Philosophy of Science (2024), **91**, 243–252
doi:10.1017/psa.2023.92

PSA PHILOSOPHY OF SCIENCE ASSOCIATION

PHILOSOPHY OF SCIENCE

DISCUSSION NOTE

Reply to Sprenger's "A Novel Solution to the Problem of Old Evidence"

Fabian Pregel

Faculty of Philosophy, University of Oxford, Oxford, UK
Email: fabian.pregel@philosophy.ox.ac.uk

(Received 04 August 2021; revised 22 April 2022; accepted 17 June 2023; first published online 10 July 2023)

Abstract

I discuss a contemporary solution to the dynamic problem of old evidence (POE), as proposed by Sprenger. Sprenger's solution combines the Garber–Jeffrey–Niiniluoto (GJN) approach with Howson's suggestion of counterfactually removing the old evidence from scientists' belief systems. I argue that in the dynamic POE, the challenge is to explain how an insight under beliefs in which the old evidence E is known increased the credence of a scientific hypothesis. Therefore, Sprenger's counterfactual solution, in which E has been artificially removed, does not resolve the problem. I consider several potential responses.

1. Introduction

According to Bayesian confirmation theory (BCT), evidence E confirms a hypothesis H if $P(H|E) > P(H)$. One venerable challenge to BCT is the problem of old evidence (POE). Garber (1983) distinguishes between an *ahistorical* and a *historical* version of the problem, and Sprenger (2015) similarly distinguishes between a *static* version and a *dynamic* version. In both versions, evidence E is already known ("old evidence"). The *dynamic/historical problem* is to explain how E can increase our belief in hypothesis H in the moment when scientists realize that H entails E. By contrast, the *static/ahistorical problem* is to explain how E can still serve as confirmation of H long after one realizes that H entails E. In this article, I discuss a contemporary solution to the dynamic problem proposed by Sprenger (2015).

The dynamic problem is motivated by Glymour's (1980, 85–86) observation that, in the history of science, there are instances when scientists (e.g., Kepler, Newton, Einstein) viewed new theories as supported by evidence that had been known for a substantial period of time. A classic example is Einstein's discovery in 1915 that the general theory of relativity implied the advance of the perihelion of Mercury (APM), a previously known but unexplained variation in the point when Mercury is closest to the sun. In 1915, APM had already been observed for half a century (Glymour 1980, 86). The dynamic problem here is that it is challenging for a Bayesian to explain how

APM increased our confidence in general relativity because, in a classical Bayesian framework, once evidence E has been observed and conditionalization has occurred, E can no longer be used as incremental support for any new hypothesis H (Glymour 1980, 86). Consider updating the belief in theory H based on prior evidence E and current beliefs P just prior to Einstein's realization in 1915:

$$P'(H) = P(H \mid E) = \frac{P(H) \times P(E \mid H)}{P(E)}. \tag{1}$$

As E had been observed half a century before Einstein's 1915 discovery, in 1915, we have

$$P(E) = 1; \tag{2}$$

consequently,

$$P(E \mid H) = \frac{P(E \,\&\, H)}{P(H)} = \frac{P(H)}{P(H)} = 1. \tag{3}$$

Substituting Equations 2 and 3 into 1 yields $P'(H) = P(H)$. Therefore, in 1915, old evidence E can no longer increase our confidence in H.

2. Attempted solutions to the dynamic problem

In response, a Bayesian could insist that the historic examples occurred only because, when E was observed, scientists did not realize that the hypothesis "general relativity" implied APM and thus did not increase $P(H)$ when E was observed. This lapse would not have occurred to a logically omniscient scientist. Bayesianism should therefore be seen as an ideal of a fully rational agent—an account called *ideal BCT* henceforth. To frame Bayesianism as an ideal may seem attractive because Bayesianism is not usually introduced as an empirically grounded behavioral account of what actual scientists do. Instead, Bayesianism is usually presented as an account of what is rational; for example, it is rational for beliefs to conform to Kolmogorov's axioms of probability to avoid a Dutch book (Easwaran 2011, 315). To the extent that scientists' actual behavior approximates that of the ideal Bayesian, Bayesianism may also be a helpful model of actual scientific study, but that is a separate matter.

