Bayesianism and Unification: A Reply to Wayne Myrvold*

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Myrvold (2003) has proposed an attractive Bayesian account of why theories that unify phenomena tend to derive greater epistemic support from those phenomena than do theories that fail to unify them. It is argued, however, that "unification" in Myrvold's sense is both too easy and too difficult for theories to achieve. Myrvold's account fails to capture what it is that makes unification sometimes count in a theory's favor.

1. Introduction. Unification is a notoriously elusive epistemic virtue. Wayne Myrvold (2003) has recently offered a Bayesian account of it. According to Myrvold's proposal, a theory h unifies the phenomena p and q, in one important sense of unification, to the extent that h makes p and q more mutually positively relevant confirmation-wise than they were on the prior probability distribution. Quantitatively, Myrvold suggests that we use $\log_2\big(\mathrm{pr}(q|pb)/\mathrm{pr}(q|b)\big)$ to measure p's bearing on q (given background b) prior to h, and he suggests that we use $\log_2\big(\mathrm{pr}(q|phb)/\mathrm{pr}(q|hb)\big)$ to measure p's bearing on q (with background b) given h.[1] Thus, the difference between these two quantities is the increase that h produces in p's bearing on q. Accordingly, Myrvold defines $\mathrm{U}(q, p; h)$ as this difference, i.e., as

$$\log_2\big(\mathrm{pr}(q|ph)/\mathrm{pr}(q|h)\big) - \log_2\big(\mathrm{pr}(q|p)/\mathrm{pr}(q)\big),$$

and he characterizes $\mathrm{U}(q, p; h)$ as measuring the extent to which h unifies the phenomena p and q. Equivalently, the degree to which h unifies p

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1. Notation: Henceforth I shall omit the ubiquitous background b. I also shall omit ampersands; by "ph," for instance, I mean the conjunction of p with h.

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and q is given by the $\log_2$ of the ratio of $\mathrm{pr}(pq|h)/\mathrm{pr}(p|h)\mathrm{pr}(q|h)$ to $\mathrm{pr}(pq)/\mathrm{pr}(p)\mathrm{pr}(q)$.

The upshot is that Bayesian confirmation theory can then readily explain why h is better supported by pq to the extent that h unifies p with q, since it follows from Bayes's theorem that

$$\log_2\big(\mathrm{pr}(h|pq)/\mathrm{pr}(h)\big) = \log_2\big(\mathrm{pr}(h|p)/\mathrm{pr}(h)\big) + \log_2\big(\mathrm{pr}(h|q)/\mathrm{pr}(h)\big) + \mathrm{U}(q,p;h).$$

In other words, the support bestowed upon h by pq can be decomposed into one contribution from p in isolation, one from q in isolation, and a third reflecting the extent to which h unifies p and q. For example, suppose that for hypotheses h_1 and h_2, we have $\mathrm{pr}(h_1) = \mathrm{pr}(h_2)$, $\mathrm{pr}(h_1|p) = \mathrm{pr}(h_2|p)$, and $\mathrm{pr}(h_1|q) = \mathrm{pr}(h_2|q)$. Then $\mathrm{pr}(h_1|pq) > \mathrm{pr}(h_2|pq)$ if and only if $\mathrm{U}(q,p;h_1) > \mathrm{U}(q,p;h_2)$. Greater unification is manifested in greater empirical support.

This argument presupposed that the support bestowed upon h by e is given by $\log_2\big(\mathrm{pr}(h|e)/\mathrm{pr}(h)\big)$. However, Myrvold recognizes that there are other ways in which we might measure this support. He allows that we might instead follow I.J. Good and use $\log_2\big(\mathrm{pr}(h|e)/\mathrm{pr}(\sim h|e)\big)$.[2] Then, Myrvold says, we could again decompose the support bestowed upon h by pq into one contribution from p in isolation, one from q in isolation, and a third reflecting the extent to which h unifies p and q:

$$\log_2(\mathrm{pr}(h|pq)/\mathrm{pr}(\sim h|pq) = \log_2(\mathrm{pr}(h|p)/\mathrm{pr}(\sim h|p) + \log_2(\mathrm{pr}(h|q)/\mathrm{pr}(\sim h|q)) + \mathrm{U}(q,p;h) - \mathrm{U}(q,p;\sim h).$$

Again, the upshot is that Bayesian confirmation theory can readily explain why h is better supported by pq insofar as the extent to which h unifies p with q exceeds the extent to which $\sim h$ unifies p with q. Accordingly, Myrvold says that we do not need to choose between these two ways of measuring the degree to which a piece of evidence supports a hypothesis, since on either choice of measure, the extent to which h unifies p with q is reflected directly in the support that pq supplies to h.

