

The Epistemic and Ontic Conceptions of Scientific Explanation

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(General Audience)

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I. Introduction

Carl Hempel and Paul Oppenheim's introduction of the Deductive-Nomological (DN) model of scientific explanation in their 1948 landmark paper has had a profound impact on the direction in which philosophical reflection of scientific explanation has progressed. Wesley Salmon remarked that "[t]his 1948 article provided the foundation for the *old consensus* on the nature of scientific explanation that reached its height in the 1960s. A large preponderance of the philosophical work on scientific explanation in the succeeding four decades has occurred as a direct result or indirect response to this article" (Salmon 2006, p. 3). Due to its influence, much philosophical work on explanation in the years following has placed emphasis on responding to the questions raised in Hempel and Oppenheim's paper, namely developing and analyzing the adequacy of specific models of scientific explanation. A pattern within the literature on scientific explanation emerged of the development of a particular model of scientific explanation, the proposal of counterexamples to the model, and then the defense, revision, or dismissal of the model.

Salmon attributes much of the ongoing debate over the adequacy of proposed models of scientific explanation as a debate over which conception of scientific explanation is correct, and distinguishes between three conceptions of scientific explanation – the epistemic, the modal, and the ontic (Salmon 1984, Salmon 2006). Salmon characterizes the epistemic conception of explanation as taking scientific explanations to be arguments, the modal as showing the explanandum as happening necessarily, and the ontic as exhibiting how the explanandum fits into natural patterns or regularities (Salmon 1984). Salmon explains that the purpose of his 1984 paper on this distinction is "to examine each conception in its strongest form, and to consider the basic philosophical issues involved in accepting or rejecting each" (Salmon 1984, p. 293). Thus, it seems that Salmon believes that much of the debate over the adequacy of different models of scientific explanation is debate over these three conceptions, and believes that only one of these conceptions can be correct.

While some follow Salmon in making this distinction and advocate for their preferred conception of scientific explanation, others have called into question whether Salmon's distinction is legitimate. For example, Bradford Skow (2014) argues that ontic explanations may also be modal, Cory Wright (2015) argues that the ontic conception of scientific explanation is a misconception, and Phyllis Illari (2013) argues that adequate explanations should conform to both epistemic and ontic constraints. In this paper I argue that the epistemic and ontic conceptions of scientific explanation *are* distinct, however I will argue that they do not compete with one another. Rather, they address two related, though distinct philosophical questions. Thus, the epistemic and ontic conceptions of explanations should not be seen as offering competing answers to the same question, but rather as responding to different (though related) questions.

In Section 2 of this paper I discuss Salmon's characterization of the epistemic and ontic conceptions of scientific explanation, and argue that this distinction does not merely address two differing conceptions of scientific explanation, but rather highlights that those who adopt the epistemic and ontic conceptions of scientific explanation are responding to two different questions. In Section 3 I argue that features that may be desirable for either the epistemic or ontic conception of explanation may not be desirable or even attainable for the other, thus an adequate response to one of the questions (the epistemic question or the ontic question) should not be assessed in light of the other.

II. The Epistemic and the Ontic Conceptions of Scientific Explanation

In this section I will argue that the epistemic and ontic conceptions of scientific explanation *are* distinct. While this first argument supports Salmon's distinction between the epistemic and ontic conception of explanation, I will argue that, *contra* Salmon, the epistemic and ontic conceptions of explanation are not competitors but rather address two entirely different questions altogether.

A prime example of the pattern within the literature on scientific explanation is Hempel's introduction of the Inductive-Statistical (IS) model, Peter Railton's criticism thereof, and Railton's proposal of his own deductive-nomological-probabilistic (DNP) model of scientific explanation. Hempel's IS model of scientific explanation is a model in which the explanation of an explanandum event cannot be guaranteed by the explanans (as is the case in his DN model), but instead can be inferred from the explanans with high inductive probability. Hempel's IS model is an inductive argument of the following form, where O_i (the explanandum) is an event of type O at a particular instance i , F_i is a set particular facts that obtain at instance i , and $P(O|F)$ is the conditional probability of O given F:

