

Informational Virtues, Causal Inference, and Inference to the Best Explanation

Abstract

Frank Cabrera argues that informational explanatory virtues—specifically, mechanism, precision, and explanatory scope—cannot be confirmational virtues, since hypotheses that possess them must have a lower probability than less virtuous, entailed hypotheses. We argue against Cabrera’s characterization of confirmational virtue and for an alternative on which the informational virtues clearly are confirmational virtues. Our illustration of their confirmational virtuousness appeals to aspects of causal inference, suggesting that causal inference has a role for the explanatory virtues. We briefly explore this possibility, delineating a path from Mill’s method of agreement to Inference to the Best Explanation (IBE).

1. Introduction

In “Can There be a Bayesian Explanationism?” Frank Cabrera (2017) argues that the explanatory virtues cannot, in general, be confirmational virtues. In particular, he argues that informational virtues—those that give a hypothesis greater informational content—cannot be confirmational virtues. We reject Cabrera’s argument on the grounds that he has a mistaken account of confirmational virtue and provide examples showing that the informational virtues can be confirmational virtues.

It has commonly been supposed that causal inference is not Inference to the Best Explanation (IBE). Indeed, Steven Rappaport (1996) criticizes Peter Lipton's (1993) account of IBE on the grounds that it's essentially an account of causal inference *as opposed to* an account of IBE. However, our response to Cabrera crucially involves causal inference, suggesting that it has a role for the explanatory virtues. In the final section, we briefly explore this prospect, delineating a path from Mill's method of agreement to IBE.

2. Cabrera's Concern with Explanatory Virtues

For Cabrera (2017, 1251), for an explanatory virtue, V , to be a confirmational virtue it must be that:

If h_1 has V and h_2 lacks V , then, other things being equal, $P(h_1|e) > P(h_2|e)$.

With this characterization in place, it's easy to see the problem for informational virtues. In each case a hypothesis that lacks the virtue is entailed by its more virtuous partner. Hence, the virtuous hypothesis cannot have a higher probability.

Thus (2017, 1254) for *mechanism*:

‘Let H_1 be the hypothesis that specifies the physico-chemical details of salt's dissolving in water, and let H_2 be the hypothesis that salt dissolves in water because water has the solubility virtue...Let P_1 be this physico-chemical explanation..

Now, clearly H_1 is a better explanation than H_2 because H_1 cites P_1 in explaining the phenomena, but, contrary to what IBE-ists want to say, H_1 is not more likely to be true because H_1 entails H_2 . It seems that H_2 is really at bottom a statement of the form "There exists some causal mechanism by which water dissolves salt" and H_1 is a statement of the form "There exists some causal mechanism by which water dissolves salt & that mechanism is P_1 ". Clearly then, H_2 cannot be less probable than H_1 because H_2 is entailed by H_1 .’

For *precision* (2017, 1255):

“The virtue of precision says that, other things being equal, if H_1 gives more details than H_2 , then H_1 is a better explanation of the evidence E than H_2 . Thus, IBE-ists such as Lipton and Psillos who admit precision as a virtue in one form or another, should say that $\Pr(H_1|E) > \Pr(H_2|E)$. But let H_1 be "Fields F_1 and F_2 differ in the average height of corn stalks by 0.5 meters" and let H_2 be "There is some difference in the average height of corn stalks in F_1 and F_2 ". Here, H_1 is more precise than H_2 ... however... H_1 entails H_2 , and so $\Pr(H_1) < \Pr(H_2)$.”

And for *scope* (1255):

“With respect to *scope*, as Salmon (1990, 196-197) in his discussion of Kuhn's criteria of theory evaluation points out, Newton's theory has greater *scope* than the conjunction of Galileo's law of falling bodies and Kepler's three laws of planetary motion. This means that Newton's theory explains phenomena beyond the conjunction of the laws of Galileo and Kepler. Newton's theory entails the conjunction of Galileo's law and Kepler's laws, but of course the IBE-ist will want to say that Newton's theory is rationally preferable because of its greater *scope*. But if Newton's theory entails the laws of Galileo and Kepler, then Newton's theory cannot be more probable than the conjunction of Galileo's and Kepler's laws.”¹

The claims that the less virtuous hypotheses are more probable in each of the above cases are straightforward. It's Cabrera's characterization of a confirmational virtue with which we have issue.

