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ARTICLE

Explanatory Reasoning and Informativeness

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Abstract
Bas van Fraassen has argued that explanatory reasoning does not provide confirmation for explanatory hypotheses because explanatory reasoning increases information and increasing information does not provide confirmation. We compare this argument with a skeptical argument that one should never add any beliefs because adding beliefs increases information and increasing information does not provide confirmation. We discuss the similarities between these two arguments and identify several problems with van Fraassen's argument.

Keywords: confirmation; explanation; inference to the best explanation; van Fraassen

Consider this example of mundane explanatory reasoning.

Missing Pizza

> You seem to recall placing a box of pizza in the refrigerator last night. You woke up this morning and discovered the box was missing. Your roommate appears to have left early for work. You know that your roommate tends to eat pizza in the morning. You infer that your roommate ate the pizza.

Your belief that your roommate ate the pizza explains the missing box of pizza. You may even come to know that your roommate ate the pizza on the basis of the quality of this explanation. But once you add this belief to your existing beliefs, the new set of beliefs is not more likely to be true than the old set of beliefs. Why? Because it is a logical fact that increasing information never increases probability. Does this mean you should never come to believe something new? Of course not.

Consider the set *S* which contains all your beliefs minus the belief that your roommate ate the pizza. Let us refer to the expanded set of beliefs that includes the belief that "my roommate ate the pizza" as S^+. Because S is a proper subset of S^+ it follows that $Pr(S) \geq Pr(S^+)$. As a result, one might infer that explanatory reasoning is suspect because it seems to license changes to one's set of beliefs that decrease the overall probability of one's set of beliefs. This line of reasoning is similar to van Fraassen's (1983) objection to explanatory reasoning on the grounds that informational virtues are not confirmational virtues.[1] It is so similar in fact that we will argue that the two stand or fall together.[2]

[1]See also van Fraassen (1985).

[2]This is so despite the fact that the first line of reasoning, which we call the "argument against belief addition," can be easily sidestepped by adopting a fine-grained degree of belief model as opposed to a course-grained belief/disbelief/withhold model. As we will see, the general thinking that underlies both arguments fails for reasons independent which belief model is accepted.

Our goal is to focus attention on this particular argument. The idea that a theory's informational content decreases its probability has been observed well before van Fraassen's work on the topic, e.g., by Popper (1959). Popper writes, "[O]f two hypotheses, the one that is logically stronger, or more informative, or better testable, and thus the one which can be better corroborated, is always less probable — on any given evidence — than the other."[3] van Fraassen appeals to this feature of theories to argue that inference to the best explanation cannot justify *belief* in an explanatory theory.[4] Our focus is on this specific criticism of inference to the best explanation in contrast to other criticisms in the literature.[5] We will not focus on van Fraassen's larger project of constructive empiricism because the alleged problem for explanatory reasoning is independent of any particular view about the goal(s) of science. Also, we will not adopt a particular view on the nature of explanation. Van Fraassen's argument, if it works, applies generally to accounts of explanation given the assumption that any account of explanation implies that the explanatory content of a hypothesis is more than a shorthand summary of the data. Moreover, we will not take a particular view of the nature of explanatory quality, i.e., an account of what makes one explanation better than another. Our focus is squarely on a challenge in the epistemology of explanation: viz., that explanatory quality does not confirm—more generally, fails to provide a reason for—the explanatory hypothesis because it increases informational content.

1. The Argument Against Belief Addition

A primary epistemic goal is to have accurate beliefs about the world. This involves the twin subgoals of believing truths about the world and not believing falsehoods about the world.[6] Explanatory reasoning often involves adding a belief that helps make sense of various facts. In the vignette above, one's belief that the roommate ate the pizza makes sense of the fact that the pizza is missing. Life is replete with examples of explanatory reasoning. Why did the team let go of their most valuable player? Answer: the team could no longer afford his salary. Why did the drug company quadruple the price of a popular drug? Answer: they knew that people would be forced to pay more for the drug, and they wanted to make more money.