$$\frac{P(O|F) = r}{\frac{F_i}{O_i}}$$

In a work Salmon calls "quite possibly the best thing written on scientific explanation since Hempel's "Aspects" essay", Peter Railton criticizes Hempel's IS model of explanation for two primary reasons (Salmon 2006, p. 120, Railton 1980). Firstly, Railton reiterates Richard C. Jeffrey's objection that probable and improbable events are equally explicable, and therefore rejects Hempel's high probability requirement. Railton provides an example of an indeterministic (irreducibly probabilistic) fortune wheel with 99 red stops and 1 black stop, and argues that is an unacceptable consequence of Hempel's IS model that if the wheel stops on red it can be explained, but if it stops on black it is inexplicable. Supposing the wheel stopped on black the inductive strength would be low ($r = .01$), so there would not be an adequate explanation, whereas if the wheel stopped on red the inductive strength would be close to one ($r = .99$), so the explanation would be adequate. Railton believes that this is unacceptable, since he holds that explanations should be evaluated according to the completeness of the explanatory information provided rather than by their inductive strength (Railton 1980, pp. 252-253). Furthermore, while Jeffrey accepts Hempel's IS account as explanatory as long as the inductive probability is high enough to allow one to reason as if it were 1, Railton rejects the IS account as explanatory altogether. Railton claims that while IS explanation may serve useful in practical decision making, explanation is not entirely a practical task (Railton 1978, p. 208).

Railton's second objection to Hempel's IS model is based on its relativization to an epistemic situation (Railton 1980 pp. 238-239). Since Hempel's requirement of maximal specificity is restricted to the total knowledge at a particular time, an explanation is adequate relative to scientific knowledge at a given time, rather than objectively correct or true. Railton insists that whether or not an explanation is adequate should not depend on our beliefs at a given time, but on objective truth. Because of this, Railton believes the probability specified in an explanation should be objective, and thus probabilistic explanation should be reserved only for

explanandum that are irreducibly probabilistic, i.e. indeterministic, since probabilistic laws do not govern deterministic events (Railton 1980, pp. 244-245).

It is important to note that Railton's first objection targets not only Hempel's IS model, but any probabilistic model of scientific explanation that fits the epistemic conception. Recall that the epistemic conception of explanation requires that scientific explanations be arguments. In the case of a deductive argument the explanans must guarantee the explanandum, while in the case of an inductive argument the explanans must or make the explanandum likely in order for the inductive inference to be warranted. Therefore, any probabilistic model of explanation that conforms to the epistemic conception must also have the high probability requirement that Railton rejects.

In addition to his criticisms of Hempel's IS model, Railton offers his own statistical model of explanation, the Deductive-Nomological-Probabilistic (DNP) model. Railton restricts the DNP model to cases in which the explanandum event is genuinely indeterministic, i.e. irreducibly probabilistic in nature. The DNP model of explanation is an argument schema of the following form:

- (a) Theoretical derivation of the laws at work
- (b) Probabilistic covering law
- (c) Particular Facts
- (d) Statement of probability of outcome
- (e) Parenthetical addendum that the indeterministic event in (d) did or did not occur.

In this model, (a) accounts for the casual mechanism, (d) follows deductively from (b) and (c), and (e) is the explanandum. Thus, it is important to note, the explanans do not entail the explanandum or even make it likely (Railton 1980, p. 263).

Railton anticipates and responds to three objections to his DNP model of explanation. Firstly, Railton addresses those that may criticize his model for being too narrow in not allowing for probabilistic explanation of deterministic yet complicated events, such as those in evolutionary biology, genetics, epidemiology, and fluid mechanics. Railton responds in a way that echoes his criticism of Hempel's epistemic relativization, and admits that while these are the most common form of probabilistic explanations in science, "if something does not happen by chance, it cannot be explained by chance" (Railton 1978, p. 223).

Relatedly, Railton acknowledges that some may find his model too broad since any event that is subject to quantum-mechanical laws must be explained probabilistically (Railton 1978, p. 223). For example, the melting of ice when heated would need to be explained probabilistically, since the molecules of the atoms that make up ice are subject to quantum-mechanical laws, even though the chance of the ice not melting is exceedingly miniscule and difficult to calculate. Railton dismisses this objection as well, and claims that, although counterintuitive, "[b]ecause they figure in the way things *work*, tiny probabilities appropriately figure in explanations of the way things *are*, even though they scarcely ever show up in the way things turn out" (Railton 1978, p. 224). In other words, if an event is governed by indeterministic laws, even to a very small degree, it cannot be omitted in the explanation of the event.

Finally, Railton addresses the criticism that his model breaks the relationship between explanation and prediction (Railton 1978 pp. 274-275). Railton dismisses this criticism as well, and claims "[i]t is a complaint against the world, not against the DNP model, that a direct, non-

statistical test for the presence or value of this probability may prove impossible” (Railton 1978, p. 274).