Yet, examples from the history of science suggest that even the best scientists do not come close to ideal Bayesianism. Copernicus showed that heliocentrism could explain well-known observations, such as retrograde motion, eighteen centuries after Aristarchus invented the heliocentric worldview (Niiniluoto 1983, 379). This lack of even approximate compliance with Bayesianism gives rise to a challenge for framing BCT as an ideal. Given science's success, whatever method scientists are using appears rational. So, given the lack of even approximate compliance with ideal Bayesianism, ideal Bayesianism appears far from the only rational method; indeed, it seems superfluous.

Glymour (1980, 91–93) and Garber (1983) suggested an alternative strategy to avoid the superfluidity conclusion—an alternative on which Sprenger's proposal is based: relax the rationality condition in Bayesianism by assuming scientists to be only semirational. How does one relax the rationality condition? The fully rational ideal

https://doi.org/10.1017/psa.2023.92 Published online by Cambridge University Press

Bayesian must assign credence 1 to true implications. For example, suppose hypothesis H implies evidence E (denoted $H \vdash E$).[1] Then, for the ideal Bayesian, $P(H \vdash E) = 1$. To see why $P(H \vdash E) = 1$, suppose the contrary, that is, that, for the ideal Bayesian, $P(H \vdash E) < 1$. If $P(H \vdash E) < 1$, the ideal Bayesian should be willing to accept a bet against $H \vdash E$, provided the payoffs are favorable enough. However, given that, by assumption, H implies E, the ideal Bayesian would be sure to lose this bet. Therefore the only probability assignment to $H \vdash E$ that avoids a sure loss (a Dutch book) is $P(H \vdash E) = 1$.

Because $P(H \vdash E) = 1$ for the ideal Bayesian ex ante, conditionalizing on $H \vdash E$ will not serve to increase their confidence in H:

$$P'(H) = P(H \mid H \vdash E) = \frac{P(H) \times \overbrace{P(H \vdash E \mid H)}^{=1}}{\underbrace{P(H \vdash E)}_{=1}} = P(H). \tag{4}$$

Therefore, for the ideal Bayesian, the discovery that H implies E seemingly has no role to play, analogous to Equation 1, in which we conditioned on E rather than $H \vdash E$.

By contrast, introducing semirationality allows scientists to learn that $H \vdash E$, that is, it permits $P(H \vdash E) < 1$. Garber (1983, 113) proposed implementing semirationality via a language change. Rather than employing a maximally fine-grained language that can describe all possible states of the world, semirational Bayesian scientists employ a more coarse-grained language localized to the problem under study. In the coarse-grained language, the sentence "$H \vdash E$" is taken as atomic. We then impose certain conditions on the probabilities P that the semirational Bayesian scientist assigns to atomic sentences—in particular, that the probabilities obey "modus ponens" (Garber 1983, 115):

$$P(E \mid H \,\&\, (H \vdash E)) = 1. \tag{5}$$

With this framework, we can revisit the dynamic POE—the realization that $H \vdash E$ would constitute confirmation of the hypothesis H if the following can be shown:

$$P(H \mid H \vdash E) > P(H). \tag{6}$$

Aside from satisfying 6, a solution to the dynamic POE should also satisfy Equation 7 to ensure that the evidence is "old" at the time the scientist realizes that H implies E:

$$P(E) = 1. \tag{7}$$

Garber (1983, 121) proved that, subject to the exclusion of certain edge cases (such as $P(H) = 1$ ex ante), an infinite number of probability functions P, representing degrees of belief, satisfy 5, 6, and 7.

