Does Evidential Variety Depend on How the Evidence Is Described?

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The Variety of Evidence Thesis (VET) says that (ceteris paribus) the more diverse (or varied) of two bodies of evidence is the more confirmatory of a hypothesis *H*. Two recent types of Bayesian explication of VET account for the intuitive force of VET by defining variety as some function of the probabilities of the propositions which collectively constitute a body of evidence. I show that these two accounts of VET are not tracking a meaningful property of bodies of evidence, but rather are tracking artifacts of how those bodies of evidence are described. According to each account, whether a body of evidence is more varied than another depends on how the bodies are split into parts. Furthermore, for each type of account there exists a way to redescribe the total evidence such that any two totalities are equally varied.

1. Introduction. It is a truism that a more diverse or varied body of evidence confirms a hypothesis more strongly than a homogeneous body of evidence (ceteris paribus, anyway). Call this the Variety of Evidence Thesis (VET). Here I examine two probabilistic strategies for explicating VET, and find them both lacking in a crucial respect: they are both dependent on how the bodies of evidence in question are described. In other words, both accounts entail that whether a body of evidence is varied or unvaried (or more or less varied than another body of evidence) depends on which conjunction is used to pick out a proposition. This does not show that VET is false, but I do think it means that the analysis of VET is not to be had by breaking an evidential proposition into pieces, and then tying facts about the relations between the *pieces* to the confirmation of a hypothesis by the *whole* evidential proposition.

In the next two sections I describe the two types of Bayesian accounts

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of VET. I then demonstrate the nature of their dependence on how the evidence is described. Then I discuss the implications of this description variance for VET.

2. Confirmational Independence. Let '$\mathcal{E}$' denote a body of evidence. It might be separated into conjuncts, E_1 and E_2, where the E_i are not logically equivalent to one another.

'Confirmational independence' is Fitelson's (2000) name for a property held by a body of evidential propositions, with respect to a hypothesis H. (I will sometimes abbreviate 'confirmational independence' by 'C-independence'.) Informally, two evidential propositions E_1 and E_2 are confirmationally independent with respect to H if and only if E_1 confirms H to the same degree as E_1 confirms H with E_2 already taken as background, and vice versa (where 'E_1' and 'E_2' are switched). C-independence, therefore, is a four-place relation between two pieces of evidence, a hypothesis, and a body of background knowledge (the notation for which is suppressed in this essay, for easier reading).

More precisely, E_1 and E_2 are *confirmationally independent* with respect to H if and only if

$$c(H, E_1) = c(H, E_1|E_2) \text{ and } c(H, E_2) = c(H, E_2|E_1),$$

where $c(H, E_i)$ represents the degree to which E_i confirms H according to confirmation measure c. Depending on which measure is substituted for c, the conditions for C-independence will differ. When discussing C-independence in this essay, I will only consider the likelihood ratio, l, where

$$l(H, E) = \frac{p(E|H)}{p(E|\neg H)}.$$

This is partly due to space restrictions and partly due to the fact that discussing one measure is sufficient to convey a more general point. Using l as the measure of degree of confirmation, E_1 and E_2 are C-independent with respect to H if and only if

$$\frac{p(E_1|H)}{p(E_1|\neg H)} = \frac{p(E_1|H \wedge E_2)}{p(E_1|\neg H \wedge E_2)} \text{ and } \frac{p(E_2|H)}{p(E_2|\neg H)} = \frac{p(E_2|H \wedge E_1)}{p(E_2|\neg H \wedge E_1)}.$$

Since the two equations are equivalent, there is only one condition for C-independence when the measure l is used.

Fitelson (2000) shows that if (1) E_1 confirms H, (2) E_2 confirms H, and (3) E_1 and E_2 are C-independent with respect to H, then the degree to which $E_1 \wedge E_2$ confirms H exceeds the degree to which either piece of evidence taken on its own confirms H (he calls this proposition '$\mathcal{D}$'). In

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other words, given C-independence, two pieces of evidence that each separately confirm H will together confirm H more than either by itself.