On Myrvold's view, the fact that a theory unifies what would otherwise be unrelated phenomena enables that theory to receive greater support from those phenomena. This result falls directly out of Bayesian

2. There are many other ways to measure degree of confirmation. See Fitelson (1999) for discussion.

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confirmation theory, without any need to cook the prior probabilities to reflect some a priori assumption that nature is apt to be parsimonious or some aesthetic or pragmatic preference for more unified theories. Myrvold's is an elegant and ingenious proposal. Though Myrvold does not claim that every case of unification is captured by this account, he does contend that it encompasses a common and important variety of unification.

I am not convinced that this is so. In this paper, I shall briefly explore some limitations of and deficiencies in Myrvold's approach. That approach is, I think, too crude to distinguish genuine unification from bogus. Unification in Myrvold's sense is at once too easy and too difficult to achieve.

2. Too Easy. If h genuinely unifies p and q, then h must possess some sort of explanatory or ontological priority over p and q. But h can "unify" p and q, in Myrvold's sense, even if h is not explanatorily or ontologically prior to them.

Consider this example (after Salmon 1975, 33). Suppose that radioactive atoms of a certain kind have three possible decay modes. When one such atom decays, the chances are 60% that it will emit an alpha particle, 20% that it will instead emit an electron, and 20% that it will instead emit a positron. Suppose we have two such atoms and each, behaving independently, happens to decay during a certain period. Let h be the hypothesis that the two decay products annihilate as particle and antiparticle (so they must be electron and positron). Let p be that atom #1 emits an electron and let q be that atom #2 emits a positron. Since h is not explanatorily or ontologically prior to p and q (indeed quite the reverse), h does not unify p and q. However, $U(q,p;h)$ is high:

$$\begin{aligned} U(q,p;h) &= \log_2(\mathrm{pr}(q|ph)/\mathrm{pr}(q|h)) - \log_2(\mathrm{pr}(q|p)/\mathrm{pr}(q)) \\ &= \log_2(1/.5) - \log_2(.2/.2) = 1 - 0 = 1. \end{aligned}$$

In Myrvold's sense, h "unifies" p and q to a great degree because once h is given, then p is strongly positively statistically relevant to q, whereas they were statistically independent prior to h. However, this statistical relevance relation is too crude to indicate whether there obtain the ontological and explanatory relations involved in genuine unification.

The analogous approach using Good's alternate measure of evidential support fares no better. Since h holds exactly when either atom #1 emits an electron and atom #2 emits a positron or vice versa, $\mathrm{pr}(h) = (.2)(.2) + (.2)(.2) = .08$, and so $\mathrm{pr}(\sim h) = .92$. Furthermore, $\sim h$ holds given q (atom #2 emits a positron) exactly when atom #1 emits an electron or an alpha particle, so $\mathrm{pr}(\sim h|q) = .8$. Thus, by Bayes's theorem,

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$$\mathrm{pr}(q|\sim h) = \mathrm{pr}(q)\mathrm{pr}(\sim h|q)/\mathrm{pr}(\sim h) = (.2)(.8)/(.92) = .17.$$

Now when p (atom #1 emits an electron) and $\sim h$ (no pair-annihilation) hold, then atom #2 emits a positron or an alpha particle, and so $\mathrm{pr}(q|p \sim h) = (.2)/(.8) = .25$. Putting it all together,

$$\begin{aligned}\mathrm{U}(q,p;\sim h) &= \log_2(\mathrm{pr}(q|p \sim h)/\mathrm{pr}(q|\sim h)) - \log_2(\mathrm{pr}(q|p)/\mathrm{pr}(q)) \\ &= \log_2(.25/.17) - \log_2(.2/.2) = \log_2(1.47) = .55.\end{aligned}$$

Since (as we saw earlier) $\mathrm{U}(q, p; h) = 1$, the extent to which h "unifies" p with q exceeds the extent to which $\sim h$ "unifies" p with q. Again, this result occurs without the ontological and explanatory relations involved in genuine unification.