However, Garber (1983) merely provided an existence proof for such probability functions. Jeffrey and Earman tried to supplement Garber's proof with sets of conditions on P from which one can prove that learning $H \vdash E$ confirms H, so that one can evaluate whether those conditions on P were plausibly met in historical cases (Sprenger 2015, 388). However, Jeffrey's and Earman's conditions suffer from several

[1] I use $H \vdash E$ in line with the existing literature on the POE, but $\vdash$ is not limited to formal deducibility in a specific deductive system (Garber 1983, 106).

https://doi.org/10.1017/psa.2023.92 Published online by Cambridge University Press

problems. I will not address them here in order to focus on Sprenger's proposal, but the reader may refer to Eells (1990, 219) and Sprenger and Hartmann (2019, 137).

3. Sprenger's approach

In light of the difficulties with Jeffrey's and Earman's proposal, Sprenger tries to provide an alternative set of conditions to derive a condition structurally similar to the desired $P(H \mid H \vdash E) > P(H)$ from 6, namely,

$$\mathfrak{P}(H \mid E \,\&\, (H \vdash E)) > \mathfrak{P}(H \mid E). \tag{8}$$

Here $\mathfrak{P}$ is a counterfactual probability function representing the degree of belief of a scientist who does not know evidence E—thus the term *counterfactual*.

Sprenger (2015, 393) then proposes the following three assumptions:

$$\mathfrak{P}(E \mid H \,\&\, (H \vdash E)) = 1, \tag{9}$$

$$\mathfrak{P}(E \mid \neg H \,\&\, (H \vdash E)) = \mathfrak{P}(E \mid \neg H \,\&\, \neg(H \vdash E)) > 0, \tag{10}$$

$$\frac{1 - \mathfrak{P}(H \vdash E \mid \neg H)}{\mathfrak{P}(H \vdash E \mid \neg H)} \times \frac{\mathfrak{P}(H \vdash E \mid H)}{1 - \mathfrak{P}(H \vdash E \mid H)} > \mathfrak{P}(E \mid H \,\&\, \neg(H \vdash E)). \tag{11}$$

Condition 9 is a counterfactual version of Garber's Equation 5: if the scientist believes H and $H \vdash E$, the scientist also believes E. Condition 10 asserts that if H is false (i.e., $\neg H$), it is irrelevant to the scientist's belief in E whether H would have implied E. Condition 11 is the most complex; I shall not try to provide an intuitive rationale for assuming condition 11 here because my criticism of Sprenger will not depend on it.

Sprenger then proves that, provided the probability measure $\mathfrak{P}$ satisfies conditions 9, 10, and 11, we indeed have 8: $\mathfrak{P}(H \mid E \,\&\, (H \vdash E)) > \mathfrak{P}(H \mid E)$ (Sprenger 2015, 393).

Sprenger's account has two main advantages over previous accounts. First, conditions 9, 10, and 11 seem more plausible than Jeffrey's conditions. For example, one of the implausible implications of Jeffrey's account is that the prior probability of H has to be less than 50 percent ($P(H) \le 1/2$) (Earman 1992, 127).

Second, in a subsequent theorem, Sprenger extends his proof of $\mathfrak{P}(H \mid E \,\&\, (H \vdash E)) > \mathfrak{P}(H \mid E)$ to the case in which hypothesis H plus $H \vdash E$ do not imply evidence E with a probability of 1 but with $1 - \varepsilon$. Formally, Sprenger (2015, 394) does this by relaxing assumption 9 to

$$\mathfrak{P}(E \mid H \,\&\, (H \vdash E)) = 1 - \varepsilon.$$

Relaxing assumption 9 has the advantage of covering a broader, more realistic set of scenarios in science, in which deductions from theories we believe in might not give us absolute certainty, for example, because the deduction involved is very complex (Sprenger 2015, 394).