This fact about two C-independent evidential propositions is taken to at least partly justify VET, which says that (ceteris paribus) when two bodies of evidence of the same 'size' both confirm H, the body of evidence that is more varied or diverse will confirm *more* than the less varied or diverse body. (I note that Fitelson explicitly allows that there may be some types of significant 'variety' that are not accounted for by the proposition $\mathcal{D}$).

3. Correlationism. 'Correlationism' is a name for a strategy for accounting for VET.[1] In particular, Fitelson (2000) lists Earman (1992) and Howson and Urbach (1993) as advocates of correlationism (though their specific proposals differ). I will not consider Earman's version of correlationism in this essay, partly because of space restrictions and partly because the versions I do discuss are more general than Earman's version.[2]

3.1. Howson and Urbach's Version. The gist of the correlationist approach is to examine the probabilities of the individual bits of evidence, conditional on each other (not on some hypothesis). The intuitive idea is that in an unvaried $\mathcal{E}$, a bit of evidence yields positive information about whether the other bits of evidence obtain. Howson and Urbach put the point this way (I have translated the quotation into my own notation):

> The idea of similarity between items of evidence is expressed naturally in probabilistic terms by saying that E_1 and E_2 are similar if $p(E_2|E_1)$ is higher than $p(E_2)$, and one might add that the more the first probability exceeds the second, the greater the similarity. (1993, 113–114)

In a two-membered body $\mathcal{E}$, the extreme case is when E_1 implies E_2; for Howson and Urbach this means that $\mathcal{E}$ is as unvaried as it could be, given the value of $p(E_2)$. The effect of a varied set $\mathcal{E}$ of evidence is to keep $p(\mathcal{E})$ relatively low, compared to what it would be if $\mathcal{E}$ were unvaried. And of course, the lower $p(\mathcal{E})$ is, the higher the boost to the posterior probability of a hypothesis (likelihood and priors being held equal).

I will refer to this version of correlationism as 'binary correlationism'. It is important that the order in which one takes E_1 and E_2 does not

1. The name originated, as far as I know, with Wayne 1995.

2. Earman's version applies, as far as I can tell, only to cases in which the evidence is implied by a hypothesis. By contrast, the versions discussed herein have no such restriction.

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matter on this type of correlationism. If $p(E_2|E_1) < p(E_2)$, then $p(E_1|E_2) < p(E_1)$.

3.2. Myrvold's Version. Myrvold (1996) tries to make the kernel of correlationism more general. He defines a measure of the degree to which a set of evidential propositions are 'varied'. This measure is called '$\mathcal{S}$':

$$\mathcal{S}(E_1, \ldots, E_n) = \frac{p(E_1 \wedge \cdots \wedge E_n)}{p(E_1) \times \cdots \times p(E_n)}.$$

Yet Myrvold's central point in that essay is that whether a body of evidence is varied depends on the hypothesis one is using the body to evaluate. So there is a version of $\mathcal{S}$ conditional on a hypothesis H:[3]

$$\mathcal{S}(E_1, E_n|H) = \frac{p(E_1 \wedge \cdots \wedge E_n|H)}{p(E_1|H) \times \cdots \times p(E_n|H)}.$$

From now on I will consider $\mathcal{S}$ as applied to a two-membered body of evidence $\{E_1, E_2\}$. $\mathcal{S}(E_1, E_2|H)$ is equal to 1 if the members of the evidential set are probabilistically independent of one another, greater than 1 if they are positively correlated, and less than 1 if they are negatively correlated. The higher the $\mathcal{S}$-score of a set, the less varied it is. It is built into the definition of $\mathcal{S}$ that it does not matter in what order one learns the members of the evidential set. I will call Myrvold's version of correlationism 'conditional correlationism', because of the way it conditionalizes on a hypothesis.

4. Description Variance. The accounts of VET discussed above are all such that the verdict on the variety of a body of evidence hinges on how the body of evidence is described. To show this, I will employ a couple of simple examples; one will apply to both C-independence and conditional correlationism, and the other will apply to binary correlationism. I begin with the former.