In fact, arbitrary p and q are "unified" by h, in Myrvold's sense, when h is simply $(p \supset q)$. For example (recalling Goodman 1983, 68–69), let p be that Queen Elizabeth the First was crowned on a Tuesday and let q be that the there are basalt outcroppings on the far side of the Moon. Then

$$\begin{aligned}\mathrm{U}(q,p;h) &= \log_2(\mathrm{pr}(q|ph)/\mathrm{pr}(q|h)) - \log_2(\mathrm{pr}(q|p)/\mathrm{pr}(q)) \\ &= \log_2(1/\mathrm{pr}(q|h)) - \log_2(\mathrm{pr}(q)/\mathrm{pr}(q)) \\ &= \log_2(1/\mathrm{pr}(q|h)).\end{aligned}$$

By the definition of conditional probability (assuming $\mathrm{pr}(h) \neq 0$), $\mathrm{pr}(q|h) = \mathrm{pr}(qh)/\mathrm{pr}(h)$, and so (since q logically entails $p \supset q$)

$$= \log_2(\mathrm{pr}(h)/\mathrm{pr}(q)).$$

Since q logically entails h, $\mathrm{pr}(q) \leq \mathrm{pr}(h)$, and so $\mathrm{U}(q, p; h) \geq 0$. But genuinely to unify p and q, a theory must reveal them to have some deep common explanatory basis. It should not suffice for a theory merely to staple p and q together with a $\supset$.

A different, somewhat puzzling result is reached regarding this case if we use the analogous approach with Good's alternate measure of evidential support. Since $\sim h$ logically entails $\sim q$, $\log_2(\mathrm{pr}(q|p \sim h)/\mathrm{pr}(q|\sim h))$ is $\log_2(0/0)$, which is then equal to $\mathrm{U}(q,p;\sim h)$. This is difficult to parse and perhaps belies the thought that Myrvold's account need not choose between the two measures of evidential support.

Here is another way to see that Myrvold's account sets the bar too low to distinguish genuine from bogus unification. In a series of papers beginning in 1905, Albert Einstein elaborated various consequences of the light-quantum hypothesis. Having first argued that Planck's empirically

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adequate equation for the black-body spectrum makes implicit use of the light-quantum hypothesis, Einstein derived from the light-quantum hypothesis an equation for the photoelectric effect. He derived Stokes's rule of photoluminescence and an equation governing the Volta effect. He applied the light-quantum hypothesis to the specific heats of solids, the generation of secondary cathode rays by X-rays, and the high-energy limit for Bremsstrahlung. Einstein unified these diverse results by showing them all to arise from the light-quantum hypothesis.

Plainly, Einstein was led to these various results by his belief (which he took to be strongly supported by the empirical success of Planck's black-body equation) that all phenomena involving light's generation, conversion, and interaction with matter are as if light is quantized. Let's call this hypothesis *h*. Of course, Einstein might have believed *h* to be true but merely as a coincidence. That is, he might have believed *h* to express "nothing more than a curious property of pure radiation in thermal equilibrium, without any physical significance" (Pais 1982, 377). If *h* were a coincidental truth, then even though *h* would still have been an empirically useful heuristic, *h* would not have genuinely unified the various equations that Einstein derived; the fact that all of those equations are as if light is quantized supplies no common explanation of those equations in the event that light is not, in fact, quantized. However, Einstein believed instead that the photon is real and, therefore, that *h*'s heuristic value is no coincidence. He took *h* to be a law rather than a coincidence; he believed that *h* genuinely unifies various phenomena involving light.

Myrvold's account does not capture the fact that h_C (i.e., that *h* is correct, but merely coincidentally so) fails to unify these phenomena whereas h_L (i.e., that *h* is a law) succeeds in unifying them.[3] Let's now see that Myrvold's account treats h_C and h_L identically. Let p be one of the