4. Two challenges for Sprenger's account

Given these advantages, has Sprenger solved the dynamic POE? Not much secondary literature exists yet. The main exception is a paper by Kinney (2019, 4004–5) criticizing Sprenger's conditions for still not accommodating a broad class of

https://doi.org/10.1017/psa.2023.92 Published online by Cambridge University Press

nondeductive relationships between *H* and *E*. However, I want to propose a more fundamental criticism based on Sprenger's use of counterfactual credence $\mathfrak{P}$.

Sprenger makes essential use of counterfactuals in his proof; conditions 9, 10, and 11 all make counterfactual claims about the probability of *E*. In using counterfactuals, Sprenger's solution differs from Jeffrey's and Earman's. There are two main difficulties with employing the counterfactual approach to resolve the dynamic problem.

4.1. Challenge 1: Constructing counterfactual probabilities

The first challenge is how to construct counterfactual probability functions. Sprenger (2015, 392) insists that, when evaluating if evidence *E* supports hypothesis *H*, scientists often think counterfactually about how likely *E* would be if *H* were true versus if *H* were false. Sprenger claims that obtaining $\mathfrak{P}(E \mid H)$ "may be straightforward, or at least a matter of consensus in the scientific community" (392).

The situation may indeed be easy in the case of a narrow, statistical hypothesis. Suppose we are rolling a die. Ex ante, we have different hypotheses about the probabilities of rolling various numbers (the die is fair, the die is loaded toward six, etc.). We proceed to roll (i.e., observe) a specific number sequence *E*. Thus, post observation, $P(E) = 1$, and, consequently, $P(E \mid H) = 1$, for any hypothesis *H* about the loading of the die. We can then calculate the counterfactual $\mathfrak{P}(E \mid H)$; that is, we calculate, for each hypothesis, how likely it is to obtain as evidence *E* the number sequence we actually observed.

However, the case of APM differs from the die case because observation *E* is interwoven with our background knowledge (call it *K*). How can we extricate *E* from *K* to calculate a counterfactual probability for *E*?

We can distinguish three different subissues. The first is obvious—what probability should we assign to $\mathfrak{P}(E \mid H)$ and $\mathfrak{P}(E \mid \neg H)$ given $P(E) = 1$?

The second subissue is how to adjust the credences of logically connected propositions. Given coherence, $P(E) = 1$ implies, for example, $P((\neg E) \rightarrow Q) = 1$ and $P(E \vee Q) = 1$ for any proposition Q. Once we delete *E*, what probability are we to assign to $\mathfrak{P}((\neg E) \rightarrow Q)$ and $\mathfrak{P}(E \vee Q)$ (Chihara 1987, 553)? We can use the addition rule $\mathfrak{P}(E \vee Q) = \mathfrak{P}(E) + \mathfrak{P}(Q) - \mathfrak{P}(E \,\&\, Q)$, but using it still requires counterfactual probabilities for *Q* and $E \,\&\, Q$.

The third subissue is what credence to assign to propositions involving beliefs in *K* that are not logically dependent on knowledge of *E* but would not be in *K* had we not observed *E*—for example, outcomes of experiments conducted because *E* was observed (Chihara 1987, 553). Those additional experiments could, for example, reconfirm *E*, lead to a better understanding of *E*, or lead to observing *E*-like phenomena elsewhere. Extricating all beliefs causally dependent on *E* would require either rewinding the clock to the point just before *E* was observed or constructing a counterfactual scientific history in which *E* was not observed. Rewinding the clock would not address the dynamic problem; Einstein's beliefs in 1915 were nothing close to those of scientists in 1859, when Urbain Le Verrier recognized the perihelion. On the other hand, constructing a counterfactual scientific history seems practically impossible.

The best defense Sprenger has available is to maintain that, in practice, these problems are overcome by actual scientists weighing the support a hypothesis receives from observed evidence, perhaps using heuristics. This defense relies on an empirical claim. If heuristics are to save the counterfactual proposal, then it would be good to understand how these heuristics work and whether they are still Bayesian. After all, Sprenger's improvement of Jeffrey's and Earman's proposal was meant to offer a more realistic set of conditions.