The argument against belief addition appeals to the claim that it is never appropriate to add a belief to one's current stock of beliefs because adding a belief will never result in a set of beliefs that is more likely to be true. We can express this argument as follows:

[3]Popper (1959, p. 374). Levi (1967) takes Popper to task on this. Popper argues that since this probability claim is true, an acceptance rule should only maximize evidential probability. Levi argues that this implies the skeptical view that one would only accept the deductive consequences of one's total evidence (see Levi 1967, p. 104). Thanks to an anonymous reviewer for drawing our attention to Levi's criticism of Popper's view.

[4]There is some question here as to whether van Fraassen intends this conclusion or only the weaker conclusion that inference to the best explanation cannot justify belief in an explanatory theory over belief in a logically weaker theory. If van Fraassen only intends to support the weaker conclusion, then, even if he is correct, there is no challenge to inference to the best explanation or the justificatory impact of explanatory virtues. Hence, we will only focus on the stronger conclusion. If this is not the best way to understand van Fraassen, then our discussion can be taken as exploring a van Fraassen-inspired argument against explanatory reasoning.

[5]For instance, the best of the bad lot objection (van Fraassen 1989), the extra boost objection (van Fraassen 1989, Okasha 2000, Salmon 2001, Douven 2022), Voltaire's objection (Lipton 2004), or the disjunction objection (McCain and Poston 2019, Schupbach 2023). Importantly, while our focus is distinct from these, our discussion of van Fraassen's argument directly bears on the latter two objections. For example, Voltaire's objection challenges the supporter of inference to the best explanation to provide grounds for thinking that better explanations are more likely to be true. If van Fraassen's argument is correct, then Voltaire's objection will be unanswerable. By showing that van Fraassen's argument is unsound, we open up the possibility of responding to Voltaire's objection. Similarly, since the disjunction objection alleges that inference to the best explanation commits one to accepting conclusions that are likely false, showing that informational virtues are relevant to confirmation helps support the idea that inference to the best explanation does not have to have this result.

[6]See James (1979/1897).

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(1) It is appropriate to add a belief to one's current set of beliefs (B) only if doing so results in a belief set (B^+) that is more likely to be true than B.
(2) Adding a belief to B never makes the resulting set more likely to be true than B.
(3) Therefore, it is never appropriate to add beliefs.

1.1 Initial reply

The argument against belief addition is essentially an argument for a radical form of skepticism. Assume that B is the empty set. This argument would yield the conclusion that it is never appropriate to believe anything because it is never appropriate to add any beliefs to B. Even setting aside the assumption that B is the empty set, this argument leads to the conclusion that it is never appropriate to form new beliefs. Even if one's evidence makes a particular belief, p, epistemically certain, the argument from belief addition would entail that it is not appropriate to believe p. After all, although adding p to B does not yield a B^+ that is less likely to be true than B, it does not yield a B^+ that is more likely to be true either.

Things are even worse than this though. A similar argument to the above would lead to the conclusion that we should give up the beliefs that we have. If we assume that one has a non-empty set of beliefs, removing any beliefs that are uncertain would increase the probability of the resulting belief set. Hence, a principle similar to (1):

(1*) it is appropriate to remove a belief from one's belief set (B) whenever doing so results in a belief set (B-) that is more probable than (B)

could lead to the conclusion that we should give up all our beliefs. But, while Pyrrhonian skeptics would readily accept this conclusion, contemporary fallibilists are more circumspect.

1.2 Rejoinder

In light of the obvious flaw perhaps it is better to understand the argument against belief addition as getting at something a tad weaker. It is never appropriate to add beliefs if doing so lowers the overall probability of one's set of beliefs. Put more formally:

(1′) It is appropriate to add a belief to one's current set of beliefs (B) only if doing so results in a belief set (B^+) that is no less likely to be true than B.
(2′) Adding an uncertain belief to B always makes the resulting set less likely to be true than B.
(3′) Therefore, it is never appropriate to add uncertain beliefs.