Suppose that on another planet, the total description of the weather consists of specifying whether or not each of four primitive weather states obtain.[4] The four states are *r* (rainy), *w* (windy), *s* (sunny), and *d* (dark). Let us suppose that no combinations of these are mutually exclusive.

Suppose that one wishes to know, on a given day, whether it is sunny. That is, let *S* be the hypothesis that state *s* obtains. Consider two distinct

3. It is worth noting that the quantity $\mathcal{S}(E_1, \ldots, E_n|H)/\mathcal{S}(E_1, \ldots, E_n)$ is identical to Myrvold's (2003) measure U of the degree to which H unifies $E_1, \ldots, E_n$ (once logarithms are dropped).

4. This example is descended from one in Miller 1974.

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bodies of evidence: $\mathcal{E}_1$ = it is rainy and windy (i.e., $r \wedge w$), and $\mathcal{E}_2$ = it is windy and dark (i.e., $d \wedge w$).

4.1. C-independence Is Description Variant. Perhaps one of $\mathcal{E}_1$ or $\mathcal{E}_2$ is C-independent with respect to S, or perhaps not. That depends on the specific probability distribution over the possible weather states. The present point is that it *does not matter* whether either body of evidence (or both) is C-independent with respect to S. That is because we can *just as well* describe our evidence sets as $\mathcal{E}_1' = \{F, G\}$ and $\mathcal{E}_2' = \{H, I\}$, where

- $F = s \vee (r \wedge w)$
- $G = \neg s \vee (r \wedge w)$
- $H = s \vee (d \wedge w)$
- $I = \neg s \vee (d \wedge w)$.

Our evidence $r \wedge w$ is logically equivalent to $F \wedge G$, and likewise $d \wedge w$ is equivalent to $H \wedge I$. Whether we choose to describe our evidence as $\mathcal{E}_1$ or $\mathcal{E}_1'$ is of no consequence to the degree of confirmation they bestow upon S, at least for a Bayesian analysis (same for $\mathcal{E}_2$ and $\mathcal{E}_2'$). That is because the logical equivalence of $\mathcal{E}_1$ and $\mathcal{E}_1'$ guarantees their probabilistic equivalence.

However, the mode of description *is* of consequence for whether the body of evidence is considered C-independent. For F and G are C-independent with respect to S, and so are H and I (if we use the measure l). That is, the following two conditions hold:

$$\frac{p(F|S)}{p(F|\neg S)} = \frac{p(F|S \wedge G)}{p(F|\neg S \wedge G)} \text{ and } \frac{p(H|S)}{p(H|\neg S)} = \frac{p(H|S \wedge I)}{p(H|\neg S \wedge I)}.$$

To see this, note that according to the definitions of F and G: (1) S implies F—this means that $p(F|S) = 1 = p(F|S \wedge G)$; and (2) $\neg S$ implies G, and therefore $p(F|\neg S) = p(F|\neg S \wedge G)$. These two facts suffice for F and G to be confirmationally independent with respect to S. A parallel argument shows the same thing for H and I.

Moreover, this newly gained confirmational independence was *guaranteed* to happen, (almost) no matter what the specific probability distribution over the weather states had been. As long as the probability distribution assures that $p(r \wedge w|\neg S) > 0$ and $p(w \wedge d|\neg S) > 0$ (if those conditions are not met, then there would be division by zero), the C-independence of *both* bodies of evidence is assured by the above recipe for redescribing the evidence. For any triple $\{H, E_1, E_2\}$ that meets this basic condition it is possible to generate a new triple $\{H, E_3, E_4\}$, such that E_3 and E_4 are confirmationally independent with respect to H, and $(E_1 \wedge E_2)$ and $(E_3 \wedge E_4)$ imply each other.

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4.2. Naturalness and Language Variance. One might be tempted to object here that representing the logical content of $\mathcal{E}_1'$ as $\{F, G\}$, which is simply an abbreviation for

$$(s \vee [r \wedge w]) \wedge (\neg s \vee [r \wedge w])$$

(as done in the previous section), is somehow 'unnatural', and therefore it is under the description $\{r, w\}$ that C-independence must be judged to hold or not hold. First, even if it is granted that the alternate description *is* unnatural, this makes no difference to the evidential bearing of the total evidence. There is nowhere in the probability calculus for 'naturalness' to go. Second, I think that what appears natural and what does not is bound to be at least in part language dependent.