Sprenger could also add that the challenge of how to construct counterfactual beliefs is not specific to his approach but is a challenge for all counterfactual Bayesian accounts. This may be true, but it could also tell against counterfactual Bayesian accounts more generally.

4.2. Challenge 2: Counterfactual solutions for the dynamic problem

The second challenge to Sprenger's account is that in the case of Einstein and the perihelion of Mercury, it was an insight in a belief system in which E was known that raised confidence in general relativity, not an insight in a belief system from which E was artificially deleted. It is this insight in a belief system in which E was known—such as Einstein's in 1915—that the dynamic problem asks us to rationalize in the Bayesian framework.

For the case under consideration in the dynamic POE, E already has probability 1. In 1915, when Einstein discovered that the general theory of relativity implied APM, APM had already been observed for half a century. The dynamic POE is how to explain, in a Bayesian framework, how Einstein's discovery nonetheless increased our credence in the general theory of relativity. Thus we need to find conditions under which $P(H \mid H \vdash E) > P(H)$ rather than conditions under which $\mathfrak{P}(H \mid E \,\&\, (H \vdash E)) > \mathfrak{P}(H \mid E)$.

Garber (1983, 103) had, in fact, already observed this difference and concluded that the counterfactual solution therefore cannot solve the dynamic problem. Thus, to put it forcefully, Sprenger appears to have provided an elegant solution to the wrong problem.

What are possible responses for Sprenger to this challenge? In the following sections, I consider five conceivable answers.

4.2.1. Response 1: Approximation

The counterfactual $\mathfrak{P}(H \mid E \,\&\, (H \vdash E)) > \mathfrak{P}(H \mid E)$ amounts to Garber's $P(H \mid H \vdash E) > P(H)$ if $\mathfrak{P}(E)$ is sufficiently close to 1. Could Sprenger use this to argue that his proposal is a solution to the dynamic problem? After all, in reality, empirical evidence is not typically—and possibly never—known for certain. The APM could have turned out to be a measurement error.

Suppose $\mathfrak{P}(E) = 1 - \varepsilon$ for a sufficiently small ε. This creates two challenges for Sprenger's account. First, Sprenger's own measure of theory confirmation $\mathfrak{P}(H \mid E \,\&\, (H \vdash E)) - \mathfrak{P}(H \mid E)$ becomes very small (namely, $\leq \varepsilon/(1-\varepsilon)$):

$$\mathfrak{P}(H \mid E \,\&\, (H \vdash E)) - \mathfrak{P}(H \mid E) = \underbrace{\mathfrak{P}(H \mid H \vdash E)}_{\approx \mathfrak{P}(H)} \frac{\overbrace{\mathfrak{P}(E \mid H \,\&\, (H \vdash E))}^{=1 \text{ by } (9)}}{\underbrace{\mathfrak{P}(E \mid H \vdash E)}_{\approx 1-\varepsilon}} - \underbrace{\mathfrak{P}(H \mid E)}_{\approx \mathfrak{P}(H)}$$

https://doi.org/10.1017/psa.2023.92 Published online by Cambridge University Press

$$\approx \left(\frac{1}{1-\varepsilon} - 1\right) \times \underbrace{\mathfrak{P}(H)}_{\leq 1}$$

$$\leq \left(\frac{1}{1-\varepsilon} - \frac{1-\varepsilon}{1-\varepsilon}\right) \times 1 = \frac{\varepsilon}{1-\varepsilon},$$

where $\mathfrak{P}(H \mid H \vdash E) \approx \mathfrak{P}(H)$ and $\mathfrak{P}(H \mid E) \approx \mathfrak{P}(H)$ because E and $H \vdash E$ only jointly confirm H, but neither E nor $H \vdash E$ is part of the background knowledge. The measure of confirmation being positive but very small may solve the qualitative aspect of the POE, but really the POE is quantitative; in the historical case, APM provided strong support for general relativity.