1.3 Surrejoinder

This revised version of the argument against belief addition is valid. Suppose one's belief set B includes the beliefs, $b_1, b_2, \ldots, b_n$. If you add a belief, q, to this set of beliefs then the relevant probability is:

$$P(b_1 \& b_2 \& \ldots \& b_n \& q) = P(b_1 \& b_2 \& \ldots \& b_n) \times P(q | b_1 \& b_2 \& \ldots \& b_n).$$

As long as

$$P(q | b_1 \& b_2 \& \ldots \& b_n) < 1 \text{ then } P(b_1 \& b_2 \& \ldots \& b_n) > P(b_1 \& b_2 \& \ldots \& b_n \& q).$$

So, the above argument implies it is never appropriate to add a belief that has a probability conditional on the evidence that is less than 1. This problem is one that afflicts explanatory reasoning because when we reason to an explanation of a phenomenon, we often are not certain

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of the truth of that explanation. Consequently, adding a belief in a claim on the basis of explanatory reasoning will often decrease the overall probability of one's set of beliefs. The cost then of expanding one's view of the world is often that it decreases the probability of one's total view. But this consequence does not just afflict explanatory reasoning. It afflicts any method of belief addition that permits adding a belief that is less than epistemically certain.

This consequence is again deeply skeptical. The revised argument against belief addition favors too heavily the injunction to disbelieve falsehoods. If, for instance, the probability of a claim on one's evidence is .98 then following this argument one ought not believe it. But it is reasonable to believe that a random draw from a deck of playing cards will result in a card other than the King of Hearts. Hence (1′), like (1), is false.

Compare this situation with the Preface Paradox (Mackinson 1965). You believe each of the claims in your non-fiction book. In the book's preface, you acknowledge that errors remain. It is natural to understand this admission as involving the belief that the conjunction of all the claims in your book is false. This is paradoxical because your beliefs are logically inconsistent; you believe each claim but believe the conjunction of all of the claims is false. The argument against belief addition would seem to counsel one to never write a non-fiction book that involves belief in each of its claims unless each claim has probability 1 (in which case the conjunction of all those claims would have probability 1 too). But this is not a good response to the Preface Paradox because the evidential quality of each specific claim can be high enough for belief, even if less than one. It is also worth observing that the Preface Paradox does not involve any claim about explanatory reasoning; rather it is about how believing on the basis of significant evidential quality can seemingly lead to inconsistent beliefs.[7]

2. van Fraassen's Argument

The argument against belief addition is deeply skeptical and should be rejected. If this were our only point, this paper would not be all that interesting. It is not our only point though. As we will show, a seemingly more respectable argument attacking explanatory reasoning is actually a version of the argument against belief addition. As a result, this seemingly more respectable argument should likewise be rejected on similar grounds.

van Fraassen identifies two kinds of virtues that a theory may possess. First, there are confirmational virtues. These are "features that give us more reason to believe this theory to be true."[8] Second, there are informational virtues. These are features by which a theory tells us more about the world than another theory. With this in mind, here is van Fraassen's argument against the claim that explanatory reasoning provides confirmation.[9]

(V1) If theory T' provides information that T does not provide, and not conversely, then T' is no more likely to be true than T.
(V2) A feature of T cannot provide more epistemic reason to believe that T unless it makes T more likely to be true.

So,

(V3) Informational virtues are not confirmational.

[7]We are not interested in defending a particular response to the Preface Paradox here. Rather, we simply note that a number of plausible responses to this paradox do not involve assigning probability 1 to each claim made in one's book (see, for example, Clarke 2017; Ryan 1991; and Smith 2010).

[8]van Fraassen (1983, p. 166)

[9]van Fraassen (1983, pp. 166–167). Cf Hempel's (1965, pp. 334–335) distinction between two kinds of why-questions: explanation seeking why-questions and confirmation seeking why-questions.

