cognitive neuroscience *as a field* utilizes those methods (e.g., as part of cognitive neuroscience graduate school training). In addition, piecemeal examples of methods do not support Piccinini's overarching claim that cognitive neuroscience provides multilevel mechanistic explanatory integration of the kind much of the book aims to defend. It is not clear that any examples are provided of a cognitive phenomenon explained in an integrated multilevel mechanistic way.

A third weakness is the treatment of nonneurocomputational mechanistic approaches to cognition. Granted, no single book can be expected to address all the relevant material in the sciences of cognition. Still, for those sympathetic to nonneurocomputational mechanistic approaches like dynamicism and radical embodiment, the engagement is wanting. The primary reason is that such alternatives are too quickly dismissed, for example, "this argument [i.e., dynamical hypothesis] presupposes that there is a contrast between dynamical systems and computational ones. There is no such contrast!" (249). Because Piccinini is so well versed in a variety of literatures, additional engagement with alternatives could have made for a fiery debate or possibly even converted some to his position. With all that said, none of these weaknesses deter from the fact that Piccinini has provided us with one of the most engaging (and provocative) works in contemporary philosophy of neuroscience.

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Review of Nancy Cartwright's *A Philosopher Looks at Science*

Nancy Cartwright, *A Philosopher Looks at Science*. Cambridge: Cambridge University Press (2022), 210 pp. $12.95 (paperback).

Nancy Cartwright's latest book,[1] *A Philosopher Looks at Science*, comprises a short introduction, three numbered chapters, and a short conclusion. The introduction focuses on three claims that Cartwright will challenge:

[1] Cartwright has written numerous books, and it's entirely possible that she will have published another one by the time this review appears.

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1. Science = theory + experiment
2. It's all physics really
3. Science is deterministic

Claims 2 and 3 have familiar labels in philosophy of science, "reductionism" and "determinism," respectively. Claim 1 might correspond to what was called the "Received View" of philosophy of science by its critics starting in the 1960s. The Received View took physics as its paradigm of science, emphasizing axiomatic formal systems ("theories") and experimental methods of generating data. The Received View was strongly associated with "positivism"—more precisely, logical empiricism as developed by the likes of Carnap and Reichenbach and later promoted by influential philosophers like Hempel and Quine—as well as Popper. This Received View was challenged by a number of intellectual and social movements: Kuhnian historiography, the disunity of science movement, the Strong Programme in the sociology of scientific knowledge, Marxist and feminist science studies, and the philosophy of science in practice.

Of course, Cartwright herself has played a major role in several of these movements. Under the influence of these movements, today many philosophers of science treat science as a diverse array of material-cognitive-social activities. However, something like the Received View does still seem to be widely held—not just among the general public but also by many practicing scientists. Consider the replication crisis that has unfolded in social psychology and biomedical research over the last decade or so. Instead of considering whether or to what extent replication is actually an appropriate norm for these fields (Leonelli 2018; Feest 2019), common responses by scientists have been to try to make these fields more physics-like, with tighter experimental protocols and/or more mathematical theorizing (Wagenmakers et al. 2012; Muthukrishna and Henrich 2019). Throughout the book, Cartwright seems interested primarily in challenging these sorts of broadly popular views about science, rather than engaging directly in scholarly debate with other historians, philosophers, and sociologists of science.

The numbered chapters focus on the three target claims in turn. Chapter 1 is the longest at sixty-eight pages (though the pages are not dense, roughly 250 words per page), including several discussions of "the melange of theory ingredients" (19): concepts, models, narratives, diagrams, and, finally, experiments. Concepts (34–53) and experiments (60–79) receive the most attention. Overall, Cartwright's argument in this chapter is that successful science requires a network or web of interdependent elements of various kinds, not just testing theories directly against experimental data. She introduces the analogy of the Meccano set. (North American readers like me might be more familiar with Erector sets, or perhaps LEGO's Technic and Mindstorms lines.) These engineering toys comprise numerous different types of parts that can be combined to construct functional machines. Because of the functional interdependence of different types of parts, no type of part is more important than any other. Just so, Cartwright says, with science.

Specifically, Cartwright argues that both concepts and experiments require "small worlds," carefully constructed and maintained situations in which the referents (of concepts) and causal relationships (investigated by experiments) behave in stable, regular ways. Those familiar with Cartwright's work will recognize small worlds as

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slight generalizations of her nomological machines, "a fixed (enough) arrangement of components, or factors, with stable (enough) capacities that in the right sort of stable (enough) environment will, with repeated operation, give rise to the kind of regular behaviour that we describe in our scientific laws" (Cartwright 1997, 66).