Second, as Sprenger notes, one can rewrite the left-hand side of his assumption 11 as a ratio of betting odds. Let the betting odds of an event X be $\text{Odds}\ (X) = [1 - \mathfrak{P}(X)]/[\mathfrak{P}(X)]$. Thus, we can rewrite Sprenger's condition 11 as follows (Sprenger 2015, 393):

$$\frac{1 - \mathfrak{P}(H \vdash E \mid \neg H)}{\mathfrak{P}(H \vdash E \mid \neg H)} \times \frac{\mathfrak{P}(H \vdash E \mid H)}{1 - \mathfrak{P}(H \vdash E \mid H)} > \mathfrak{P}(E \mid H \,\&\, \neg(H \vdash E)),$$

$$\frac{\frac{1 - \mathfrak{P}(H \vdash E \mid \neg H)}{\mathfrak{P}(H \vdash E \mid \neg H)}}{\frac{1 - \mathfrak{P}(H \vdash E \mid H)}{\mathfrak{P}(H \vdash E \mid H)}} > \mathfrak{P}(E \mid H \,\&\, \neg(H \vdash E)),$$

$$\frac{\text{Odds}\ (H \vdash E \mid \neg H)}{\text{Odds}\ (H \vdash E \mid H)} > \mathfrak{P}(E \mid H \,\&\, \neg(H \vdash E)). \tag{12}$$

As $\mathfrak{P}(E)$ approaches 1, the right-hand side of the inequality 12 approaches 1 as well because, by the definition of conditional probability, $\mathfrak{P}(E \mid H \,\&\, \neg(H \vdash E)) = \{\mathfrak{P}[E \,\&\, (H \,\&\, \neg(H \vdash E))]\}/\{\mathfrak{P}[H \,\&\, \neg(H \vdash E)]\}$. Therefore, as $\mathfrak{P}(E)$ approaches 1, condition 12 tells us that Sprenger's assumption 11 becomes equivalent to the rather odd requirement that it is more likely that H implies E (i.e., $H \vdash E$) if H is true than if H is false. This requirement may be met in individual cases but appears to be a contingent matter.

4.2.2. Response 2: Already conditionalizing on E

Alternatively, Sprenger could object to the idea that we need to find conditions under which $P(H \mid H \vdash E) > P(H)$ rather than conditions under which $\mathfrak{P}(H \mid E \,\&\, (H \vdash E)) > \mathfrak{P}(H \mid E)$. After all, in the counterfactual case, we are still conditionalizing on E, and so, in a sense, the evidence is "old."

Now, by assumption, Einstein's beliefs in 1915 were not $\mathfrak{P}(X \mid E)$ but $P(X)$, for any event X, because the evidence E was known and so incorporated into the credences. This much is uncontroversial—$\mathfrak{P}$ is defined as counterfactual after all. Of course, if we set the counterfactual credences conditioned on the evidence $\mathfrak{P}(X \mid E)$ equal to the actual credence $P(X)$, then the criticism that we are not discussing the actual credence P is blunted. However, in that case, the POE enters into the counterfactual version: if $\mathfrak{P}(X \mid E) = P(X)$ for any event X, then, in particular,

$$\mathfrak{P}(H \mid E \,\&\, (H \vdash E)) = P(H \mid H \vdash E) \tag{13}$$

https://doi.org/10.1017/psa.2023.92 Published online by Cambridge University Press

$$\mathfrak{P}(H \mid E) = P(H). \tag{14}$$

Furthermore, from the POE for the actual (i.e., not counterfactual) degrees of belief in Equation 4,

$$P(H \mid H \vdash E) = P(H). \tag{15}$$

Combining Equations 13, 14, and 15, we obtain

$$\mathfrak{P}(H \mid E \,\&\, (H \vdash E)) = \mathfrak{P}(H \mid E).$$

Therefore Sprenger's desired $\mathfrak{P}(H \mid E \,\&\, (H \vdash E)) > \mathfrak{P}(H \mid E)$ from 8 can no longer be shown.