¹ These laws are recoverable as an approximation from Newtonian mechanics rather than entailed, but that shouldn't be used to impede Cabrera's argument—we could easily modify the example to serve his purpose.

3. What is a confirmational Virtue?

For Cabrera, V being a confirmational virtue demands:

If h_1 has V and h_2 lacks V , then, other things being equal, $P(h_1|e) > P(h_2|e)$.

Here's a straightforward reason to reject this characterization. Confirmation is about *inferences*. Hence, confirmational virtues should be features of a hypothesis that facilitate confirming inferences—in terms of personal probability, features that facilitate increase in our probability for that hypothesis under the impact of evidence. The fact that, *synchronically*, one hypothesis has a higher probability than another is beside the point.² A counterfactual criterion provides a more reasonable characterization:

V is a confirmational virtue of a hypothesis, h , if, other things being equal, had h not possessed V , then it would not have been so strongly confirmed by the evidence, e .

² We don't think this point should be controversial, but proponents of *Inference to the Best Explanation* (IBE) really should insist on it when defending IBE. Closely related concerns can be raised about Roche and Sober's (2013) Screening off Thesis (SOT) for evidential relevance.

Thus, we also reject the comparative feature of Cabrera's characterization. There's good reason for this. In examples of the kind considered by Cabrera, an entailed hypothesis that lacks the explanatory virtue of the entailing hypothesis, may get confirmed precisely because we can exploit the relevant explanatory virtue to confirm the entailing hypothesis. As we shall see, this happens in the case of mechanism, for instance. So, the fact that the entailed hypothesis lacks the virtue, *V*, need not manifest itself as a failure to get (strongly) confirmed.

Without further ado, let's show how the informational virtues can function as confirmational virtues.

4. Informational Virtues as Confirmational Virtues

4.1 Mechanism and Argument by Analogy

We begin with mechanism. In terms of modern chemistry a sodium salt is formed by the union of a sodium ion with the anion formed from an acid when a hydrogen ion has been removed from it. One family of sodium salts consists of those formed by the union of a sodium ion with a carboxylic acid with one hydrogen removed. The simplest member of this family has the molecular structure HCOONa (i.e., a hydrogen bonded to a complex consisting of a carbon and two oxygens with one oxygen bonded to a sodium ion). The next, $\text{H-CH}_2\text{-COONa}$, has a similar structure but with an extra unit consisting of a carbon bonded

to two hydrogens inserted into the chain. The other members differ only in the number of CH₂ units inserted: H-CH₂-CH₂-COONa, H-CH₂-CH₂-CH₂-COONa, and so on. There is no limit to the number of CH₂ units that can be inserted to generate novel chemical kinds that belong to this family of sodium salts, and so it is not feasible to observe members of each chemical kind. How then, might we reasonably *strongly* confirm that *all* sodium salts in this family burn yellow?

The similarities in molecular structure between the different kinds of sodium salts give us some reason to *suspect* these sodium salts might have some relevant causal similarities, but they're clearly insufficient to *assume* that all will burn similarly. However, as we gather data regarding increasingly complex members of this family and find they invariably burn yellow, at some point we can very reasonably cease to believe the differences in molecular structure among that family of sodium salts are causally relevant dissimilarities. We cease to hold that adding arbitrary numbers of CH₂ groups to the chain are causally relevant disanalogies. Hence, a rational agent will acquire high confidence that all the sodium salts in this unlimited family burn yellow.

Roughly, the relevant argument looks like this:

- (P1) Each of the molecules in the family are potentially relevantly causally similar in regard of color of burning because they possess a common molecular structure of form H(CH₂)_nCOONa, for $n \geq 0$.