3. This distinction is epistemically important: Whereas Einstein believed that the photon might be real if it turned out to be broadly useful, and therefore took the success of Planck's black-body equation to warrant advancing the photoelectric equation, Robert Millikan (1915, 355–356, 383, 388; 1917, 230) believed the photon unreal even if it turned out to be broadly useful. He championed its utility for the photoelectric effect (by experimentally establishing the accuracy of Einstein's equation) while holding that the success of Planck's equation constituted no evidence at all for "the bold, not to say the reckless hypothesis" of the photon and the photoelectric equation. Millikan's view was initially almost universal. Owen Richardson, for example, thought it coincidental that an empirically correct equation for the photoelectric effect followed from the light-quantum, and so he did not regard the accuracy of the light-quantum hypothesis in this respect as confirming its accuracy regarding other phenomena. Rather, he concluded that Einstein's photoelectric equation "evidently has a wider basis than the restricted and doubtful hypothesis used by Einstein" (Stuewer 1970, 259). Most physicists did not regard the photoelectric equation's success as evidence for the light-quantum until after the Compton effect's discovery in 1922.

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equations derived by Einstein from the light-quantum hypothesis, and let q be another of these diverse equations, governing a distinct phenomenon. Note that these equations are not logically entailed by h_L (or h_C) and b (the ever-present background), since the equations include the specific value of Planck's constant, which is left unspecified by h_L (or h_C) and b. Rather, h_L (or h_C) and b must be supplemented by one of these equations in order to logically entail the other. Even though h_C fails genuinely to unify p and q, Myrvold's account says otherwise:

$$\mathrm{U}(q,p;h_c) = \log_2(\mathrm{pr}(q|ph_c)/\mathrm{pr}(q|h_c)) - \log_2(\mathrm{pr}(q|p)/\mathrm{pr}(q)).$$

Prior to h_C, p and q are approximately independent, and so

$$\mathrm{U}(q,p;h_c) = \log_2(1/\mathrm{pr}(q|h_c)),$$

which is large and positive. So U(q,p; h_C) fails to capture the extent to which h_C unifies p and q. But my main point is that if h_C is replaced in the above calculation by h_L, then the calculation is otherwise unchanged. This replacement should make a dramatic difference to the degree of unification. Yet $\mathrm{U}(q,p;h_c) = \mathrm{U}(q,p;h_L)$. Myrvold's notion of unification is insensitive to the great difference in unifying power between h_C and h_L.

Let's look at one final example in which Myrvold's account fails to capture the factors responsible for a theory's power to unify and in virtue of which that theory possesses an epistemic advantage over its chief rival. The classical Big-Bang theory leaves unspecified the value of Ω in the early universe, where Ω is defined as the ratio of the universe's gravitational potential energy to its kinetic energy. (This ratio is a dimensionless quantity.) In view of observational data placing Ω's current value within roughly an order of magnitude of 1, the theory says that Ω at 10^{-43} seconds after the Big Bang was within a mere 10^{-59} of 1. The classical Big-Bang theory fails to unify the two components of Ω; they are independent parameters. In contrast, the inflationary Big-Bang theory posits a period of extremely rapid cosmic expansion before the universe reaches 10^{-32} seconds of age. This expansion leaves Ω (in any observable patch of the universe) with a current value near to 1 no matter what Ω's initial value had been.

In Myrvold's sense, the inflationary Big-Bang theory h unifies the two components of Ω: the approximate value of the universe's current gravitational potential energy (specified by p) and the approximate value of the universe's current kinetic energy (specified by q). Since hp logically entails q, whereas p and q were largely independent on the prior probability distribution, U(q,p;h) is large and positive. So far, so good. (The

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same verdict is given by the analogous approach with Good's alternate measure of evidential support: since $\mathrm{pr}(q|p \sim h) \approx \mathrm{pr}(q| \sim h)$, it follows that $\mathrm{U}(q,p;\sim h) \approx 0$, and so $\mathrm{U}(q,p;h) - \mathrm{U}(q,p;\sim h) \approx \mathrm{U}(q,p;h) \gg 0$.) However, Myrvold's account would have given exactly the same result for a theory entailing that the universe's current gravitational potential energy is (let's say) 3.78×10^{-27} times its current kinetic energy (had the observational data suggested this value). All that matters to the "unity" forged by h is that hp logically entails q.