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Recognizing that better explanations often provide more information, we can draw out another conclusion from van Fraassen's argument that makes explicit its connection with explanatory reasoning.

(V4) The fact that T' is a better explanation than T is no epistemic reason to believe T' over T.

One might attempt to mitigate the skeptical consequences of van Fraassen's view by drawing on his distinction between belief and acceptance. After all, this distinction is at the core of van Fraassen's constructive empiricism. As he says, "Acceptance of a theory involves as belief only that it is empirically adequate" (van Fraassen 1980, p. 12). This is importantly different than *believing* a given theory.[10] Consequently, van Fraassen allows that informational virtues might make one theory more worthy of *acceptance* than another theory, even if such virtues do not make a theory more worthy of *belief* than its competitors. Belief involves committing to the truth of the theory whereas acceptance involves treating the theory as true for the purposes of investigation (e.g., making the theory a working hypothesis). So, on his view, while explanatory quality offers no reasons to believe a theory over its competitors, it can offer reasons to accept a theory. This does not, however, remove the skeptical consequence of (V4).[11]

In the following, we offer several reasons that the argument from (V1) to (V4) is not persuasive. To anticipate, we argue that (V1) is limited in scope and so does not apply to explanatory reasoning generally. We then present three independent problems with (V2) that suggest either (i) it is true but not relevant to explanatory reasoning, or (ii) it is false and so does not threaten explanatory reasoning. The upshot of our discussion is that the informativeness challenge to explanatory reasoning should be dismissed. Let us turn to the details.

2.1 Regarding V1

The first premise of van Fraassen's argument construes T' as a proper expansion of T. All the information in T is likewise in T' and there is additional information in T'. This premise exploits the logical fact, explained above, that the probability of a proper expansion of a belief set is never greater than the probability of the original belief set. This should give us pause as it suggests that van Fraassen's argument here may be nothing more than the above revised argument against belief addition.

Although we grant the truth of (V1) in our discussion, it is worth noting that it has limited force in an argument against explanatory reasoning. When we think about the nature of theories and the relationships between theories, a new theory T' may provide more information by explaining how other well-supported theories are consistent with the earlier T, and in doing so provide further support for T. Kepler's second law (Law of Equal Areas) was effectively explained and generalized by Newton's laws. Kepler's second law states that a line segment joining a planet and the sun sweeps out equal areas during equal intervals of time. This law implies that a planet moves faster when it is closer to the sun and slower when it is farther from the sun. Newton's law of universal gravitation and the conservation of angular momentum explained that the reason for the acceleration and deceleration of planets is the gravitational pull of the sun, which changes in strength with the distance between the sun and the planet. Newton's laws replace and generalize Kepler's law. The change from Kepler's

[10]Some argue that van Fraassen's position here is inconsistent because his construal of acceptance renders it the same as belief (see, for example, Blackburn 1984, Mitchell 1988, and Horwich 1991; see Maher (1990) for responses on behalf of van Fraassen). We set this concern aside here and allow that acceptance and belief are genuinely distinct attitudes.

[11]McKay (2023) also argues that van Fraassen's attack on inference to the best explanation leads to absurdly skeptical consequences. The problems that we highlight for van Fraassen's argument are distinct from McKay's considerations, and our diagnosis of where van Fraassen's thinking goes astray is different. Nevertheless, our responses to van Fraassen are in the same spirit.

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explanatory view to Newton's is one of substraction—getting rid of Kepler's laws—and replacement —accepting the more general theory. (V1) does not apply to this sort of standard theory change.[12]

2.2 Regarding V2

We raise three points against (V2) which claims that only an increase in a theory's probability can provide an epistemic reason for the theory.

2.2.1 Support ≠ probability-raising

(V2) is false because it glosses over the important distinction between the balance of evidence and the weight of evidence.[13] The balance of evidence is the probability of a claim on the evidence. Additional evidence may result in an increase in a claim's probability. If so, then the balance of evidence has changed with respect to the relevant claim. The weight of evidence is a matter of how much evidence there is for a claim. If, for instance, a claim is based on one eyewitness report and then another witness comes forward, then there is an increase in the weight of evidence. The weight of evidence will always increase whereas the balance of evidence may increase, decrease, or remain the same.

