Book Review

Scientific Representation: Paradoxes of Perspective

Bas van Fraassen
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It probably goes without saying that the advent of a new book by Bas van Fraassen is a major event in the world of philosophy of science. Indeed, Scientific Representation does not disappoint. It's full of interesting and erudite discussions, and presents controversial arguments that philosophers of science will want to come to grips with.

There are two ways one could review a book like this. One could just go through the book, step by step, and highlight the key discussions and arguments. Or, one could look at the book through the lens of van Fraassen's previous work in philosophy of science, and focus on the things van Fraassen says that directly relate to his previous work. I'll take the latter approach. Van Fraassen is famous for promulgating a version of scientific anti-realism known as constructive empiricism: the doctrine that science aims to give us theories which are empirically adequate, and that acceptance of a theory involves as belief only that it is empirically adequate (van Fraassen 1980, p. 12). That was van Fraassen's characterization in *The Scientific Image* of how an aspiring empiricist like him should understand science. While van Fraassen is still a constructive empiricist, he has more to say about how an empiricist should understand science, and he does so in parts of Scientific Representation.

Before I focus my review on issues related to empiricism in science, a brief overview of the whole book is in order. The book is divided into four parts. In Part I, *Representation*, van Fraassen gives a high-level discussion of the nature of representation. He points out that representation can happen with physical or mathematical artifacts, and that distortion can sometimes be crucial to accurate representation. He also argues that there is an essential indexical element to representation.

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Part II, *Windows, Engines, and Measurement*, focuses on measuring. Van Fraassen argues that «measuring, just as well as theorizing, is representing. [...] measuring locates the target in a theoretically constructed logical space» (p. 2). Van Fraassen looks at measurement two ways. First, he does so from within the historical process, when measurement procedures are still being established. A crucial point is that «there is no independent epistemic access to the parameters to be measured – no access independent of measurement, that is» (p. 138). Second, he looks at measurement from a standpoint where measurement procedures have already been established, and provides a general theory of measurement, in part motivated by the work van Fraassen has done on measurement in quantum mechanics.

I'll talk about Parts III and IV in more detail below, but briefly: in Part III, van Fraassen argues for an empiricist version of structuralism in science. In Part IV, van Fraassen argues that a theory need not provide a full account of how measurement outcomes link to reality.

Scientific Representation is a somewhat long book – over 400 pages total, with the main body of the text a little over 300 pages. But if one is just interested in the parts of the book that are especially relevant to constructive empiricism and related issues, one can just read about 100 pages. Parts I and II can be skipped (with the exception of about 15 pages, as I'll discuss below). Parts III and IV comprise about 120 pages, but the first half of Part III is a historical discussion of structuralist views in late 19th century/early 20th century physics. While I found it fascinating, the less patient reader can skip it. Thus, after looking at the Introduction (pp. 1-3), a reader would not be remiss in starting at the discussion of Putnam's Paradox on p. 229 and reading to the end (p. 308). The appendix to the last chapter, provocatively titled "Retreat(?) from *The Scientific Image*", is also worth reading (pp. 317-319).[1]

But between the Introduction and Putnam's Paradox, there is one fascinating discussion that directly addresses a key counterintuitive claim of constructive empiricism, the claim that science does not aim to give us truths about what is seen through an optical microscope. This discussion takes place from pages 96 to 110. Here, van Fraassen argues that the optical microscope should not be thought of as a window on the invisible world, but instead as «an engine creating new optical phenomena» (p. 109). Specifically, he thinks that

[1] It takes up van Fraassen's changing views about probability, and about what it is for a probabilistic theory to be empirically adequate

the images produced by an optical microscope should be thought of as a "public hallucination", akin to a rainbow. Saying that one sees a rainbow, for van Fraassen, is like saying that (while looking through an optical microscope) one sees a paramecium. He writes: «As long as ordinary discourse is not filtered through some theory it does not imply that [the rainbow and paramecium] are objects» (p. 110).