But it is crucial to the epistemic advantage possessed by the inflationary Big-Bang model, in virtue of unifying p and q (and thereby addressing the so-called "flatness problem"), that $\Omega = 1$ is not an arbitrary value (such as 3.78×10^{-27}). Rather, $\Omega = 1$ is privileged by the classical Big-Bang theory itself. To begin with, $\Omega = 1$ is the critical point in determining the space-time geometry and fate of the universe. If $\Omega > 1$, then the universe is "closed" and will end in a Big Crunch. If $\Omega < 1$, then the universe is "open"; it will expand forever. Furthermore, according to the Big-Bang theory, $\Omega = 1$ is an unstable equilibrium (and the unique equilibrium value). Once it is the case that $\Omega = 1$, this value will persist; but once Ω departs even slightly from 1, then it will increasingly diverge from 1.

Because $\Omega = 1$ is uniquely privileged by the Big-Bang theory, the fact that the theory requires the kinetic and gravitational potential energies to be set so that $\Omega = 1$ seems suspicious—to amount to unnatural fine-tuning (Sciama 1983, 495). Therefore, the inflationary Big-Bang theory derives support from the fact that it unifies the kinetic and gravitational potential energies by demanding that they be about equal. However, if the current value of Ω were instead about 3.78×10^{-27}, which is not privileged in any way by the Big-Bang theory, then it would not necessarily count very much in favor of some version of the Big-Bang theory that it dictates something like this value. This sort of "unification"—if we are prepared to call it that—would not redound to the theory's advantage, any more than we would be impressed by a theory of solar-system formation requiring the Sun's angular diameter in the Earth's sky to be approximately equal to the Moon's angular diameter in the Earth's sky. We are perfectly content for this approximate equality to be deemed a coincidence, just as we would be so to regard $\Omega = 3.78 \times 10^{-27}$, since the fine-tuning needed for the classical Big-Bang theory to accommodate this value of Ω involves nothing *suspicious*. Myrvold's account appears to leave no room for these sorts of considerations to affect the value of $\mathrm{U}(q,p;h)$; again, all that matters is that hp logically entails q.

In short, Myrvold's account is correct in deeming the inflationary Big-Bang theory to have unified Ω's two components. But Myrvold's account does not correctly identify the source of this unification or why it counts in favor of the inflationary model.

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In view of these various examples, it might be suggested that Myrvold's account identifies a feature of many unifying theories (namely, that they make the phenomena they unify mutually positively relevant confirmation-wise), a feature that these theories share with some theories that achieve no unification at all. This feature contributes to the evidential support received by whatever theory possesses it. Whether there is some attenuated sense of "unification" that every theory possessing this feature achieves, or whether "unification" properly so-called requires that the unifying facts be ontologically or explanatorily prior to those they unify, is merely a terminological matter, not a substantive one.[4]

However, the examples I have given suggest that insofar as theories that unify in the stronger, ontological-explanatory sense derive greater support in virtue of the unification they achieve, they do so not solely in virtue of their achieving unification in the weaker, creating-mutual-positive-relevance sense. The stronger sense of unification is epistemically significant. In the case of the light-quantum hypothesis, h_C and h_L both supply unity in the weaker sense, but Einstein took h_L to receive greater support from the phenomena than h_C by virtue of h_L's unifying those phenomena in an ontological-explanatory sense. Likewise, in the Big-Bang case, the inflationary model receives greater support by virtue of unifying Ω's two components in the stronger sense. Unity in the stronger sense is thought to have some substantial likelihood because Ω's two components are about equal. A theory that achieves this sort of unity is thereby rendered more plausible. Any epistemic value deriving from unity in the weaker sense would arise whether Ω's value turned out to be privileged or arbitrary—that is, would arise regardless of whether Ω's value made unity in the stronger sense likely. The fact that the inflationary model supplies the stronger sort of unity, over and above the weaker sort, contributes to the support that the theory receives from the phenomena it unifies. Myrvold's proposal, then, does not enable Bayesian confirmation theory to account fully for the epistemic value of unification.

3. Too Difficult. In the preceding section, I argued that Myrvold's account sets the bar for unification too low. Now I shall argue that it also occasionally sets the bar too high. A hypothesis h can genuinely unify p and q although it is not the case that $\mathrm{U}(q, p; h) > 0$.