- (P2) For a sufficient variety of values of n , the observed color of burning for molecules that include n of the (CH_2) units is invariantly the same.
- (P3) There are no other causally relevant disanalogies between molecules of form $\text{H}(\text{CH}_2)_n\text{COONa}$, for $n \geq 0$.
- (C) Hence, for all values of n , molecules of form $\text{H}(\text{CH}_2)_n\text{COONa}$ are relevantly causally similar in regard of color of burning (burn the same color and for the same reason)

(P1) is reasonable. Granted that molecular structure is a variable we consider potentially causally relevant to color of burning, some of the commonalities in molecular structure held between members of this family *might* be the features relevant to color of burning. On the other hand, perhaps adding in CH_2 units to the molecular chain is causally relevant to the color of burning. Thus, we must gather evidence that shows that for a significant range of variations in n , $\text{H}(\text{CH}_2)_n\text{COONa}$ invariably burn the same color, justifying (P2). (P3) is justified by our confidence that the molecular structure of compounds, at least for this kind of case, exhausts the causally relevant properties. Hence we can be justifiably highly confident in (C), all the members of that family hold in common the factor that is causally relevant to color of burning. And since in gathering evidence for (P2) we observed that the compounds uniformly burned *yellow*, we can rationally confidently infer that the sodium salts in this unlimited family uniformly burn *yellow*.

If the hypothesis about this family of sodium salts burning yellow had not specified the generic molecular structure for the different kinds of sodium salts formed from carboxylic acid we would have had no basis for inferring that conclusion. An entailed hypothesis of the kind specified by Cabrera that merely asserts that there is some (unknown) set of properties that causes the yellow burning does not facilitate such an argument by analogy. More generally, confirmation by analogy regarding causally relevant properties *requires* mechanism, even if the invoked mechanism is vastly less sophisticated than molecular structure, because it is analogy regarding *causally relevant properties*. So, mechanism is a confirmational virtue.

One might, perhaps, contrive some alternative means of confirming that all sodium salts in this family burn yellow. However, in cases where there are distinct methodologies that might be used to confirm a hypothesis, that clearly shouldn't undermine the status of a confirmational virtue that facilitates confirmation using one of the methodologies. So, we need not argue that there is *no other possible way* of rationally strongly confirming this hypothesis other than by analogy. Thus, for clarity we should slightly modify our criterion for confirmational virtue:

V is a confirmational virtue of a hypothesis, h, for confirmational methodology, M, if, other things being equal, had a hypothesis not possessed V, then it would not have been so strongly confirmed by the evidence, e, using methodology M.

With this refinement in place, mechanism clearly merits the status of a confirmational virtue.

4.2 Precision

Let's again suppose that we're interested in the color with which sodium salts burn, and that in this case, we're highly confident that all instances of a particular kind of sodium salt, say sodium fluoride, are *relevantly causally similar* in this regard. We don't know what color they burn, nor what particular wavelength of light they emit when burned, but we're highly confident that all sodium fluoride causes the same color flame, and emits the same wavelength of light, whatever it is.³ We might reasonably acquire this opinion by determining that there are no interesting variations in the physical structure of sodium fluoride—it only manifests in one particular crystal structure, say—and holding that only variations in crystal structure or chemical kind could plausibly be relevant.

Let's compare the confirmation of hypotheses of differing levels of precision. Suppose we assign 0.9 as our probability that all sodium fluoride is relevantly causally similar, and we distinguish 9 different colors. So, the candidate hypotheses we countenance that are consistent with relevant causal similarity are “all sodium fluoride burns *yellow*”, “all sodium fluoride burns *green*”, “all sodium fluoride burns *bluish-green*”, and so on, for 9

³ Assume for simplicity that we're confident the emitted light will be monochromatic.

different colors. We're not going to worry about the priors assigned to these hypotheses. As we shall see, they will get rapidly washed out once the evidence comes in.