Chapter 2 develops two arguments against reductionism. First, reductionism has not been an especially productive research program. Philosophers have had to gradually weaken claims of reductionism, from type–type reduction to supervenience to grounding (91–103). And even in chemistry, strict theoretical reduction to physics—namely, the Schrödinger equation—has been successful in only a few special cases. "For the more common cases that do not have analytic solutions, solving the Schrödinger equation involves a battery of approximate methods and models … [that are] founded on presuppositions that belong to classical chemistry" (106). That is, when the Schrödinger equation is usefully deployed in chemistry, typically, this is not a reduction to quantum physics but instead an ad hoc combination of quantum physics and classical chemistry. Cartwright's second argument is that the theoretical accomplishments of physics require highly complex material constructions that can serve as the necessary small worlds in which the appropriate experiments can be conducted. Constructing these small worlds in turn depends on accomplishments not just in fields like engineering and chemistry but also in economics, social psychology, and management (118). Importantly, Cartwright's point is that knowledge of these other fields is essential to justify a claim that "every [confounding] factor that can affect the outcome of interest … has been eliminated or shielded against" (119), in other words, that the experiment is operating correctly. In this way, the reach of these other fields extends into the "context of justification" of physics. And so, epistemologically, physics cannot stand alone. At the end of the chapter, Cartwright returns to the Meccano set analogy, this time with many different scientific fields making their distinctive contributions to a project. Inspired by Neurath, she calls this "unity [of science] at the point of action" (121).

In chapter 3, Cartwright contrasts determinism with her own dappled world metaphysics, "a world rich in different things with different natures behaving in different ways. The laws that describe this world are a patchwork, not a pyramid" (126). After reviewing the historical rise of mechanical philosophy and the disenchantment of nature (128–34), Cartwright's primary foil is an argument that "because the laws of physics are so successful at helping us predict and control the world they must be imposing an underlying order everywhere" (144), a sort of no-miracles argument that the world is governed by the laws of physics. Note that governance is logically weaker than physical determinism: a world determined by the laws of physics is governed by the laws of physics, but physical law could govern the world without strict determinism, for example, if all the laws were probabilistic.

Cartwright's challenge to this argument is basically the same as her challenge to reductionism in chapter 2: physics is only successful in small worlds. Sometimes small worlds occur naturally (the motions of the planets in the solar system), but more often, they must be carefully manufactured (147–48). Indeed, "most situations do not seem well structured [as naturally occurring small worlds]. Physics does not have concepts available to describe all the causes operating in [most situations]. And many of the causes do not look to have the right features to allow them to be described in the precise kind of language that makes physics so powerful" (155–56). Thus the

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argument from the success of physics only applies to the patchwork small worlds, natural or artificial, and not more generally.

In place of governance by physical law, Cartwright offers two interpretations of scientific laws as "tendency laws," which characterize "what the factors in view tend to or try to produce even in large worlds where much else is going on" (156). On the *toolbox view*, "scientific principles and law claims are seen as tools; often very delicate, powerful tools that we deploy to create successful models, measurements, predictions and technology" (157). They are artifacts that we have constructed to help us act in the world. Although this might sound like classical instrumentalism, Cartwright appears to deny this: the toolbox view is "no less committed to electrons and positrons or masses and forces or people and incentives than if the principles were true wherever we put them to use" (165). This seems to be primarily a negative metaphysics: the toolbox view is neither realist nor instrumentalist, without a clear positive characterization.

The second, *powers view* "sees laws as describing powers that exist in systems to act and to bring about change" (157). It thereby carries stronger metaphysical commitments than the toolbox view, with what appears to be a simple realist commitment to powers. But this gives the powers view "the further advantage that it provides a sense of governance"; namely, the powers govern the world, albeit in a more decentralized and messy (democratic?) way than "imperious" (126, 138) deterministic laws. Personally, this doesn't strike me as a major advantage, but I suppose politically I've always had a respect for anarchist critiques of socialism.

It's a little difficult to pin down the purpose and target audience for *A Philosopher Looks at Science*. The ideas and arguments are generally familiar from Cartwright's many previous books, especially *The Dappled World* (1999). And, again, Cartwright doesn't really engage in scholarly debate here, refining those previously stated views in response to criticism. So fellow travelers are likely to find this book redundant, while critics are likely to find it unproductive. The book is probably too esoteric for a general educated audience or most undergraduate courses, especially the long discussion of concepts in chapter 1. It might serve well for graduate students who need an introduction to her metaphysical views. This book does require much less knowledge of physics than "How the Laws of Physics Lie" (Cartwright 1983) or *Dappled World*, although, for use in a graduate seminar, I would have preferred shorter chapters. Chapter 1, in particular, would be very difficult to cover in a single week.

While this review was under review, Cartwright noted that *A Philosopher Looks at Science* was published as part of Cambridge University Press's A Philosopher Looks series, in which "a well-known thinker offers a personal and philosophical meditation on a topic that we frequently encounter in our everyday lives" (Cambridge University Press n.d.). We might read *A Philosopher Looks at Science* as an essay in Montaigne's sense, where the aim is for the author to think through their own view on a topic, with less concern about addressing a particular audience.

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