Interestingly, even though van Fraassen pushes hard for the view that what one potentially sees through an optical microscope falls on the "unobservable" side of the observable/unobservable distinction, he ends on a concessive note. He writes:

> I draw the [observable/unobservable] line this side of things only appearing in optical microscope images, but won't really mind very much if you take this option only, for example, for the electron microscope. After all, optical microscopes don't reveal all that much of the cosmos, no matter how veridical or accurate their images are. The empiricist point is not lost if the line is drawn in a somewhat different way from the way I draw it. The point would be lost only if no such line drawing was to be considered relevant to our understanding of science. (p. 110, *emphasis in original*)

It would be worth thinking about how the arguments for constructive empiricism from *The Scientific Image* would change were one to draw the observable/unobservable line in such a way that things viewed through the optical microscope count as observable objects. Van Fraassen does not discuss this issue, beyond the paragraph I just quoted.

Moving on to Part III, we find an argument for an empiricist version of structuralism in science. Van Fraassen starts by reviewing the history of structuralism, and arguing that past structuralist views failed because they didn't adequately take into account the crucial indexical role in scientific representation. He holds that «structuralism finds its proper articulation only in an empiricist setting» (p. 237). Empiricist structuralism «is not a view of what nature is like but of what science is» (p. 239). Structuralists often say that "all we know is structure" and van Fraassen takes that on board with a caveat: «all we know through science is structure» (p. 238). What science does is represent the empirical phenomenon as embeddable in certain mathematical models, and these mathematical models are describable only up to structural isomorphism. The empirical phenomena are represented by a data model, and a successful theory will have the data model appropriately link to a theoretical model. But there's more to our understanding of a scientific theory than that. A crucial indexical aspect is needed, to provide the appropriate link between the data models and reality (p. 257). Van Fraassen holds that we can know that the indexical propositions which provide the link are true, and yet the propositions cannot be part of a scientific theory (p. 261).

Let's move on to the final chapter of the book, which, to my mind, is the most provocative. Van Fraassen calls it *Rejecting the Appearance from Reality Criterion*, but as I'll explain, he could have called it "Against Philosophy of Quantum Mechanics", or "Why the Measurement Problem is an Artifact of Bad Philosophy". But before getting to the Criterion, I have to lay out some terminology.

"Appearances", for van Fraassen, are the contents of measurement outcomes. He distinguishes them from "phenomena", which are observable entities of any sort (p. 283). In a interesting footnote, he writes: «I have only slowly come to see the importance of marking such a distinction. In *The Scientific Image* I did not make this distinction either carefully or clearly» (p. 391, n. 24).

Now, the Appearance from Reality Criterion holds that appearances must clearly derive from what is really going on (p. 282). As van Fraassen explains, this derivation sometimes happens in science. For example, Copernicus derived the appearance of retrograde motion from (what his theory said was) the real motions of planets around the sun. But van Fraassen does not think that the Appearance from Reality Criterion is a completeness criterion for science: a theory can be just fine even if it doesn't explain how the appearances are derived from reality (p. 295).

Van Fraassen recognizes that it's «quite generally accepted at least amongst philosophers» that the Appearance from Reality Criterion is a completeness criterion for science (p. 280). His argument against these philosophers appeals to the norms of science, as exemplified by the actual practices of physicists. The basic argument is that in the context of quantum mechanics, physicists are generally perfectly happy with simply using the Born rule to make predictions for measurement outcomes (where, roughly, the Born rule is the rule that gives probabilities for the possible outcomes on the basis of the quantum state of the system). But nothing in the theory of quantum mechanics as typically used by physicists tells one how the particular appearance we actually get links to reality. As van Fraassen writes, at the very end of the last chapter of Scientific Representation:

> Advocates of the Appearance from Reality Criterion will not be satisfied with quantum mechanics. [...] Conversely, irenic acceptance of the theory – such as that which we have seen prevalent in the physics community, throughout the last century – would seem to signal an attitude content without any sustained attempt to satisfy that Criterion. This, it seems to me, should allow us to draw the right moral about what are and what are not norms that govern scientific practice. (p. 308)