4.2.3. Response 3: The accusation of question begging

However, one may sense that there is another response in the vicinity. Perhaps it is simply question begging to insist that $P(H \mid H \vdash E) > P(H)$ rather than $\mathfrak{P}(H \mid E \,\&\, (H \vdash E)) > \mathfrak{P}(H \mid E)$ be shown. After all, Sprenger is explicit about his counterfactual approach. So, is criticizing Sprenger's very approach not question begging?

In response, it may be helpful to introduce the following distinction: to be question begging is to assume the very point one is trying to prove. But it should be legitimate to challenge whether a proposed solution to a well-specified problem is indeed a valid solution. Refusing a proposed solution is not automatically question begging. It would be question begging if no argument was being made to substantiate the refusal. But we have just such an argument: by looking at the definition of the dynamic POE and its motivation, we observe that Sprenger's solution does not show what was supposed to be shown. For example, as noted earlier, Garber (1983, 103) had already observed that a counterfactual solution does not address the dynamic problem.

Of course, this does not need to be the end of the dialectic; one may ask, for example, whether the dynamic problem, rather than being solved, is instead misconceived or illusory and should be reframed or dissolved.

As is evident from both the title and the discussion, Sprenger's article is framed as a solution to the dynamic POE rather than as an attempt to convince us that the problem is illusory—the very title of Sprenger's article is "A Novel Solution to the Problem of Old Evidence." Nonetheless, we can ask whether Sprenger would be better off pursuing this alternative—responses 4 and 5.

4.2.4. Response 4: A counterfactual theory

One may insist that Bayesianism is simply a counterfactual theory and that therefore $\mathfrak{P}(H \mid E \,\&\, (H \vdash E)) > \mathfrak{P}(H \mid E)$ rather than $P(H \mid H \vdash E) > P(H)$ ought to be shown. In fact, Sprenger (2015, 386) endorses Howson's approach of a counterfactual interpretation of Bayesianism. Similar to Sprenger, Howson (1984, 246) proposed measuring the strength of support theory H receives from evidence E as $\mathfrak{P}(H \mid E) - \mathfrak{P}(H)$, relative to background knowledge K from which E is subtracted (denoted $K - \{E\}$).

However, because whether E confirms H is assessed relative to background knowledge $K - \{E\}$, we have $\mathfrak{P}(E) \neq 1$. In fact, in most practical scenarios, $\mathfrak{P}(E)$ will be far below 1. Therefore the dynamic problem does not arise in counterfactual Bayesianism. Because E is not known, there is no POE. But that also means that, provided we are willing to adopt Howson's counterfactual framework, Sprenger's Garber-style solution appears unnecessary to solve the dynamic problem. Howson (2017, 674), in fact, dismissed the need for a Garber-style solution to the dynamic problem.

4.2.5. Response 5: The hybrid problem

Sprenger and Hartmann's (2019) book *Bayesian Philosophy of Science* takes a slightly different approach than Sprenger's (2015) article. They suggest that the proposed counterfactual solution addresses a "hybrid" version of the problem:

> We are not interested in reconstructing why X [whether H implies E] confirmed H for the actual discoverer of H, but in whether X should confirm H for all scientists in the community. This question is related to the static POE in so far as confirmation is detached from an agent's actual degrees of belief at a particular time. We explicate evidential support by explanatory discoveries relative to a counterfactual probability function, like in the static POE. That's why we would like to call it the hybrid POE. (143)

I think this suggestion is blending two separate proposals—both of which have merit, but only one of which could help the Bayesian with the POE. For the sake of argument, let us suppose that we can aggregate individual scientists' beliefs at a given time into a coherent assignment of probabilities for a scientific community. Focusing on such a scientific community then seems justified—after all, what beliefs Einstein held in 1915 may be somewhat idiosyncratic. Einstein may, for example, already have attributed greater credence to the theory of general relativity than the scientific community. However, whether we focus on Einstein specifically or the whole scientific community at some time point seems orthogonal to solving the POE—in either case, the challenge is to explain, in a Bayesian framework, how learning that H implies E increases the credence of H when E is already known.