To see why, let us return to the weather example. Suppose that some other inhabitants of the alien planet speak a language different from that of the inhabitants who speak the language containing $\{s, d, r, w\}$. Following Miller (1974), we introduce two new predicates a and m, which have the following properties:

- $a \leftrightarrow (s \leftrightarrow r)$
- $m \leftrightarrow (s \leftrightarrow w)$.

The language of these inhabitants contains the simple predicates $\{s, d, a, m\}$, while the first language mentioned contains the simple predicates $\{s, d, r, w\}$. The biconditionals mentioned above ensure that the two languages are expressively equivalent.

The 'unnatural' description $\mathcal{E}_1'$ is expressed in the new language as

$$\mathcal{E}_1'' = \{s \vee (\neg a \wedge \neg m), \neg s \vee (a \wedge m)\}.$$

I submit that much if not all of the 'unnaturalness' of $\mathcal{E}_1'$ is not present in $\mathcal{E}_1''$. For in the latter description, it is intuitively clear that "if S is true, then a and m must be true, while if S is false, then neither a nor m can be true." That is, it appears 'syntactically obvious' that (given the evidence) S and $\neg S$ make different predictions, specifically, *contrary* (as opposed to contradictory) predictions. By contrast, when expressed as $\mathcal{E}_1'$ it appears syntactically obvious that in light of $\mathcal{E}_1'$, S and its negation make the *same* predictions (namely, r and w).

The suggestion that the evidence should be expressed in a manner as close to a conjunction of atomic propositions as can be done also comes to nothing, since the condition is language variant. The atoms of one language are the molecules of another, as the two languages just mentioned show.

Whether a description of the evidence is 'natural' cannot affect the logical force of the body of evidence, because naturalness varies with one's

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choice of expressively equivalent language, and such a choice cannot affect the evidential strength or virtue of a body of evidence.

4.3. Correlationism Is Description Variant. Correlationist accounts of variety are description variant as well. First I will demonstrate this for binary correlationism, using a new simple example. Then I will return to the weather example to to show conditional correlationism's description variance.

4.3.1. Binary Correlationism. Suppose that our evidential set is $\mathcal{E} = \{E_1, E_2\}$, where '$E_1$' is 'the culprit is a six footer', and 'E_2' is 'the culprit is a brown-haired Brazilian'. Let some probabilities be as follows: p(six footer) = 0.45; p(brown-haired) = 0.317; p(Brazilian) = 0.417; p(brown-haired Brazilian) = 0.1; p(brown-haired six footer) = 0.2; $p(\mathcal{E}) = 0.067$.

According to Howson and Urbach, the set $\mathcal{E}$ is unvaried, since $p(E_2) < p(E_2|E_1)$. But now suppose we consider $\mathcal{E}' = \{E'_1, E'_2\}$, where '$E'_1$' is 'the culprit is a brown-haired six footer' and 'E'_2' is 'the culprit is a Brazilian'. Now $\mathcal{E}'$, is varied, since $p(E'_2) > p(E'_2|E'_1)$.

$\mathcal{E}$ and $\mathcal{E}'$ express the same total evidence; all that happened was that a conjunct was taken from one side of this totality and stuck on the other. The two bodies of evidence rule out all the same suspects, yet one is varied while the other is unvaried, according binary correlationism. (I also note that this example infects the unconditional version of $\mathcal{S}$.)

4.3.2. Conditional Correlationism. The description variance of correlationism is especially prevalent in the case of the measure $\mathcal{S}$. In fact, a redescription similar to the one used in the discussion of confirmational independence will suffice to show that (almost) any two bodies of evidence admit of redescription according to which they are equally varied (according to $\mathcal{S}$). Let our evidential set be $\mathcal{E} = \{r, w\}$, and let 'B' be some proposition in the background corpus (perhaps an auxiliary assumption). This means that B is always conditionalized upon, whether or not H is as well. (We suppose that B meets the basic condition that $p(r \wedge w|B) > 0$.) Let 'F' stand for the proposition $B \vee (r \wedge w)$, and let 'G' stand for the proposition $\neg B \vee (r \wedge w)$. Then our total evidence, $r \wedge w$, is logically equivalent to $F \wedge G$. (This is not as odd as it may sound; if we pick the right B, such as 'the instrument is working properly', then both F and G are individually informative).