The balance of evidence and the weight of evidence can come apart from one another. Consider the following case adapted from an earlier example of ours (McCain and Poston 2014).

> Suppose one has a six-sided die, which looks fairly typical. What is the epistemic probability it does not land on "1" on the next roll? If you knew the non-epistemic, objective chance of it not landing "1" on the next roll that should be the probability you assign. But failing that, you must use your available evidence to determine the relevant non-epistemic, objective chance. Since your evidence indicates that the die is fair and the various bias hypotheses you entertain are symmetrically counterbalanced, you assign a value of 5/6 to the next roll not resulting in "1". Now suppose one rolls the die a million times and it lands "1" approximately one sixth of the time. What is the epistemic probability that the next roll is not "1"? The answer is the same, 5/6. Pr_t(not "1" on next roll | k) = 5/6 and Pr_{t+e}(not "1" on next roll | k&e) = 5/6, where k is one's background evidence, e is that there have been approximately 1/6 "1"s among a million rolls, $Pr_t(-- \mid --)$ is one's initial probability assignment and $Pr_{t+e}(-- \mid --)$ is the probability assignment after learning only e. Even though there's no change in the balance of probability, one's evidence for that assignment has increased significantly.

Here, the *weight* of evidence increases although the *balance* of evidence stays the same. Accordingly, one has more reason to believe that the die will not land on "1". Similarly, it could be that features of a new theory T' increase the weight of evidence for the original theory T without changing T's probability.

Suppose, for instance, one has overwhelming statistical evidence that smoking causes cancer, but then one discovers a causal explanation of why smoking causes cancer. It may be that the epistemic probability that smoking causes cancer does not change with the discovery of the causal explanation because one already had overwhelming statistical evidence that smoking causes cancer. Even so the added causal explanation increases the weight of evidence that smoking causes cancer.[14] Witness: if a problem were discovered with the statistical evidence (if a part of the data were fabricated), then

[12]van Fraassen's understanding of informational content as sensitive to contextual and pragmatic features is in tension with a general comparison of the informational content between theories. While this is not a challenge to (V1), it does show that in general (V1) has limited scope.

[13]See Joyce (2005). The distinction is originally formulated by Keynes (1921: Ch VI).

[14]See Roche and Sober (2013) for a challenge to inference to the best explanation from a case involving strong statistical evidence concerning the relationship between smoking and cancer. See our (2014) for a reply.

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the causal explanation would still suffice for the epistemic probability of the causal claim to remain high. Insofar as weight of evidence is important (and it sure seems to be!), features that increase *T*'s weight of evidence can be reasons to believe *T* even if those features do not change the balance of evidence.[15]

At this point two objections to our contention that the balance/weight distinction undermines (V2) might be tempting. First, some object that (V2) can be reformulated to apply only to balance of evidence.[16] That reformulation yields.

> (V2′) A feature of *T* cannot provide more epistemic reason to believe that *T* unless it increases the balance of evidence in favor of *T*.

While this would sidestep the balance/weight distinction, we think our argument shows that (V2′) is false. An increase in the weight of evidence does provide more epistemic reason to believe even if it does not effect the balance of evidence.

Second, some object on principled grounds to the balance/weight distinction.[17] In the original die tossing case, they argue that the additional evidence changes the balance of evidence concerning the objective probability that the die is fair. Initially, one may have a merely high credence that the die is fair, but after the million rolls one has near complete confidence that the die is fair. As a result, one might insist that while the balance of evidence for thinking that the next roll is not "1" does not change, the balance of evidence for thinking that the die is fair does change and this is what matters.