Regarding the likelihoods, assume we know the samples we'll be burning are sodium fluoride. In that case where e_i specifies that a sample burns the i^{th} color and h_j is "being sodium fluoride causes burning with the j^{th} color", we will simply have $P(e_i|h_j) = 1$ for $i = j$, and $P(e_i|h_j) = 0$ for $i \neq j$.

Suppose our first observed sodium fluoride sample burns yellow i.e., $e =$ "this sample of sodium fluoride burned yellow". At that point, we immediately decisively disconfirm all the uniform color hypotheses, bar one, since for all j , bar one, $P(e|h_j) = 0$. Thus, provided that observation of yellow burning doesn't for some strange reason decrease our confidence in relevant causal similarity, Bayesian conditionalization on e gives the entire 0.9 to "all sodium fluoride burns yellow", which we'll call h_3 , i.e., we have:

$$P(h_3|e) = 0.9$$

Bayes's theorem specifies that:

$$P(h_3|e) = [P(e|h_3)/P(e)] \cdot P(h_3)$$

Since $P(e|h_3) = 1$, it must be that $P(e)$ suitably *matched* the prior for h_3 , $P(h_3)$. The general requirement is that $P(h_i)$ and $p(e_i)$ must match in the following sense:

$P(e_i)$ should equal the proportion of the probability assigned to relevant causal similarity (i.e. to the disjunction of hypotheses that posit invariant color of burning for all sodium fluoride) that is assigned to $P(h_i)$.

In this particular case, $P(e)$ should equal the proportion of 0.9 that is assigned to $P(h_3)$. So, if $P(h_3) = 0.1$, $P(e) = 0.1/0.9 = 1/9$.

This assignment for $P(e)$ is clearly rationally permissible, and is satisfied provided that, quite reasonably, we don't modify our confidence in relevant causal similarity on learning the sample burned yellow.

Let's compare this with confirmation of a more precise hypothesis. Suppose we are now interested in the wavelength of the emitted light, and let's assume that our confidence in relevant causal similarity, as before, is 0.9. That is, our probability that all instances of sodium fluoride uniformly emit the same wavelength of light (and hence, burn the same color) is 0.9.

Let $\Lambda =$ "burning sodium fluoride uniformly emits light with $\lambda = 589\text{nm}$ ". Given that we know that light with $\lambda = 589\text{ nm}$ is yellow light, $P(\Lambda) \leq P(h_3)$. Indeed, a rational agent may well have $P(\Lambda) \ll P(h_3)$. For definiteness, suppose we are willing to countenance 1,000 different values for the wavelength, including $\lambda = 589\text{ nm}$. We might reasonably have $P(\Lambda)$ of the order of $1/1000$, say, and let us say that $P(h_3) = 1/10$ as before.

Suppose our first ignited sample of sodium fluoride emits light of wavelength $\lambda = 589$ nm i.e., $e =$ “the emitted light has $\lambda = 589$ nm”. The confirmational phenomenology will be identical to the previous case where we were only interested in color of burning. The first observation will eliminate all the causally uniform competitors i.e., all of the hypotheses that specify that all instances of burning sodium fluoride uniformly emit some particular wavelength, λ , other than 589nm. And, again, such an observation need not affect our probability that all instances of sodium fluoride are relevantly causally similar i.e., they invariably emit the same wavelength of light and the same color. So, we have $P(\Lambda|e) = p(h_3|e) = 0.9$.

Thus, conditionalization on e will raise our personal probability for both Λ and h_3 to 0.9, but our prior for Λ was much smaller than our prior for h_3 . So, on any reasonable measure of confirmation, Λ is better confirmed than h_3 by e .⁴ Moreover, the only difference would seem to be the precision of the hypotheses. If Λ had not been so precise, it would not have been so strongly confirmed, since other things being equal, it would have had a higher prior. Had h_3 been more precise, it would have been better confirmed, since other things being equal, it would have had a lower prior. So, precision can function as a confirmational virtue.