Now, it would be open for a philosopher to argue in response to van Fraassen that physicists are simply wrong or confused if they reject the Appearance from Reality Criterion, or if they don't understand why a solution to the measurement problem is needed to for quantum mechanics to be a complete theory. But for a philosopher to give that response doesn't fit with the deference to science that philosophers nowadays typically show.[2]

I wish there were another appendix to the last chapter, called *Retreat(?) from Quantum Mechanics: An Empiricist View*. Van Fraassen is putting forth a position on quantum mechanics that does not come up in his 1991 Quantum Mechanics book, but it's not obvious to me whether the new position is meant to be complementary to the 1991 position. My sense is that the views are in tension, because in the 1991 book van Fraassen puts on the table a particular solution to the measurement problem, known as the Copenhagen Variant of the Modal Interpretation.[3] The CVMI solves the measurement problem by postulating that systems sometimes have 'value states' in addition to the quantum state, and the probability that a system has a particular value state at the end of a measurement is given by the standard Born Rule (and moreover, what it is to be a measurement is given a purely physical characterization). This sort of solution makes sense if one endorses the Appearance from Reality Criterion: the reality is that the system has a certain value state at the end of measurement, and that accounts for why the appearance – the measurement result – is what it is. If van Fraassen is rejecting the Appearance from Reality Criterion, and is hence saying that there is no measurement problem, then there's no need to postulate an interpretation like the CVMI.

But perhaps van Fraassen's 1991 view of quantum mechanics really is compatible with his new position. In Scientific Representation, van Fraassen

[2] It also doesn't fit with one of the motivating themes of van Fraassen's work, which is to admire science as a paradigm of rational inquiry.

[3] Moreover, van Fraassen played a prominent role in the whole development of modal interpretations.

does not say that we should never postulate links between appearances and reality; he just says that we should reject the Appearance from Reality Criterion as a completeness criterion for science. In other words, it's permissible to seek to link appearances with reality, but we shouldn't fault a scientific theory if it doesn't provide the link. But what then would be the point of postulating an interpretation of quantum mechanics that provides the link if the link is unnecessary? Perhaps the answer is that postulating interpretations gives us a better understanding of the theory. The idea is that each interpretation provides an answer to the question «how could the world possibly be the way this theory says it is?» (van Fraassen 1991, p. 4) Thus, it's worthwhile to seek many solutions to the measurement problem, because each "solution" helps us to better understand the ways in which the theory could be true.[4]

But the last paragraph of Scientific Representation provides a potential challenge to that view. We would think that physicists would want to understand quantum mechanics, but physicists for the most part irenically accept the theory – they do not concern themselves with trying to solve the measurement problem. So perhaps scientific understanding goes just fine without solutions to the measurement problem, and it's only deep-seated sympathies toward the Appearance from Reality Criterion that leads some to think otherwise.

I explained above that the last chapter poses a provocative challenge to those philosophers of science who endorse the Appearance from Reality Criterion. We now see that the last chapter poses a provocative challenge to those philosophers of quantum mechanics who think that there is a measurement problem that needs to be solved. If there is no need to explain how measurement outcomes link to reality, then what is the point of finding solutions to the measurement problem? Perhaps the answer is just that the solutions help give us a better understanding of the theory, but it's not clear whether that answer fits with actual scientific practice. Moreover, even if that is the answer, it becomes a serious open question as to whether all work on the measurement problem makes sense when seen in that guise. It's one of the virtues of Scientific Representation that it puts these important questions on the table – van Fraassen is continuing his tradition of giving philosophers something provocative to talk about.

[4] And indeed, personal communication with van Fraassen confirms that he does still think that these interpretations aid our understanding of the theory.

REFERENCES

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Van Fraassen, B. (1991). *Quantum Mechanics: An Empiricist View*. Oxford: Oxford University Press.