quotation given above (from [253])? Secondly, if what we are being given here is an account of accurate representation, then do we not also need an account of how inaccurate representation works on van Fraassen's empiricist structuralism?

Perhaps there is another problem with my reconstruction, too, or instead: perhaps van Fraassen's 'How can . . . ?' question is not adequately paraphrased by my 'What makes it the case that . . . ?' After all, van Fraassen's picture is emphatically not one on which representation relations hold purely in virtue of the obtaining of two-place relations between vehicle and target. But then how exactly should we understand the 'How can . . . ?' question? (See also [33] here.)

There is, then, room for further elucidation of van Fraassen's response to what he sees as the fundamental problem facing structuralism. Until we engage in such further elucidation, I think it must remain an open question whether his response is successful; but I do want to urge further exploration of the intriguing ideas van Fraassen is presenting here.

In Part IV van Fraassen turns to the task of clarifying the sense in which science knowledge is objective. He does this in part as counterpoint to his repeated emphasis on the perspectival nature of various aspects of science, and his claims about the indexicality of science 'in use'. His approach is to discuss a series of completeness criteria to which philosophers have historically attempted to hold the sciences. Van Fraassen claims that the first three have fallen by the wayside (although he acknowledges that this is a disputed claim with respect to the third, Reichenbach's principle of the common cause), and then identifies a fourth which, he quite plausibly claims, still holds sway over the philosophical imagination. This he dubs the 'Appearance from Reality' criterion, and it is that science '*must explain how [the] appearances are produced in reality*' [281]. (Early in the book van Fraassen distinguishes appearances and phenomena. The ap-

pearances are the 'contents of observation or measurement outcomes' [8], whereas the phenomena are the observable entities, events, and processes which appear one way or another to us.) The terms 'explain' and 'produced' have to be uttered in sonorous tones to capture the intent of the Appearance from Reality criterion, however. It will not be enough, according to this completeness criterion, to be able merely to deduce or predict the appearances from the account of reality postulated by our scientific representations; what is intended, rather, is 'a connection of the order of explanation through necessity and/or causal mechanisms . . . ' [283]. Van Fraassen's main aim in this last part of the book is to persuade us that contemporary physics violates this constraint, and that it too should be rejected; the result will be a clearer vision of contemporary science and of the 'abstract structural forms' it employs in representing the world [267].

This is a full and complex work. It develops and synthesises various ideas van Fraassen has been presenting in article form in recent years, and contains much new material, too; it is sure to provide fertile ground for ongoing research. The treatment is subtle, nuanced, and interesting throughout, and though I have made no attempt to convey it, van Fraassen draws on a remarkable breadth of material from the histories of the physical sciences, mathematics, philosophy, and art. He handles a dense tangle of issues with deftness and originality, and the result is a book which makes for exciting and indispensable (if not always easy) reading for anyone with an interest in the philosophy of science.

Martin Thomson-Jones
Oberlin College

REFERENCES

Giere, R. N. 1988. *Explaining Science: A Cognitive Approach*, Chicago and London: The University of Chicago Press.

Rosen, G. 1994. What is Constructive Empiricism?, *Philosophical Studies* 74/2: 143–78.

van Fraassen, B. C. 2005. On Taking Stances: An interview with Bas van Fraassen, *The Harvard Review of Philosophy* 13/2: 86–102.