For example, let h be the hypothesis that Jones has systemic lupus erythematosus. Let p be that Jones has pleuritis and q be that Jones has a malar ("butterfly") rash. These are two symptoms of lupus but neither guarantees lupus and neither is guaranteed by lupus. A physician's personal probabilities are plausibly as follows: $\mathrm{pr}(p) = .055$, $\mathrm{pr}(q) = .050$,

4. Myrvold made a suggestion along these lines in correspondence, for which I am grateful.

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$\mathrm{pr}(h) = .035$, $\mathrm{pr}(p|h) = .500$, $\mathrm{pr}(q|h) = .650$, $\mathrm{pr}(h|p) = .318$, $\mathrm{pr}(h|q) = .455$, and $\mathrm{pr}(h|pq) = .700$. It follows that $\mathrm{pr}(p|q) = .325$ and $\mathrm{pr}(q|p) = .297$, so since $\mathrm{pr}(p|q) > \mathrm{pr}(p)$ and $pr(q|p) > \mathrm{pr}(q)$, p and q are mutually positively statistically relevant.

However, given lupus, pleuritis and malar rash are statistically independent symptoms (Winslow et al. 1958, 78–79; Ross and Wells 1953, 145): $\mathrm{pr}(p|qh) = \mathrm{pr}(p|h) = .500$ and, consequently, $\mathrm{pr}(q|ph) = \mathrm{pr}(q|h) = .650$. Thus, h makes p and q less mutually positively statistically relevant than they were on the prior probability distribution. Hence, h fails to unify p and q in Myrvold's sense. Indeed,

$$\begin{aligned} \mathrm{U}(q,p;h) &= \log_2(\mathrm{pr}(q|ph)/\mathrm{pr}(q|h)) - \log_2(\mathrm{pr}(q|p)/\mathrm{pr}(q)) \\ &= \log_2(1) - \log_2(.297/.050) \\ &= -\log_2(5.94) \\ &\approx -2.57. \end{aligned}$$

That is, h leaves p and q less unified (in Myrvold's sense) than before.

(The same verdict is given by the analogous approach with Good's alternate measure of evidential support. By Bayes's theorem,

$$\mathrm{pr}(h|p) = \mathrm{pr}(h)\mathrm{pr}(p|h)/\mathrm{pr}(p) = (.035)(.500)/(.055) = .318.$$

By the theorem of total probability,

$$\mathrm{pr}(q|p) = \mathrm{pr}(q|ph)\mathrm{pr}(h|p) + \mathrm{pr}(q|p \sim h)\mathrm{pr}(\sim h|p).$$

Substituting the values we already ascertained,

$$.297 = (.650)(.318) + \mathrm{pr}(q|p \sim h)(.682).$$

Hence,

$$\mathrm{pr}(q|p \sim h) = .132.$$

Again, the theorem of total probability tells us that

$$\mathrm{pr}(q) = \mathrm{pr}(q|h)\mathrm{pr}(h) + \mathrm{pr}(q| \sim h)\mathrm{pr}(\sim h).$$

Substituting the values we already ascertained,

$$.050 = (.650)(.035) + \mathrm{pr}(q| \sim h)(.965)$$

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Hence,

$$\mathrm{pr}(q|\sim h) = .028.$$

Thus,

$$\begin{aligned}\mathrm{U}(q,p;h) - \mathrm{U}(q,p;\sim h) &= -\log_2(\mathrm{pr}(q|p\sim h)/\mathrm{pr}(q|\sim h))\\ &= -\log_2(.132/.028) = -\log_2(4.71) \approx -2.24.\end{aligned}$$

So, on this approach, the extent to which $\sim h$ unifies p with q exceeds the extent to which h does.)

Yet this is surely mistaken: h would supply p and q with a common cause. Clearly, a physician trying to diagnose a patient afflicted with both pleuritis and a malar rash should (*ceteris paribus*) prefer a unified explanation to distinct explanations of the two symptoms:

> In medical school, I learned that when you are confronted with two apparently unrelated symptoms, the best way to find a diagnosis is to consider each symptom on its own, making two separate lists of potential causes. Then you compare the lists, and the causes that appear on both become possible diagnoses. (Sanders 2003, 14)

A unified, common-cause explanation is (in the absence of other considerations) more likely, though Myrvold's account does not recognize the unity that such a hypothesis brings to the otherwise apparently unrelated symptoms.

Of course, as I noted earlier, Myrvold does not claim that his proposal captures every variety of unification, merely a common and important sort. Here is a common and important sort that it fails to capture.

To conclude, it appears to me that Myrvold's approach, although admirable, fails to capture the epistemic advantages that unification often provides.

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