BOOK REVIEWS

Scientific Representation: Paradoxes of Perspective. BAS C. VAN FRAASSEN. New York: Oxford University Press, 2008. 320 p. Cloth $50.00.

Bas van Fraassen's *Scientific Representation* evolved from his Locke Lectures at Oxford University in 2001. The central focus of the book is the development of an empiricist version of structuralism. As such, it is continuous with van Fraassen's earlier formulations of constructive empiricism. Indeed, this substantial book is perhaps best read as providing a sketch for a subtle reformulation of constructive empiricism, one that results from careful reflection on the nature of scientific representation. While he intends for his discussion of scientific representation to be neutral between realist and empiricist tenants, the book is throughout in the service of developing an empiricist version of structuralism, and van Fraassen ultimately argues that structuralism finds its proper articulation only in a constructive empiricist setting. There is, however, much here for structural realists, pragmatists, and empiricists more generally, and most anyone interested in the ways of scientific inquiry will profit from the fresh reconstruction, evaluation, and synthesis of arguments from such as Mach, Boltzman, Planck, Hertz, Duhem, Carnap, Russell, and Goodman.

The starting point for the discussion of representation is Boltzman's version of the *Bildtheorie* account of science. On this view, the goal in formulating a physical theory is to construct an inner picture or representation of the external world by attaching definite concepts to objects in order that our thoughts might model the world they represent. Boltzman, however, conceded that we can know little concerning the relationship between our thoughts and the objects they represent. To this van Fraassen agrees and argues that it is more productive, and less mysterious, to imagine scientific representation by means of concrete (for example, graphs and scale models) and abstract (for example, mathematical models) artifacts. Among the representational artifacts employed by science are measurement outcomes, and insofar as they provide the standard of theoretical adequacy for the empiricist, the problem of representation as it obtains for measurement outcomes is of central importance.

On van Fraassen's account, the pointer on a measuring instrument at the end of a successful measurement locates the target of the measurement in a logical space. The logical space is a theoretical construction,

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and so is the measurement target as represented by the theory. More specifically, the measurement target is an item that the investigator has classified within the domain of the theory at hand and the logical space is provide by the theory to represent the range of possible states or characteristics of such items (logical spaces include hue, brightness, and saturation for color perceptions; pressure, volume, and temperature for the physical states of classical thermodynamics; and Hilbert space for quantum-mechanical states). Measurement outcomes represent empirical phenomena, but only relative to the representational use and practice of the inquirer, which, in turn, is contingent on the theory that characterizes the measurement target and logical space and the concrete experimental set-up under which the measurement is performed. Such contingencies represent the essential indexicality of measurement and representation more generally.

This essential indexicality is for van Fraassen at root a consequence of the pragmatic model of representation that he endorses. Nothing simply represents something else; rather, theoretical models, data models, measurement outcomes, and other representational artifacts represent only by means of the role they play in the use and practice of inquirers. van Fraassen describes representation as a three-place relation between the representational artifact, the target, and the user; where the indexical component provided by the user is a subtle business involving the complete conditions of the user's representational use and practice.

While this indexical understanding of representation is taken as a necessary step in the successful formulation of structural empiricism, it also leads to problems for the empiricist. In his recitation of his version of the empiricist creed van Fraassen asserts that (i) the primary criterion of scientific success is empirical adequacy, (ii) the acceptance of a theory has a pragmatic element insofar as it guides future actions and research, and (iii) the acceptance of a theory need involve no more than that the theory is empirically adequate. But what exactly might it mean for a theory to be empirically adequate when one has recognized the deeply contingent indexical nature of even measurement outcomes as representations?

As van Fraassen would have it, a measurement outcome is always achieved relative to particular experimental setup designed by the user and characterized by his theory. On the other hand, insofar as a measurement outcome provides evidence for empirical adequacy and empirical adequacy provides the primary criterion of scientific success, one does not want measurement outcomes to be entirely contingent on the theory in which the measurement is characterized, or, for that matter the contingent interests of the user. Unless there is

something appropriate and genuinely outside the theory *to push back*, one has at best only theoretical coherence, in which case there can be no meaningful empirical evaluation of theories.

This is a puzzle that generates a useful tension throughout the book. van Fraassen takes phenomena (observable entities like rocks, seas, stars, people, and bicycles) to be the proper target of scientific representation and theoretical models to be the vehicles for such representation. But since theoretical models are abstract structures and abstract structures are mathematical structures and mathematical structures are not distinguished beyond isomorphism, how is it possible for theoretical models to represent phenomena at all? And if one cannot say how theoretical models represent phenomena, how could phenomena test the theory? In short, if one has only an abstract theoretical structure, then one has no empirical content to test.

Once more, while is sufficient to test the empirical adequacy of a theory that one compare one's theoretical model against a data model (or surface model) that one takes to represent one's experimental results, how can we explain how a theory represents phenomena by appeal to a relationship between theoretical models and data models when both of these are abstract entities? The answer must be that the data model somehow represents the phenomena, but then why doesn't this just push the problem back one step? van Fraassen's recurring answer is that while there is nothing in the abstract structure *itself* that can determine that it is the relevant data model to be matched to the theory, the "construction of the data model is precisely the selective relevant depiction of the phenomena *by the user of the theory* required for the possibility of the representation of the phenomena" (253).