According to Salmon, the debate between Hempel and Railton is due to the different conceptions of scientific explanation that they each endorse. Hempel’s Inductive-Statistical model of explanation fits the epistemic conception of scientific explanation, while Railton’s DNP model fits the ontic conception of scientific explanation. However, it seems to me that the dialogue and debate between Hempel and Railton’s models of explanation illustrate that the epistemic and the ontic conceptions of scientific explanation are not offering competing solutions to the same problem, but rather attempting to answer different questions altogether.

Railton’s criticism of Hempel’s IS model and defense of his own DNP model suggest that Railton’s view of what serves as an adequate explanation is vastly different from Hempel’s. While Railton sees it as unproblematic that very few, if any, DNP explanations may be tenable since “a direct, non-statistical test for the value of [the objective probability required for explanation] may prove impossible” (Railton 1978, p. 224). However, if follow Hempel and consider explanation to be a goal of science, then this seems like an unacceptable consequence.

In “Re-orienting discussions of scientific explanations: a functional perspective” Andrea Woody argues that philosophical work on scientific explanation has been dominated by questions regarding the adequacy of individual scientific explanations, and there has been comparatively little focus on questions about what role explanation plays in science, and why explanation should be justified as a theoretical virtue (Woody 2015). However, as Woody points out, these questions are inter-related. “[W]e could expect that any response to one might well place constraints on acceptable responses to the others. One persistent weakness of the explanation literature, in my mind, is how seldom the interconnected nature of these issues is acknowledged” (Woody 2015, p. 80). Woody remarks that “[p]erhaps philosophers within this tradition have been grappling, in effect, with the nature of explanation *simpliciter*. Science provides the epistemic warrant for the information provided in an explanation, but the explanation itself is not so much a *scientific* explanation as it is *the* explanation” (Woody 2015, p. 80).

This distinction (between *scientific* explanation and explanation, *simpliciter*) seems to be what is lying beneath the disagreement between Hempel and Railton. Consider Railton’s characterization of explanation: “[E]xplanation is an activity not wholly practical in purpose. The goal of understanding the world is a theoretical goal, and if the world is a machine – a vast arrangement of nomic connections – then our theory ought to give us some insight into the structure and workings of the mechanism, above the capability of predicting and controlling its outcomes” (Railton 1978, p. 208). Contrast this with Hempel’s characterization of explanation in “The Logic of Functional Analysis”: “Empirical science, in all its major branches, seeks not only to *describe* the phenomena in the world of our experience, but also to *explain* or *understand* them” (Hempel 1965, p. 297). While Hempel seems to be concerned with the analysis of explanation as a practical goal of the empirical sciences, Railton’s characterization of explanation seems to suggest his concern with the what it is for a set of explanans to explain an explanandum that is scientific in nature. Namely, Hempel seems to be concerned with answering the question ‘what is *scientific* explanation?’, while Railton seems to be concerned with answering the question ‘what is scientific *explanation*?’. While the first question is focused on what it is to offer a genuine explanation of an event that is scientific, the latter question focuses more on what role explanation serves within science, and judges the adequacy of a model of explanation on its ability to serve this role.

This distinction between *scientific* explanation and scientific *explanation* seems to apply to the epistemic and ontic conceptions of explanation, more broadly. Proponents of the epistemic

conception of explanation¹ focus more on explanation as a goal of scientific practice, whereas advocates of the ontic conception² see explanation as capturing a relationship that exists among objects in the world and are less concerned with the use of explanations with scientific practice. For example, in advocating for the epistemic conception, William Bechtel claims that “[e]xplanation is fundamentally an epistemic activity performed by scientists” (Bechtel 2008, p. 18). Compare this to Carl Craver, who, in arguing on behalf of the ontic conception, claims that explanation “are facts, not representations” (Craver 2007, p. 27).

While philosophical analysis of each of these conceptions is important, I will argue that we should not judge a putative answer to one on the basis of the other. In the remaining section I consider the case of contrastivity, and argue that while it is incompatible with the ontic conception of explanation, it is an acceptable (and perhaps even desirable) feature of the epistemic conception of explanation.

III. Why the Distinction Matters: The Case of Contrastivity

Besides providing insight into Hempel and Railton’s differing views of explanation (or between the epistemic and the ontic view, more generally), distinguishing the epistemic and ontic conceptions of explanation as being concerned with two different questions (the question of ‘what is an adequate *scientific* explanation?’ and ‘what is an adequate scientific *explanation*?’), allows us to analyze debates over models scientific explanation, keeping in mind that what serves as an adequate answer to one question may not suffice as an adequate answer to the other. For example, while Salmon argues we should abandon the requirement of *contrastivity* because it is incompatible with indeterminism, I will argue that this is only the case if one is assuming the ontic question – if we have the epistemic question in mind, this is not necessarily the case (Salmon 1984).