⁴ See Fitelson (1999) for a general discussion of such measures.

4.3 Explanatory Scope and Unification

To the extent that a theory increases its explanatory scope by facilitating more predictions, explanatory scope can be a confirmational virtue. If $P(e) < 1$, and the theory, T , in tandem with the background assumptions codified in $P(\cdot)$, predicts e , then $P(e|T) = 1$. Hence, by Bayes's theorem, $P(T|e) > P(T)$. Thus conditionalizing on e will confirm T . However, other things being equal, if T 's scope were reduced so that it no longer explained or predicted e , it would not have been confirmed by e . Explanatory scope can indeed be a confirmational virtue.

Regarding Salmon's example, Newtonian mechanics provides better explanations of various phenomena than the conjunction of Galileo's law of falling bodies and Kepler's laws of planetary motion, at least in part, because it provides a *unified*, or *consilient*, explanation of the subsumed phenomena. Since unification often goes hand in hand with explanatory scope, let's briefly explore how unification can facilitate confirmation.

As discussed, a rational agent may strongly confirm "being a sodium salt formed from a carboxylic acid causes yellow burning" by an argument from analogy. That argument only works if we can infer that the subsumed cases are not relevantly causally disanalogous. So, it works only if the inferred hypothesis provides a *unified* explanation. There's no good reason why such an argument from analogy should not generate a very high level of confidence in such a unifying hypothesis, notwithstanding its enormous scope—it covers an

unlimited family of chemical kinds. So, there's no obvious general reason to think that explanatory scope is a serious impediment to our strongly confirming a theory.

Indeed, confirmation of unifying hypothesis can plausibly elevate the probabilities of entailed hypotheses of lesser scope to *much* higher levels than they would otherwise have had. An agent who does not see any analogy between the various kinds of sodium salts will presumably—for preface paradox like reasons, at least—assign arbitrarily low probabilities to arbitrarily long conjunctions of the form “being the first chemical kind of sodium salt in this family causes yellow burning & being the second chemical kind of sodium salt in this family causes yellow burning &...”. Such finite conjunctions are of lesser scope than the unifying explanatory hypothesis. However, an agent who sees the analogy and strongly confirms the unifying explanation will thereby elevate all the entailed conjunctions of lesser scope to at least the same probability.

5. Prospects: Causal Inference as Inference to the Best Explanation

As noted, it has commonly been supposed that causal inference is not IBE. However, our argument from analogy crucially involves relevant causal similarities and dissimilarities, and hence, so does the associated account of unification. Causal inference was also explicitly implicated in our defense of precision. This suggests a connection. Let's briefly explore this possibility, focusing on the confirmation of “all sodium salts formed from carboxylic acids burn yellow”.

Our argument from analogy strongly resembles an application of Mill's (1875, 451) method of agreement:

If two or more instances of the phenomenon under investigation have only one circumstance in common, the circumstance in which alone all the instances agree, is the cause (or effect) of the given phenomenon.

The premises of the analogy indeed specify only one causally relevant circumstance that all the molecules in that family have in common, the common molecular form $\text{H}(\text{CH}_2)_n\text{COONa}$, and its conclusion is that all molecules with that common structure cause the same color of burning and for the same reason.

There is an important difference, however. Mill viewed his method of agreement (1875, 455-6) as tentative, providing only modest support for its conclusion. Indeed, he held that we only ultimately rely upon it when we're incapable of experimentally realizing the conditions for application of the superior method of difference. By contrast, we hold our argument from analogy as capable of strongly confirming its conclusion and not a mere poor relation of the method of difference.

The difference is due to the fact that our argument is more demanding than Mill's method of agreement. Mill demands only "two or more instances of the phenomenon". We demand:

(P2) For a sufficient variety of values of n , the observed color of burning is invariantly the same.

What's a sufficient variety? A sufficient variety to justify holding that for *every* possible variation of the disagreeing factors—in this case, every molecular structure in the family $\text{H}(\text{CH}_2)_n\text{COONa}$, for $n \geq 0$ —we invariantly get the same color of burning.