In response, we think that this rejoinder may well work for the die case, but it does not work in general. Cases involving multiple lines of independent evidence do not seem to fit the intended response to the die case. For instance, one line of evidence may settle the appropriate credence in a proposition. Then learning about the additional lines of evidence reinforce that particular credence value. Suppose several independent witnesses come forward each with an excellent track record of accurately indicating the truth on a particular matter. The witnesses assert "*p*". This may drive one's credence in *p* close to 1. Then one discovers several additional independent witnesses. These witnesses do not change one's credence. It was already close to 1. In this case, there is no higher-order belief about an objective probability that changes with the increase in evidence from the extra independent witnesses.[18]

A second line of response is that even if the response to the die case goes through generally it does not undermine our argument against (V2). Why? We can then reframe our concern about (V2) in terms of the contribution explanatory considerations can make to what it is reasonable to think

[15]See Christensen (1999) for a different case involving weight of evidence. His case involves learning that there are deer in the woods by observing deer droppings. Later one discovers shed deer antlers. Christensen claims the additional discovery provides support for one's belief but does not increase the epistemic probability that there are deer in the woods.

[16]From Kenny Boyce personal conversation.

[17]See, e.g., Climenhaga (2017).

[18]The phenomenon of "redundant evidence" supports this idea. A particular item of evidence is redundant evidence for *p* when it is evidence for *p*, but it makes no justificatory difference to one's doxastic attitude toward *p*. Feldman (2014) defends this idea by appealing to cases of certainty. Consider, if you are currently experiencing an excruciating pain, it is plausible that "I am in pain" is certain for you. If a neurologist were to inform you that pain receptors in your brain are quite active right now, that is evidence that you are in pain. Nevertheless, this does not make you any more justified in believing that you are in pain. Importantly, it does not seem that redundant evidence only occurs in cases of certainty. One of us, (McCain 2020), argues that redundant evidence is easily generated. Here's one way to do so. Start with your justified belief that *p*. Take a proposition, *q*, that is entailed by *p*. You can easily come to have a new justified belief, *p* v *q* by way of disjunction introduction. Given that the justified belief that *p* is evidence for *q*, the new justified belief *p* v *q* is also evidence for *q*. However, adding the justified belief that *p* v *q* to your evidence does not improve your epistemic position relative to *q*. The justified belief that *p* v *q*, though evidence for *q*, is redundant evidence. Here's the key point. While this redundant evidence does not add to the balance of your evidence, it does seem to increase the weight. After all, your justified belief *p* v *q* does not make *q* any more probable for you. Nevertheless, it provides an additional support for *q* because if you were to somehow lose the belief that *p* while retaining the justified belief that *p* v *q*, you would remain justified in believing that *q*.

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about the objective probability (e.g., a credence in an objective probability). In the case where one has strong statistical evidence about the proportion of smokers who develop cancer, for instance, the discovery of an explanatory story linking smoking to cancer can change what it is reasonable to think about the relevant objective probability that a particular smoker will develop cancer (rather than, as we see it, changing the weight of evidence). So, general reservations about the balance/weight distinction do not undermine our overall point against (V2).

2.2.2 A questionable model of belief addition

In the previous subsection we argued that (V2) is false because explanatory quality may increase the weight of evidence thereby providing more epistemic reason to believe a theory without changing the balance of evidence for a theory. We now shift our focus to arguing that if we move to a Bayesian view of "belief addition," (V2) is true but no longer provides an objection to explanatory reasoning. This is because, as we will show, if explanatory quality is reflected in the likelihoods, Bayesian updating can boost the credence of an explanatory hypothesis.[19]

The second problem with (V2) is that it relies on a questionable model of belief addition. So far, we have gone along with the view that we are adding and substracting beliefs from, say, a belief box. Instead of this, we might conceive of the belief box as never changing its content; it includes all the claims there are. Rather what changes in the belief box are the particular credences associated with each claim in the box.[20]