It is the user's design of the experiment that allows measurement outcomes to represent phenomena, it is the user's construction of the *relevant* data model from such outcomes that allows the data model to represent phenomena in a way appropriate for testing the theory at hand, and it is the user's identification and comparison of the relevant part of the theoretical model against the data model that allows him to judge that the theory adequately represents the phenomena. It is only by dint of this theory-laden, purposeful chain of representational use and practice that phenomena can push back against the theory at all. The theory is judged to be empirically adequate when there is a (presumably, partial and temporary) equilibrium between one's theoretical model, one's relevant data model, and one's theoretical use and practice. It is a consequence of this view then that empirical adequacy comes in as many varieties as there may be indexical uses and practices.

Given the degree of contingent representational indexicality involved in judgments of empirical adequacy, there is a threat of a strong relativism that results from exactly that indexicality that is supposed to be required for the possibility of structural representation. Since the only empirical matching is between theoretical models and data models, the theory does not confront the observable phenomena but rather only the observable phenomena *as described*, contingent on the understanding and interests of the user. van Fraassen calls this the *loss of reality objection*. The strategy he favors for addressing it is one that seeks to dissolves the problem (258).

van Fraassen begins by conceding that the claim that a theory is adequate to the phenomena *is not the same* as the claim that it is adequate to the phenomena as represented by a user of the theory. While the representation of phenomena in a data model is a contingent construction for our contingent purposes, he takes the phenomena themselves to be objective. On the other hand, van Fraassen argues that, in checking the empirical adequacy of a theory, we have no recourse but to compare the theoretical model against our contingent data model. What is supposed to dissolve the problem is that (i) the theory being empirically adequate to the phenomena as represented by us and (ii) the theory in fact being empirically adequate *are the same for us*. More specifically, van Fraassen appeals to the pragmatic tautology that there is *for a person* no difference between the question of whether a theory fits his representation of the phenomena and the question of whether the theory fits the phenomena—if it fits the first, he cannot deny that it fits the second (259–60).

But while van Fraassen is certainly right that I cannot do better than to judge my representation of the phenomena against what I take to be the relevant part of the theoretical model; insofar as I hold with van Fraassen that all such representation is contingent, I cannot simply pretend that my data model is something more than *my contingent construction*. Further, and perhaps more important, insofar as I hold that it is possible to err in the scientific representation of phenomena, and I find myself so committed, it would be a methodological error for me to mistake my contingent representation of the phenomena for the phenomena themselves.

While I have no choice but to call empirical adequacy as I see it, even as I call it, *even I* recognize that my call is contingent in a sense that allows for error in the assessment of adequacy of the theory to the phenomena *properly understood*. More specifically, I recognize the contingency of my own judgments of empirical adequacy in my recognition of the error of other inquirers' empirical judgments, my recognition of error in my own past empirical judgments, and my conviction that my

current epistemic situation is ultimately like both my own past epistemic situation and the current epistemic situation of other inquirers' *in kind*. Once I recognize the live possibility of representational error, the pragmatic tautology provides little comfort, and I find van Fraassen's dissolution of the loss of reality objection consequently unconvincing. In order to take even my own judgment of the empirical adequacy of a theory seriously here, I must take the judgment to concern the match between the relevant part of the theoretic model and *a representation of the phenomena concerning which I am committed to eliminating representational error whenever I find it*. If this is right, then the force of my judgment of empirical adequacy rests in my pragmatic methodological commitment to eliminate representational error, not in the pragmatic tautology.

In order to show how structural empiricism meshes with the actual practice of science, van Fraassen ends the book with an explanation of how structural empiricism makes sense of the Copenhagen interpretation of quantum mechanics and thereby dissolves the quantum measurement problem. This example also illustrates the contingency of judgments of empirical adequacy on this view.

After explaining why (if one assumes that the linear dynamics describes the evolution of the composite system) the result of a measurement cannot supervene on the quantum-mechanical state of the observer, the measuring device, and/or the object being measured, van Fraassen explains why this is not a problem for the empiricist. The idea here is that there is nothing in quantum mechanics or the practice of using the theory, properly conceived, that requires that

> *what happens in the actual situation must be displayed as entirely identifiable in the theoretical model*. The most stringent demand that can be made here is that the relative frequencies of certain events in this sort of situation must have a good fit to probability functions, extrapolated from them in surface models, which are identifiable as parts of corresponding probability functions in the theoretical models.... When this demand is met—whether strictly or to some approximation—the theory is borne out by the experimental results.... (305).

Quantum mechanics then might be judged to be empirically adequate *even when there is nothing in the theoretical model that one can take to represent the actual determinate physical measurement records that one in fact observes*. Rather than require the theory to successfully represent each determinate measurement record, here one only requires that it save the phenomena *in statistical aggregate*. The theory might be taken as empirically adequate because the theoretical model corresponds to a surface model that captures the overall statistical properties of measurement outcomes.

The measurement problem is solved here not by honest toil but by exploiting the freedom one has in stipulating what counts as the appropriate data model to match to the theoretical model. Insofar as one might always construct a data model that would allow one to judge a given theory to be empirically adequate, it is a methodological mistake to take advantage of this freedom to achieve empirical adequacy. Indeed, an empiricist might properly worry over the prospect of even having this degree of representational freedom.

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