Salmon defines contrastivity as follows: “If, on one occasion, the fact that circumstances of type C obtained is taken as a correct explanation of the fact that an event of type E occurred, then on another occasion, the fact that the circumstances of type C obtained cannot correctly explain the fact that an event of type E’ (incompatible with E) occurred” (Salmon 1984, p. 209). In other words, the same explanans cannot be used to explain incompatible explanandum. Salmon claims that “this demand for the “rather than” component stems from the Laplacian deterministic context in which the same circumstances always lead to the same outcome...The Laplacian orientation strikes me as scientifically anachronistic” (Salmon 1984, p. 301), however I will argue that this is only the case if one is concerned with the ontic conception of explanation.

Christopher Hitchcock argues that the idea that contrastivity and indeterministic explanation are incompatible “is nothing more than a manifestation of our unexorcised demons [of determinism]” (Hitchcock 1999, p. 586). Hitchcock argues that contrastivity can be preserved in the explanation of an indeterministic event, since explanation takes place against a background of presuppositions that determine the irrelevance or relevance of potential explanatory factors and the appropriate contrast class (Hitchcock 1999). Hitchcock provides an example of a student of quantum mechanics who observes a photon passing through a polarizer. In Hitchcock’s example the student, who has “deterministic leanings”, knows all of the relevant explanatory factors to the photon being transmitted and that these explanatory factors determine a certain probability for the photon to be transmitted, however still wonders why the photon was transmitted rather than

¹ See Bromberger 1966, Greeno 1970, Hanna 1978, van Fraassen 1980, Bechtel 2008, Wright 2015.

² See Scriven 1975, Wright 1976, Craver 2007, Craver 2012.

absorbed (Hitchcock 1999, p. 601). According to Hitchcock, “[g]iven what she presupposes, her explanatory request cannot be met. There is no further information to give. If the explanation-seeking question ‘why was the photon transmitted rather than absorbed’ introduces just this presupposition, then it will indeed be impossible to answer” (Hitchcock 1999, p. 601). Within the theory of quantum-mechanics the contrast class for the question ‘Why did the photon transmit?’ does not include the case that the photon is absorbed, however outside of the theory it is possible that this is included in the contrast class.

Hitchcock argues that while this is the kind of case that underlies the intuition of those who believe indeterminism is incompatible with contrastivity, this line of reasoning is incorrect since it already presupposes everything that is explanatorily relevant to the explanandum. However, note that this response reveals that Hitchcock is concerned with the role explanation plays *within* scientific practice itself, rather than on an ontic notion of explanation. Within scientific practice we have the ability to determine a more restricted contrast class relative to a specific scientific theory, thus allowing for contrastive explanation of the event. Thus, within a theory we are able to render the question ‘why was the photon transmitted rather than absorbed’ as nonsensical. Therefore, while the explanation of why the photon was transmitted cannot be contrastive in the ontic sense, a request for such an explanation is rendered nonsensical in the epistemic sense. While Salmon’s argument seems to suggest that contrastivity is at least not a clear requirement for ontic explanation, and at most wholly incompatible with indeterminism, it seems like it is not only an attainable feature of epistemic explanation, but perhaps even a desirable one.

Thus, a feature that may be desirable for either epistemic or ontic explanation (such as contrastivity) may not be desirable or even attainable for the other. In addition to aiding in the discussion of requirements of scientific explanation, distinguishing the two questions can provide a more fruitful analysis of what the goals are for each of them.

IV. Conclusion

In this paper I have argued that the debate on probabilistic explanation between Hempel and Railton, and between those who argue on behalf of the epistemic and ontic conceptions of scientific explanation, more broadly, are not due to different conceptions of explanation, but rather due to each of them responding to different questions altogether. While Hempel and those who adopt the epistemic conception of scientific explanation are concerned with the question ‘what is *scientific* explanation?’, Railton and those who argue on behalf of the ontic conception are focused on a question akin to ‘what is scientific *explanation*?’. While each of these questions are important, it becomes problematic when notion of explanation is critiqued in light of the other. Thus, while these two philosophical problems are clearly related, separating them into two separate philosophical investigations will hopefully lead to further progress on each of them.

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