For illustration, suppose we learn p and q. There are only two competing explanations for p and q, $E1$ and $E2$. Given background evidence, k, $P(E1|k) = .3$ and $P(E2|k) = .7$. But $E1$ provides a much better explanation of p and q than $E2$. This explanatory difference is reflected in the high probability $E1$ gives to both p and q, and the low probability $E2$ affords to both p and q. Suppose we have these values: $P(p|E1\&k) = P(q|E1\&k) = .9$ and $P(p|E2\&k) = P(q|E2\&k) = .3$. Furthermore, let us suppose for ease of calculation that p and q are probabilistically independent given $E1$. Since $E1$ and $E2$ are rival explanations and exhaust the space of possible explanations, p and q are also probabilistically independent given $E2$. This means that $P(p\&q|E1) = P(p|E1) \times P(q|E1)$. Mutatis Mutandis for $E2$.

van Fraassen points out that if one adds $E1$ to the set $\{p, q\}$ then the probability of the new set is less than the probability of the old set. This is correct. But it is not relevant on a Bayesian picture in which explanatory quality is reflected in one's probability function. $P(p\&q) = 1$ since by assumption $P(p) = 1$ and $P(q) = 1$. But

$$P(E1\&p\&q) = P(p\&q) \times P(E1|p\&q) = P(E1|p\&q).$$

Why? p and q have been established as true; thus, the probability of the conjunction reduces to the probability that $E1$ is true given p and q. This probability is given by Bayes' theorem.

$$P(E1|p\&q) = \frac{P(p|E1)P(q|E1)P(E1)}{P(p|E1)P(q|E1)P(E1) + P(p|E2)P(q|E2)P(E2)} = \frac{.9*.9*.3}{(.9*.9*.3) + (.3*.3*.7)} \approx .79$$

So, if one adds $E1$ to the set $\{p, q\}$ then this decreases the overall probability of one's set of beliefs. You move from a set of beliefs with probability 1 to a set of beliefs with probability .79. Yet this misses the crucial fact that there are exactly two explanations of p and q. And once we conditionalize on the evidence, the probability for $E1$ increases from .3 to .79 and accordingly the probability of $E2$ decreases from .7 to .21. So here the explanatory virtues of $E1$ with respect to p and q provide strong

[19]We are not assuming here that explanatory quality is only located in the likelihoods. We are in general amenable to the view of Okasha (2000, p. 73) that the goodness of an explanation is located in either the priors or the likelihoods.

[20]This belief box model reflects a particular consequence of the Bayesian assumption of logical omniscience, that one has a credence over every claim in logical space. More on this below.

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reason to believe it. The evidence confirms $E1$. If one thinks of "adding" the belief that $E1$ as coming from nowhere then it does look curious that one moves to a new set of beliefs with a lower probability. But the crucial fact is that $E1$'s ability to explain the relevant evidence *increases* its posterior probability. A better picture of what is going on here is that $E1$ was already among one's credence set and its informational cum explanatory virtue with respect to p and q is reflected in its credence bump.

At issue here is the difference between full belief and degrees of belief. If we consider belief as an all-or-nothing matter, then it can seem puzzling that we should add an uncertain belief because when one adds a belief that is not certain this decreases the probability of one's set of beliefs. But if we consider belief as coming in degrees then we see here that the explanatory quality of $E1$ gives it a boost in probability. On the degree of belief model, there is an algebra over all propositions in accord with the probability calculus. The set of one's "beliefs" on this model does not change (more accurately, the set of propositions one has a credence over does not change); rather as one learns, one's credence is adjusted in accord with Bayesian updating. As the above example shows, explanatory reasoning can lead to an overall increase in probability. Hence, on the degree of belief model, there is no particular problem for explanatory reasoning.

The problem of logical omniscience is close at hand though.[21] In our brief story, we say that the contents in the belief box do not change; only the credences do. Standard Bayesianism states that rationality requires that the probability of every logical truth is 1. In the case of explanatory theories, the disjunction of a partition of explanatory theories ought to have probability 1. So standard Bayesianism implies that people have a credence over every possible explanatory theory. But actual people often violate this because they have not conceived of some relevant space of explanatory views, and so they do not have a credence function over all such propositions. Explanatory reasoning often results in adding a new explanatory proposition to the set of relevant alternatives. In this context it looks like explanatory reasoning leads to an overall decrease in the epistemic probability of one's beliefs. On our view, this is a mistaken impression arising from the problem of logical omniscience. One first adds the explanatory hypothesis to one's credence set and then examines whether it receives a credence boost on account of its explanatory power.