Suppose also that there is a second body of evidence $\mathcal{E}' = \{d, w\}$. We want to know whether $\mathcal{E}$ or $\mathcal{E}'$ is more varied. Let 'K' denote the proposition $B \vee (d \wedge w)$ and 'L' denote the proposition $\neg B \vee (d \wedge w)$. Then, $d \wedge w$ is logically equivalent to $K \wedge L$.

Depending on what the probability distribution over S, r, w, and d is

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like, $\mathcal{S}(r, w)$ and $\mathcal{S}(r, w|S)$ will have some particular value. The same is true for $\mathcal{S}(d, w)$ and $\mathcal{S}(d, w|S)$. We need not be concerned with the specific values here, because (almost) no matter what they are, there is a description of the two bodies such that they are equally varied. In particular, we describe the contents of $\mathcal{E}$ as $\{F, G\}$ and the contents of $\mathcal{E}'$ as $\{K, L\}$. Then it follows[5] that

$$\mathcal{S}(K, L) = \mathcal{S}(F, G) = 1 = \mathcal{S}(F, G|S) = \mathcal{S}(K, L|S).$$

Thus every body of evidence, in some sense, is equally varied under conditional correlationism.[6] Indeed, every body of evidence has a 'neutral' variety score!

5. The Import of Description Variance. Both the confirmational independence and correlationist accounts of VET are dependent on the clothing in which we dress the proposition that expresses our total evidence, rather than on the proposition itself. Yet, confirmation in the Bayesian sense—both qualitative and quantitative—has no such dependencies. Logically equivalent bodies of evidence are confirmationally equivalent. As one shifts the mode of description of the evidence, its degree of confirmation remains fixed, while the verdicts on the 'variety' of the evidence shift every which way. This leads one to wonder why one should care about variety.

It may be objected that these accounts of variety are tied to confirmation using ceteris paribus clauses. They have the form '*if* so and so, then the more varied body of evidence confirms more strongly than such and such'. For example, consider the measure $\mathcal{S}$. If we take $r(H, E)$ as the measure of the degree to which E confirms H, where $r(H, E) = p(H|E)/p(H) = p(E|H)/p(E)$, then, for a two-membered evidential set (Myrvold 1996, 663),

$$r(H, E_1 \wedge E_2) = r(H, E_1) \times r(H, E_2) \times \frac{\mathcal{S}(E_1, E_2|H)}{\mathcal{S}(E_1, E_2)}.$$

5. Since B implies F, $p(F|S) = 1 = p(F)$ and $p(F \wedge G|S) = p(G|S)$. This makes $\mathcal{S}(F, G|S) = 1$. Conditionalizing on B also guarantees that $p(F \wedge G) = p(G)$, which in combination with $p(F) = 1$ (from above) implies that $\mathcal{S}(F, G) = 1$. A parallel argument establishes the same result for $\mathcal{S}(K, L|S)$ and $\mathcal{S}(K, L)$. So, no matter what the two bodies of evidence are, and no matter what their conditional and unconditional $\mathcal{S}$-scores are, there is a redescription in which the two bodies are equally varied.

6. This very same recipe will also work on binary correlationism. That is, if we make $\mathcal{S}(F, G) = 1$, then $p(F \wedge G) = p(F)p(G)$, from which it follows that both $p(F) = p(F|G)$ and $p(G) = p(G|F)$. The latter two equations mean that $\{F, G\}$ is a body of 'neutral' variety. Moreover, (almost) any other body of evidence will also be made 'neutral' by the same recipe. Hence, in some sense, every body of evidence is equally varied, under binary correlationism.