How should we generally specify the set of kinds of cases we must cover? For a kind to merit inclusion we must believe that its individuating factor could be a cause of disconfirmation: we won't include *sodium formate burnt on the weekend* and *sodium formate burnt on a weekday* as kinds unless we have very unusual background beliefs about potential causal relevance. Further, we should also be confident that cases of a kind are relevantly causally similar: granted such confidence, a rational agent is positioned to strongly confirm that all cases of that kind burn yellow. If we believe that sodium formate might be realized in different crystal forms and that such variations might well be causally relevant to flame color, merely observing that sodium formate samples burn yellow won't justify strongly confirming that all sodium formate does. So, in specifying our set of kinds, we "drill down" until we're confident that cases of each kind are relevantly causally similar. Thus, the kinds of cases that must be covered by our data are causally individuated kinds of Potential Disconfirmers (hereafter, "kinds of PDs") of the generalization in question i.e., kinds for which:

- (i) We have a high degree of confidence that the subsumed cases are relevantly causally similar,
- (ii) There is a single individuating factor that we believe might be causally relevant to the production of disconfirming cases.

With this definition in place, we can specify our modified method of agreement as follows.

To strongly confirm the causal generalization, we must (1) determine the set of possible kinds of PDs for that generalization, and (2) acquire evidence that justifies holding that each such kind indeed conforms to the generalization.

Our modified methodology can justify strongly confirming “all sodium salts formed from carboxylic acids burn yellow”. Confirmation that a kind of PD conforms to the generalization is straightforward. Given (i), a high degree of confidence that all sodium formate, say, is relevantly causally similar, an agent that is inductively rational will strongly confirm “being sodium formate or something associated with that causes yellow burning” given observation of only a modest number of uniformly yellow burning samples of sodium formate.⁵ Similarly, we can strongly confirm the corresponding causal generalizations for

⁵ Inductively rational in the minimal sense that, excepting situations where the agent has very unusual background beliefs, merely learning that the samples uniformly burn yellow will not prompt her to lose confidence that all sodium formate is relevantly causally similar. We appealed to this assumption in our brief formal discussion in 4.2.

each of a suitable variety of kinds of PDs corresponding to different values of n . Hence, we can plausibly justify (P2), and by way of our argument from analogy, strongly confirm “all sodium salts formed from carboxylic acids burn yellow”. Moreover, we can see how similarly strongly confirming that other families of sodium salts burn yellow could ultimately lead, by a similar argument by analogy now prosecuted over the set of such families, to strongly confirming “all sodium salts burn yellow”.

We’ll now briefly argue that another canonical explanatory virtue, simplicity, also has a natural role in this account. Paul Thagard (1978, 87) characterizes simplicity as inversely related to the size of the set of auxiliary assumptions, A , required by T to explain the set of facts F , where an auxiliary hypothesis “is a statement, not part of the original theory, which is assumed in order to help explain one element of F , or a small fraction of the elements of F .” He introduces a comparative notion on which we adjudicate between Theories T_1 and T_2 by comparing the associated sets of auxiliary hypotheses AT_1 and AT_2 . However, as he recognizes, it’s unclear how to make that comparison. We can’t just count the number of sentences in the two sets, since we can trivially amalgamate all the auxiliaries in each set into one conjunction, and we can’t use a subset relation, since competing theories will commonly employ entirely distinct sets of auxiliaries.

Causal inference yields an account that fits Thagard’s reasonable concern with auxiliary hypotheses but doesn’t involve problematic sentence counting or subset relations. Consider Huygens’s (1950) original wave theory of light which posits a single hypothesis for

the propagation of light through arbitrary media: take each point in the medium as a source of spherical wavelets. We can test this hypothesis by observing the propagation of light through a variety of different kinds of media, and if we find that across a broad variety of such media light uniformly propagates in a manner explained by the spherical wavelet principle, we can strongly confirm it. In terms of our account of causal inference, each medium or suitably individuated species of medium will constitute a kind of PD for the spherical wavelet hypothesis, and strongly confirming that each of a suitable variety of kinds of PDs conform underwrites an argument by analogy that allows us to well confirm the spherical wavelet hypothesis.