2.2.3 *Infallibilism again*

We've presented two independent lines of reasoning against (V2). First, it is false on account of the balance/weight distinction. Second, if one adopts a Bayesian model of belief addition, (V2) is true but does not affect explanatory reasoning. Now we return to the earlier discussion from section 1 of the argument against belief addition. Perhaps the biggest flaw with van Fraassen's attack on explanatory reasoning is that, at its heart, it is tantamount to embracing infallibilism about justification (that one should only accept beliefs for which one is absolutely certain). In the case we just discussed, adding $E1$ to the set $\{p, q\}$ results in a new set of beliefs with an overall probability that is less than one. But $E1$'s probability has *increased* from .3 to .79. The upshot is that van Fraassen's argument does not target explanatory reasoning in particular. Rather, accepting (V2) yields a general argument against ever adding any beliefs that are less than certain. While there may be reasons to be an infallibilist in some cases, as a general practice it seems to conflict both with our everyday experiences as well as with our best scientific practice.

This may be surprising because (V2) does not say anything about certainty. Rather it requires that epistemic reasons should increase probability. But in the context of van Fraassen's argument he focuses on expanding one's view of the world. The worry is that expanding one's view of the world diminishes the overall probability of one's view. Diminished overall probability is, all other things being equal, something we should avoid for our views. But in many cases all other things are not equal. Sometimes we can only achieve a more expansive view of the world at the expense of

[21]See Garber (1983).

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decreased overall probability. There are cases where gaining the most understanding of the world requires taking an increased risk of being wrong.[22]

This point generalizes. Believing on less than certain evidence is simply a risky endeavor. What we gain in terms of expanding our view on the world comes at the cost of the possibility of an incorrect view. But this general problem affects any rule for uncertain belief addition. Even the simple rule of enumerative induction where one infers a generalization from a set of instances comes under fire from van Fraassen's argument. Perhaps, there's a defensible argument that one ought never add uncertain beliefs. But even if there is, it is not a particular problem for explanatory reasoning. We conclude then that the criticism that explanatory virtues are informational virtues and as such aren't confirmational virtues does not isolate a particular problem with explanatory reasoning. To the extent that argument is good, it is a general skeptical argument against expanding one's view of the world.[23]

3. Conclusion

van Fraassen's influential critique of explanatory reasoning is multifaceted. We have only considered here his specific criticism that explanatory reasoning is suspect because informational virtues aren't confirmational. We've argued that this turns out to be an instance of a more general argument that one ought never form uncertain beliefs. While such skepticism may be worth serious consideration, van Fraassen's argument does not target explanatory reasoning in particular. Additionally, we have presented reasons for thinking that this argument is not persuasive.[24]

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[22]In fact, some (e.g., de Regt 2015, Elgin 2004, 2017, and Potochnik 2017) argue that understanding is often enhanced by not only taking a risk of being wrong but by relying upon idealizations that we know to be false. In the formal literature on explanatory inference, see Glass and Schupbach (2024) and Schupbach (2023) for a different approach to the idea that explanatory inference is not always threatened by diminished probability.

[23]Sober (1993, p. 46) argues that van Fraassen's logical point that the claim that a theory is empirically adequate is more probable than the claim that the theory is true does not get one very far. He observes that there are weaker statements like *T* is empirically adequate concerning events on Mondays, Wednesdays, and Fridays, but that obviously does not imply there is something suspect about the logically stronger claim that *T* is empirically adequate every day of the week. See also Giere (1985) for a discussion of logically stronger and weaker views in connection with van Fraassen's position.

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