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Let the product of the individual confirmations—that is, $r(H, E_1) \times r(H, E_2)$—be called the '*i*-product' of H with respect to $E_1 \wedge E_2$. The above equation underwrites a ceteris paribus claim about why variety is good.

> (**CET**). Holding the *i*-product of H with respect to $\mathcal{E}$ fixed, and holding fixed the degree to which H renders those bits of evidence more or less diverse, $\mathcal{E}$ confirms H more strongly to the extent that it is more varied (unconditional on H).

If in one description, the ceteris paribus condition holds and one evidential body is more varied than the other, then in any redescription in which the degrees of variety either become equal or invert, the ceteris paribus clause—in this case, the *i*-product—will also shift accordingly. So, the truth of the ceteris paribus proposition will not be affected by changes of description, though the satisfaction of the antecedent might.

That is correct. Yet, to think that this fact alone vindicates confirmational independence or correlationism is to trivialize VET. If being an evidential virtue simply means 'there exists some ceteris paribus condition such that if it holds, then the body of evidence with your favorite probabilistic property V is more confirmatory than a body of evidence without V', then there are an infinite number of virtues. For one can cook up an arbitrary quantity Q such that, say,

$$r(H, E_1 \wedge E_2) = Q \times V,$$

where V is anything you want to be a 'virtue'.

For example, let j be the numeric index of the first letter in the English description of the hypothesis, and let k be the numeric index of the first letter in the English description of the conjunction $E_1 \wedge E_2$. Where '$r(H, E_1 \wedge E_2)$' is the degree to which $E_1 \wedge E_2$ confirms H, it is a theorem that

$$r(H, E_1 \wedge E_2) = \frac{j}{k} \times \left(\frac{p(E_1 \wedge E_2 | H)}{j} \times \frac{k}{p(E_1 \wedge E_2)} \right).$$

Call the quantity j/k the 'alphabetic ratio', and the other multiplicand 'the degree of virtue V'. Then the virtue V has its own ceteris paribus proposition associated with it: *If* two hypotheses have equal alphabetic ratios, then the one with the greater degree of V is more highly confirmed than the other. Plainly, having a high degree of V is not a virtue, for it is an artifact of something completely irrelevant; j/k could be tinkered with at will. Yet degrees of variety, on the accounts considered, are fundamentally no different from V. For the mode of splitting the total evidence into conjuncts, which is arbitrary, takes the place of j and k.

Moreover, if (CET) suffices to make a low value of $\mathcal{S}$ (unconditional

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on H) a virtue, then it should equally suffice to make the *i*-product a virtuous quantity. But it is strange to think of the *i*-product as potentially virtuous.

The upshot is that the existence of a true ceteris paribus proposition in which some property plays a role does not suffice to make that property a virtue. Thus, one cannot simply appeal to such ceteris paribus clauses in defense of accounts of variety that are description variant.

6. Conclusion. If VET is true and something like C-independence or correlationism is the right way to think about varied evidence, then the epistemological virtue of variety depends on the conjunction used to express the evidence. But *real* virtue should *not* be so dependent. One cannot alter the evidential power of a proposition simply by uttering the proposition in a different manner. Bayesians should agree with this sentiment; their explications of 'confirmation' and 'degree of confirmation' are constructed solely from the probabilistic features of propositions, and pay no attention to any manner of describing or picking out the propositions.

It may be objected that two bodies of evidence may be distinct even though they are logically equivalent. This type of objection fails to cut any ice, at least when leveled against probabilistic theories of evidence. *Even if* it is granted that logical equivalence does not ensure propositional identity, it remains that logically equivalent propositions are probabilistically equivalent. This ensures that, for example, even if '$F \wedge G$' is a different proposition from '$r \wedge w$', they have all the same evidential force. This holds not just for Bayesianism, but also for Likelihoodist and Hypothetico-Deductivist views of confirmation and evidence.

If we do not want to reject probabilistic confirmation theory, VET must have an explication other than C-independence or correlationism, and the correct explication must either be description invariant, or be tied to some property for which description variance is not a problem. For example, there is no prima facie demand that pragmatic, as opposed to epistemic or evidential, virtues be description invariant.

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