The element in Sprenger and Hartmann's (2019) proposal of relevance to the dynamic problem is their insistence that even in a counterfactual framework, the impact of implication learning needs to be explained. As we saw earlier, there is no POE in the counterfactual framework because $\mathfrak{P}(E)$ is not 1 and is typically far less. Consequently, there is no need for a Garber-style solution to such a problem in the counterfactual framework. However, the need to relax the logical omniscience assumption in the way Garber did can still be motivated by the empirical observation that scientists are, in fact, working out theoretical implications over time. Thus a *credible* counterfactual theory should still account for implication learning over time. Sprenger's proposal may be suited to filling that gap. However, this is a separate matter, for, as we saw, in the counterfactual framework, the dynamic POE does not arise. Solving this challenge, the "hybrid problem" in Sprenger and Hartman's terminology, should thus not seduce us into thinking that Sprenger's (2015) article has provided a successful solution to the dynamic POE.

Acknowledgments. I am very grateful to Alexander Bird, Alexander Paseau, the participants of the Defective Science workshop at UNILOG 2022, and *Philosophy of Science*'s referees for their comments and suggestions.

References

Chihara, Charles Seiyo. 1987. "Some Problems for Bayesian Confirmation Theory." *British Journal for the Philosophy of Science* 38 (4):551–60.

Earman, John. 1992. *Bayes or Bust? A Critical Examination of Bayesian Confirmation Theory*. Cambridge, MA: MIT Press.

Easwaran, Kenny. 2011. "Bayesianism I: Introduction and Arguments in Favor." *Philosophy Compass* 6 (5):312–20.

Eells, Ellery. 1990. "Bayesian Problems of Old Evidence." In *Scientific Theories*, edited by C. Wade Savage, 205–23. Minnesota Studies in the Philosophy of Science 14. Minneapolis: University of Minnesota Press.

Garber, Daniel. 1983. "Old Evidence and Logical Omniscience in Bayesian Confirmation Theory." In *Testing Scientific Theories*, edited by John Earman, 99–132. Minnesota Studies in the Philosophy of Science 10. Minneapolis: University of Minnesota Press.

Glymour, Clark. 1980. "Why I Am Not a Bayesian." *In Theory and Evidence, 63–93*. Princeton, NJ: Princeton University Press.

Howson, Colin. 1984. "Bayesianism and Support by Novel Facts." *British Journal for the Philosophy of Science* 35 (3):245–51.

Howson, Colin. 2017. "Putting on the Garber Style? Better Not." *Philosophy of Science* 84 (4):659–76.

Kinney, David. 2019. "Inductive Explanation and Garber-Style Solutions to the Problem of Old Evidence." *Synthese* 196 (10):3995–4009.

Niiniluoto, Ilkka. 1983. "Novel Facts and Bayesianism." *British Journal for the Philosophy of Science* 34 (4):375–79.

Sprenger, Jan. 2015. "A Novel Solution to the Problem of Old Evidence." *Philosophy of Science* 82 (3): 383–401.

Sprenger, Jan, and Stephen Hartmann. 2019. *Bayesian Philosophy of Science*. Oxford: Oxford University Press.

Cite this article: Pregel, Fabian. 2024. "Reply to Sprenger's "A Novel Solution to the Problem of Old Evidence"." *Philosophy of Science* 91 (1):243–252. https://doi.org/10.1017/psa.2023.92