Huygens was compelled to introduce an auxiliary posit of spheroidal as opposed to spherical wavefronts for Iceland crystal and other birefringent substances. Once we introduce the auxiliary, instead of one hypothesis we have two, the spherical and spheroidal wavelet hypotheses that respectively cover only the non-birefringent and birefringent media. While we can strongly confirm each by analogy, we can't well confirm their conjunction in that way. So, at best, our explanatory theory for all optical media consists of the conjunction of two strongly confirmed hypotheses, and other things being equal, that plausibly gets a lower probability than a single hypothesis that covers all the cases as would have been Huygens's initial hope. More generally, the more an explanatory hypothesis or theory fragments the domain to be explained, the less strongly our data can confirm it, *ceteris paribus*. So, simplicity seems to have a natural place in our account of causal inference.

Moreover, Thagard's arbitrariness problem has gone away. In causal inference, simplicity is not about number of auxiliaries; it's about the number of distinct explanations invoked to explain a phenomenon across a given set of kinds of cases. Thus, it's inversely related to the number of domain-specific laws or causal generalizations invoked. On this construal, unification and simplicity are closely, and inversely, related: a unified explanation of a given set of kinds of cases will be simpler than a non-unified one.

We have a very partial outline of an account of causal inference that is recognizably IBE, offering as it does a home for mechanism, analogy, simplicity, unification, and precision. Much more must be said to properly develop it. However, we can't do that here. It should be noted that, given the normative force of rational causal inference, the Bayesian version of this account will neither be a heuristic account of the kind advocated by Lipton (2004) and others, nor an emergent compatibilist account of the kind proposed by Henderson (2014). Its causal basis also differentiates it from proposals of the kind endorsed by Huemer (2009) and Poston (2014). So, it should ultimately yield a novel, objective Bayesian confirmation theory.

References

Cabrera F. 2017. "Can there be a Bayesian Explanationism? On the Prospects for a Productive Partnership." *Synthese* 194: 1245-1272.

Fitelson, B. 1999. "The Plurality of Bayesian Measures of Confirmation and the Problem of Measure Sensitivity." *Philosophy of Science* 66: S362-S378.

Henderson, L. 2014. "Bayesianism and Inference to the Best Explanation." *British Journal for the Philosophy of Science*, 65: 687–715.

Huemer, M. 2009. "Explanationist Aid for the Theory of Inductive Logic." *British Journal for the Philosophy of Science*, 60: 345-375.

Huygens, C. 1950. *Treatise on Light* (trans. Silvanus P. Thompson). Chicago: University of Chicago Press.

Lipton, P. 1993. *Inference to the Best Explanation*. New York: Routledge

Lipton, P. 2004. *Inference to the Best Explanation* (2nd Edition). New York: Routledge.

Mill, J.S. 1875. *A System of Logic, Ratiocinative and Inductive Vol. I* (9th edition). London: Longmans, Green, and Co.

Poston, T. 2014. *Reason and Explanation*. Basingstoke: Palgrave Macmillan.

Rappaport, S. 1996. "Inference to the Best Explanation: Is it really different from Mill's Methods?" *Philosophy of Science*, 63: 65-80.

Roche, W. and Sober, E. 2013. "Explanatoriness is evidentially irrelevant, or inference to the best explanation meets Bayesian confirmation theory." *Analysis* 73: 659-68.

Salmon, W.C. 1990. "Rationality and Objectivity in Science or Tom Kuhn meets Tom Bayes" in *Scientific Theories* ed.C. Wade Savage, 175-204. Minneapolis: University of Minnesota Press.

Thagard, P. 1978. "The Best Explanation: Criteria for Theory Choice." *The Journal of Philosophy* 75: 76-92.